JOHN M. COLLINS



MILITARY GEOGRAPHY

FOR PROFESSIONALS AND THE PUBLIC

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAR 1998		**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Military Geography for Professionals and the Public	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Defense University,Institute for National Strategic Studies,Washington,DC,20319**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**446**	

MILITARY GEOGRAPHY
FOR PROFESSIONALS AND THE PUBLIC

To Professor Samuel Van Valkenburg
and Swift:

He stimulated my interest in military geography way back in 1950;
she was his private secretary,
who abandoned civilian life to become my Army bride.

MILITARY GEOGRAPHY
FOR PROFESSIONALS AND THE PUBLIC

John M. Collins

1998



National Defense University Press
Washington, DC

The Institute for National Strategic Studies (INSS) is a major component of the National Defense University (NDU), which operates under the supervision of the President of NDU. It conducts strategic studies for the Secretary of Defense, Chairman of the Joint Chiefs of Staff, and unified commanders in chief; supports national strategic components of NDU academic programs; and provides outreach to other governmental agencies and the broader national security community.

The Publication Directorate of INSS publishes books, monographs, reports, and occasional papers on national security strategy, defense policy, and national military strategy through NDU Press that reflect the output of NDU research and academic programs. In addition, it produces the INSS *Strategic Assessment* and other work approved by the President of NDU, as well as *Joint Force Quarterly*, a professional military journal published for the Chairman.

Opinions, conclusions, and recommendations expressed or implied within are solely those of the authors, and do not necessarily represent the views of the National Defense University, the Department of Defense, or any other U.S. Government agency. Cleared for public release; distribution unlimited.

Portions of this book may be quoted or reprinted without permission, provided that a standard source credit line is included. NDU Press would appreciate a courtesy copy of reprints or reviews.

NDU Press publications are sold by the U.S. Government Printing Office. For ordering information, call (202) 512-1800 or write to the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Library of Congress Cataloging-in-Publication Data

Collins, John M., 1921-

Military Geography for Professionals and the Public / John M. Collins

p. cm.

Includes bibliographical references and index.

ISBN 1-57906-002-1

1. Military geography. I. Title.

UA990.C554 1997

355.4'7—dc21 97-34721

CIP

First Printing, March 1998

CONTENTS

FOREWORD XVII
PREFACE by John W. Vessey, Jr. XIX
ACKNOWLEDGMENTS XXI
AUTHOR'S INTRODUCTION XXIII

1. OVERVIEW 3
Military Considerations 3
Regional Quirks 5
Avoidable Abuses 7
Analytical Techniques 8

PART ONE:
PHYSICAL GEOGRAPHY

2. SPATIAL RELATIONSHIPS 11
Location 11
Size 17
Shape 18

3. LAY OF THE LAND 27
Land Forms 27
Rivers and Reservoirs 32
Geology and Soils 36
Vegetation 39

4. OCEANS AND SEASHORES 47
Sea Water Attributes 47
Sea Surface Behavior 49
Marine Topography 55
Representative Naval Ramifications 59

5. EARTH'S ATMOSPHERE 69
Atmospheric Phenomena 69
Climatology for Military Strategists 79
Meteorology for Military Operators 80

6. REGIONAL PECULIARITIES 93
Frigid Flatlands 93
Frigid Seas 98
Mountainous Regions 102
Arid Regions 109

Tropical Rain Forests 115
Wetlands 121
Coastlands and Small Seas 126

7. INNER AND OUTER SPACE 137
Space Compared with Land and Sea 137
Region I: Aerospace Interfaces 139
Region II: Circumterrestrial Space 143
Region III: Moon and Environs 144
Region IV: Outer Envelope 146
Tips for Military Space Planners 146

8. NATURAL RESOURCES AND RAW MATERIALS 153
Sources and Shortages 153
Compensatory Programs 158
Resource Deprivation 159

PART TWO:
CULTURAL GEOGRAPHY

9. POPULATIONS 177
Demography 178
Physical Attributes 180
Cultural Characteristics 182
Current Attitudes 187
National Personalities 188
Cross-Cultural Skills 189

10. URBANIZATION 195
Sites and Structures 196
Urban Sprawl 198
Conventional Urban Combat 199
Unconventional Urban Combat 204
Conventional Urban Bombardment 206
Urban Centers and Nuclear Strategy 208
Overall Urban Vulnerabilities 209

11. LINES OF COMMUNICATION 215
Roads 215
Railroads 223
Military Airports 228
Seaports and Harbors 232
Spaceports and Flight Paths 236
Inland Waterways 238
Pipelines 240

12. MILITARY BASES 245
U.S. Home Bases 245
U.S. Cold War Bases Abroad 246
Post-Cold War Retrenchment 261

APPENDIX A: Acronyms and Abbreviations 389
APPENDIX B: Glossary of Geographical Terms 391
APPENDIX C: A Basic Geographic Library 407
INDEX 417
ABOUT THE AUTHOR 437

FIGURES

1. Land Forms Displayed Schematically 28
2. Elevation and Local Relief 29
3. Slopes and Gradients 30
4. Line-of-Sight and High-Angle Trajectories 31
5. Selected Stream Characteristics 33
6. Water Tables, Aquifers, and Wells 36
7. Sea Water Stratification 49
8. Lunar and Solar Influences on Tides 52
9. Ocean Wave Motions and Measurements 53
10. Conditions Conducive to Surf 53
11. A Typical Beach Profile 56
12. Plimsoll Line Markings 60
13. Effects of Wave Action on Ship Stability 61
14. Land and Sea Breeze Regimes 72
15. Cloud Types Depicted 76
16. Cloud Ceilings Related to Terrain 77
17. Anatomy of a Thunderstorm 78
18. Nuclear Fallout Related to Wind 86
19. Conditions Conducive to Avalanches 108
20. Typical Coastal Topography 127
21. Shallow Water Antisubmarine Warfare Suites 130
22. Aerospace Interfaces 140
23. Gravity Versus Space Vehicle Velocity 142
24. Earthly and Lunar Gravity Wells 145
25. Electromagnetic Pulse Propagation 148
26. U.S. and Soviet Mineral and Metal Imports 156
27. Oil Fields and Facilities 164
28. Present and Projected World Populations 179
29. Assorted Street Systems 198
30. Three Layers of Urban Obstacles 202
31. Highway and Byway Attributes 217
32. Bridge Types Depicted 219
33. Bridge Superstructures and Substructures 220
34. Traditional Rail Yard Facilities 227
35. Airfield Construction Stages 231
36. Typical Naval Port Facilities 233
37. Wharf and Pier Configurations 234
38. Offensive Force Boundaries 320
39. Exits Inland from Omaha Beach 359
40. Monsoonal Regimes at Tchepone, Khe Sanh, and Da Nang 375

13. FORTRESSES AND FIELD FORTIFICATIONS 267
Precedents and Prognoses 267
Fortified Points 268
Fortified Lines 270
Offensive Fortifications 271
Fortifications in the Nuclear Age 272
Citadels Versus CW and BW Weapons 273

PART THREE:
POLITICAL-MILITARY GEOGRAPHY

14. MILITARY SERVICE PREDILECTIONS 277
Diversified Viewpoints 277
Integrated and Updated Views 283

15. GEOPOLITICAL FRICTION 285
Territorial Limits 285
Strategic Friction 287
Economic Friction 291
Cultural Friction 293
Environmental Friction 297

16. MILITARY AREAS OF RESPONSIBILITY 307
Global Subdivisions 307
Regional Areas of Responsibility 311
Useful Insights 318
Theater and Tactical AORs 318

PART FOUR:
AREA ANALYSES

17. FORMAT FOR AREA ANALYSIS 339
Geographical Data Bases 339
Military Missions 341
Military Implications 341
Effects on Courses of Action 344

18. OPERATION *NEPTUNE* 347
Selection of the Lodgment Area 347
Description of the Lodgment Area 349
Assessments of the Lodgment Area 355
Effects on Allied Courses of Action 361
Wrap-Up 364

19. OPERATION PLAN *EL PASO* 367
The Ho Chi Minh Trail 367
Mission Planning 377
Logistical Limitations Within Vietnam 380
Logistical Shortcomings Inside Laos 382
Wrap-Up 383

20. FINAL REFLECTIONS 387

MAPS

1. Selected Russian Naval Bases 12
2. Bottlenecks That Inhibit the Russian Navy 13
3. Mao's Long March 19
4. The Battle of the Bulge 21
5. Operation *Market Garden* 22
6. Beleaguered Berlin 23
7. Regional Vegetation 40
8. Ocean Currents 51
9. Crucial Naval Choke Points During the Cold War 58
10. Beaches and Approaches at Inchon 63
11. Regional Climates Depicted 81
12. Frigid Flatlands 94
13. Iceberg Routes to the North Atlantic 101
14. The "Murmansk Run" 102
15. The Arctic Ocean and Peripheral Seas 103
16. Major Mountainous Regions 104
17. The Himalayan Hump 107
18. Arid Regions 110
19. Tropical Rain Forests 117
20. The Kokoda Trail and Shaggy Ridge 119
21. The Pripet Swamp and Its Offshoots 123
22. The Mekong Delta and Rung Sat Special Zone 124
23. The Earth-Moon System 138
24. Cislunar Space 145
25. Japanese Territorial Holdings in 1942 160
26. Saudi Arabian Oil Fields and Facilities 163
27. Profile of the Burma Road 222
28. The Trans-Siberian Railroad and Baikal-Amur Magistral 228
29. U.S. and Soviet Space Launch Sites and Control Centers 237
30. Earth Support Satellite Orbits 239
31. Ballistic Missile Early Warning System (BMEWS) 249
32. U.S. Cold War Arctic Outposts (1960s) 250
33. U.S. Cold War Bases in Great Britain (1979) 251
34. U.S. Cold War Bases in France (1966) 255
35. U.S. Cold War Bases in West Germany (1979) 256
36. U.S. Cold War Bases in Iberia (1979) 257
37. U.S. Cold War Bases in Italy (1979) 258
38. U.S. Cold War Bases in Greece and Turkey (1979) 259
39. U.S. Cold War Bases in the Philippines (1979) 262
40. U.S. Cold War Bases in Japan and Korea (1979) 263
41. The World According to Mackinder (1904 and 1919) 279
42. U.S. and Allied Encirclement of the Soviet Union 281
43. De Seversky's View of the Globe 282
44. Soviet Buffers in Central Europe 289
45. Chinese Border Disputes 290
46. The Spratly Islands 292
47. Territorial Claims in Antarctica 294
48. The Horn of Africa 295
49. Boundary Disputes in Jammu and Kashmir 297

50. U.S. Cold War Areas of Responsibility . . . 310
51. NATO's Basic Areas of Responsibility . . . 312
52. AFCENT Areas of Responsibility . . . 314
53. Pacific Ocean Area and Southwest Pacific Area . . . 316
54. Amphibious Boundaries at Tarawa . . . 322
55. Route Packages in North Vietnam . . . 324
56. Soviet Core Areas . . . 342
57. Potential Lodgments in Western Europe . . . 348
58. Natural Regions in Northwestern Normandy . . . 350
59. Drainage Patterns in Northwestern Normandy . . . 351
60. Utah, Omaha, Gold, Juno, and Sword Beaches . . . 352
61. Cross-Channel Routes from England to Normandy . . . 358
62. U.S. Expeditionary Airfields in Manche and Calvados . . . 363
63. The Ho Chi Minh Trail . . . 369
64. The Laotian Panhandle at Midpoint . . . 370
65. Monsoonal Regimes in South Vietnam and Laos . . . 376
66. OPLAN *El Paso*'s Tactical Area of Responsibility . . . 379
67. Supply Requirements Associated with OPLAN *El Paso* . . . 380

TABLES

1. Geographic Factors . . . 4
2. Land Forms Listed . . . 28
3. Selected Soil Characteristics . . . 37
4. Beaufort Wind Scale Related to Sea States . . . 54
5. Beaufort Scale Related to Surface Winds Ashore . . . 71
6. Militarily Important Temperature Statistics . . . 72
7. Wind Chill Factors . . . 73
8. Fog Linked to Visibility . . . 74
9. Cloud Classifications . . . 75
10. Regional Climates Described . . . 82
11. One Dozen Militarily Useful Minerals and Metals . . . 154
12. Crude Oil Producers and Proven Reserves . . . 157
13. Military Dead and Missing, World Wars I and II . . . 178
14. Causes of U.S. Wartime Casualties . . . 181
15. Representative Racial, Ethnic, and Tribal Relationships . . . 183
16. Ten Leading Languages (1990s) . . . 185
17. Linguistic Clutter in the Caucasus . . . 185
18. Principal Religions and Selected Denominations . . . 186
19. Variable Town and City Components . . . 197
20. Present and Projected Megalopoli . . . 199
21. U.S. Military Aircraft Runway Length Calculations . . . 229
22. Advantages Available from the Panama Canal . . . 241
23. U.S. Cold War Collective Security Pacts . . . 248
24. Typical Trouble Spots, Mid-1990s . . . 288
25. Area Analysis Format . . . 340
26. Selected Climatic Statistics for Manche and Calvados . . . 354
27. Populated Places in Manche and Calvados . . . 355
28. U.S. Expeditionary Airfields in Manche and Calvados . . . 363
29. Transportation on the Ho Chi Minh Trail . . . 368

30. OPLAN *El Paso* Airfields 373
31. OPLAN *El Paso* Road Opening Schedules 382
32. Schedules for Dual-Laning Route 9 in Laos 383

PHOTOGRAPHS

Amphibious Troops Cross a Coral Reef 168
A Typical Tidewater Swamp 168
Vehicle Mired in Mud 169
Elephant Grass 169
Monastery Atop Monte Cassino 170
Switchback Curves on the Burma Road 171
Mobility in Mountains 172
Rhine River Bridge at Remagen 172
Perfume River Bridge at Hué 173
Wicked Weather at Changjin Reservoir 173
Warm Weather Aids Medics 173
Clouds West of Khe Sanh 174
Rough Weather vs. Resupply at Sea 174
Submarine Surfaces Through Arctic Ice 175
"Follow the Leader" Through Antarctic Ice 175
Frozen Salt Spray on an Icebreaker 176
Water Distribution in the Desert 176
Oil Fires in the Kuwaiti Desert 329
Transferring Supplies over Perilous Routes 329
The Berlin Airlift 330
Rock Quarries Facilitate Military Construction 330
An Expeditionary Airstrip 330
A Typical Jungle Helipad 331
The Consequences of Urban Combat 332
Industrial Bomb Damage 333
Siegfried Line Fortifications 334
Cobblestones on Utah Beach 334
Hedgerows Hamper Tanks 334
The Banghiang River at Tchepone 335
Mulberry "A" Before and After Demolishment 336
A Typical Bypass and Ford in Laos 337
Refurbishing Route 9 337
The Abandoned Airfield at Ban Houei Sane 338

FOREWORD

This book will arguably become the most comprehensive treatment of military geography in print. The author presents a sweeping, sophisticated interpretation of the term "geography," covering not just the lay of the land, but the human beings who live on the land, change it, and are shaped by it. He relates virtually every aspect of the physical world we live in to every imaginable endeavor in the military realm, from reading a tactical map to conducting a major campaign in some far-flung corner of the Earth. He considers military operations in every geographical environment, while taking into account ever-changing strategies, tactics, and technologies on all levels. He enriches his text with many practical examples that span recorded history. Finally, he writes in plain, direct language to reach the widest possible audience.

The dearth of consolidated studies on the discipline of military geography came to John Collins' attention early in his long and distinguished career as a soldier and scholar. Thus he began and kept up an interest in the subject for more than 40 years, amassing voluminous files on the subject. Finally afforded the opportunity to research and write on his avocation at the National Defense University, he spent 2 years as a Visiting Fellow, tapping not only his own wealth of data and experience but a wide variety of well-informed opinions on every facet of military geography.

The resultant volume, the culmination of a life-long career, fills a gap in the professional and technical literature. The National Defense University is pleased to have hosted John Collins and to publish his work. No other book, to our knowledge, marries military art with that of the geographer so deftly and completely. The volume seems destined to meet its stated purposes for years to come, namely, to provide a textbook for students, a handbook for military professionals, and an enlightening survey for any appreciative lay reader.

Richard A. Chilcoat

RICHARD A. CHILCOAT
Lieutenant General, U.S. Army
President, National Defense University

PREFACE

A major American news magazine in the spring of 1997 included an article about the effects of new technology on national defense. It observed that "In future wars, knowledge may be more important than terrain," but geography still exerts enormous influence on military operations, war, and security as it has throughout history. Great commanders, past and present, understand that topography, weather, and climate not only affect strategies but battle and support plans. History in fact is replete with enormous penalties incurred by those who paid too little attention to geographic factors.

Military commanders in the "Information Age" will surely receive data more rapidly and consequently know more than their predecessors about battlefield situations. Information technologies may help military planners and operators better understand geographic factors—they may even disprove Clausewitz's contention that "most intelligence is false"—but other words he wrote on that subject are likely to endure: "geography and the character of the ground bear a close and ever-present relation to warfare. They have a decisive influence on the engagement, both as to its course and to its planning and execution."

Geographic influences were omnipresent during my service as an enlisted soldier in the Tunisian desert fighting of 1942-43, as a junior officer in the Italian mountains 1943-45, and many years later (1966-67) as a battalion commander in the totally different terrain of the War Zone C jungles in Vietnam. Those experiences, which were very personal, had a great deal to do with the health and comfort of my comrades and myself; they affected our casualty rates and often posed more formidable challenges than the enemies we faced. I often wondered if we were "victims" of geography or "victims" of the higher command's appreciation for geography.

Those early lessons from geography's "school of hard knocks" were helpful later, when I held positions of greater authority for planning and directing military operations in widely varied geographic circumstances, first as a new brigadier in Laos in 1972-73, then as Commander of the United Nations Command in Korea, 1976-79, and finally as Chairman of the Joint Chiefs of Staff. A lot of work and study nevertheless was required by me and my staff officers before we could satisfactorily integrate geography's influence on land, sea, and air operations. Despite our efforts, I suspect that many of the Soldiers, Sailors, Airmen, Marines, and Coast Guardsmen who implemented our plans sometimes felt "victimized" by geography or our lack of appreciation for it, just as I felt so many years earlier.

The Armed Forces of the United States have been, and will continue to be, committed to every conceivable type of military operation in every conceivable geographic environment. Whether for war-fighting, war-preventing, or peacekeeping operations, they must prepare to excel wherever they are sent—all too commonly on short notice. *Military Geography for Professionals and the Public*, a textbook and handbook written in simple, straightforward

terms that tie relevant factors together in a fashion understandable to lay readers as well as the uniformed professionals of all military services, is a rare, if not unique, survey of relationships between geography and military affairs. It ought to be required reading for policymakers, military planners, commanders, and staff officers at all levels. It also will be a very useful reference for political leaders, educators, members of the news media, and concerned citizens in the "Information age." I wish it had been in my knapsack for the past 55 years.

JOHN W. VESSEY, JR.
General, U.S. Army (Ret.)
Chairman of the Joint Chiefs of Staff, 1982-1985

ACKNOWLEDGMENTS

This book is my legacy to the U.S. military education system that has done so much for me since 1942, from basic courses through the Army Command and General Staff College, the Armed Forces Staff College, the Industrial College of the Armed Forces, and the National War College. It helped me expand my professional horizons for 55 years and has kept me gainfully employed since retirement on January 3, 1996.

General John M. Shalikashvili, as Chairman of the Joint Chiefs of Staff, arranged a perch for me at National Defense University (NDU), the perfect place to research and write a book about military geography or any other subject related to the profession of arms. "Hard core" contacts with extensive practical experience and assorted persuasions thereafter answered countless spot requests for information, helped me overcome mental blocks, and rigorously reviewed the first draft chapter-by-chapter during the gestation period.

Two retired Army four-star generals merit special mention in that regard: General Frederick J. Kroesen identified the need for "Key Points" at the end of each chapter; General Robert C. Kingston, the first Commander in Chief of U.S. Central Command, became the world's highest ranking research assistant. Lieutenant General William H. Ginn, Jr., U.S. Air Force (Ret), scrubbed bits about military air operations.

Army Colonel James H. Kurtz and Navy Captain John W. McGillvray, both former division chiefs in the Joint Staff's Directorate for Strategic Plans and Policy (J-5), furnished a landslide of facts, opinions, anecdotes, and source materials on almost every subject. Colonel Bill Allen represented the U.S. Army War College. Retired Army Major General John Murray, a life-long transportation specialist, and Herb Longhelt, Deputy Chief Engineer for AMTRAC, sharpened my views about lines of communication. Dr. Ed Whitman, who works for the Oceanographer of the Navy, helped a whole lot within his field. Colonel "Westy" Westenhoff, then assigned to the Air Force Deputy Chief of Staff for Plans and Operations, Scot Crerar at Betac Corporation, retired Army Colonel Chester B. McCoid (my boss long ago in the 82nd Airborne Division), and Patrick O'Sullivan, a professor who emphasizes military geography, likewise made me think. So did my son Sean Kevin, whose doctorate in aeronautical and astronautical engineering from Massachusetts Institute of Technology underpinned much of Chapter 7 (Inner and Outer Space).

Ed Bruner, Steve Bowman, Bob Goldich, Clyde Mark, and George Siehl, all former colleagues from the Congressional Research Service (CRS), brought broad, in-depth knowledge to bear from start to finish. Other former CRS colleagues with specialized expertise included Bob Bamberger (petroleum); Marjorie Browne (law of the sea); Ray Copson (Africa); Rich Cronin and Barbara LePoer (India and Pakistan); Ida Eustis (legal matters); Susan Fletcher (environmental problems); Rick Greenwood (minerals and metals); Dick Grimmett (U.S. overseas bases); Dianne Rennack and Barbara Hennix (finders of the

unfindable); Shirley Kan (China); Julie Kim (former Warsaw Pact countries and former Yugoslavia); Jon Medalia (strategic nuclear capabilities); Al Prados (Middle East); Rinn-Sup Shinn (Korea); Stan Sloan (NATO); Marsha Smith (space); Bob Sutter and Kerry Dumbaugh (East Asia).

Nine members of the Campaign Planning Group, U.S. Army Vietnam in 1967-1968 painstakingly pieced together input for Chapter 19 (Operation Plan *El Paso*): Army Lieutenant Colonels Dominic Canestra, the Deputy Chief; Robert Duvall (Army aviation), Robert Rufsvold, who was wounded in action on an aerial reconnaissance mission during December 1967 (engineering); David Hutchison, his replacement; and Reed Schultz (operations); Army Majors Bert Esworthy (intelligence) and George Pitts (land transportation); Air Force Majors John Pohle (weather) and Edward Reed (tactical airlift).

The National Defense University library reference staff provided peerless support. None could have been more knowledgeable; all repeatedly stopped whatever they were doing to help. I therefore owe great gratitude to Sarah Mikel, the Director, Ann Parham, Chief of the Research and Information Services Division, Robert Adamshick, Bonnie Dziedzic (who helped a lot with maps), Jeanmarie Faison, Howard Hume (who met me many weekday mornings before 0600), Jane Johnson, Benard Strong, Bruce Thornlow (who assisted on many Saturday mornings), and Carolyn Turner.

Colonel James V. Dugar, ANG, President of the NDU Foundation, and Colonel Thomas E. Gallagher, USA (Ret.), his Executive Director, admirably administered funds that the Smith Richardson Foundation donated to convert draft maps and figures into professional products at Art Services, Inc., where Andy Hemstreet skillfully responded to all requests. Jim Peters, who is Production Coordinator for *Joint Force Quarterly*, helped me assemble suitable photographs. So did Fred Rainbow at the U.S. Naval Institute and Colonel Tom Vossler, who oversees the U.S. Army Military History Institute. Fred Kiley ensured that *Military Geography for Professionals and the Public* enjoyed a high priority at the onset; and Robert A. Silano, his successor as Director of Publications, brought the project to completion and planned the book's launch. George Maerz and the staff of NDU Press contributed at various stages to the editorial process.

Swift, my versatile bride, performed every administrative, logistical, and fiscal task for the Collins household while I struggled to finish this project, which never would have reached fruition without her help. Finally, I recognize the index finger of my right hand, the nail of which was driven into my wrist before it finished hunt-and-peck typing the entire draft, because I was quite unfamiliar with any computer.

JOHN M. COLLINS
Alexandria, Virginia
March 1998

AUTHOR'S INTRODUCTION

When a Chief of the Imperial General Staff wrote that he had "never had time to study the details of military [geography]" . . . it was as if the President of the Royal College of Surgeons said he never had time to study anatomy, or do any dissection.

B. H. Liddell Hart
Thoughts on War

NO SAVANT EVER TAUGHT MILITARY GEOGRAPHY TO PERSIAN MONARCHS CYRUS, CAMBYSES, DARIUS, AND Xerxes, who assembled the world's first sprawling empire that by 480 B. C. stretched from the Indus River to the Aegean Sea. Teenage Alexander learned a lot at Aristotle's knee before he conquered even larger territories 150 years later, but military geography was not one of his tutor's strong points. Ghenghis Khan, whose Golden Horde rode roughshod across Eurasia in the 13th century A. D., established the record for seizing real estate by force of arms without resort to any book about military geography in his saddlebags.

Modern warfare, however, is so complex that commanders at every level must consistently manipulate geographic influences advantageously to gain a decisive edge. Most soldiers, sailors, airmen, and marines unfortunately learn painful lessons mainly from the school of hard knocks, because few schools and colleges conduct courses in military geography, none confers a degree, instructional materials seldom emphasize fundamentals, and most service manuals have tunnel vision. The four-volume bibliography compiled at West Point, which is 4 inches thick and totals several thousand citations on 1,059 pages, addresses an admirable scope but is minimally useful to most uniformed practitioners of military art, their civilian supervisors, concerned citizens, and members of the news media, because many of them lack easy access to the sources cited while others are too busy to bother.

My contacts in the Pentagon and Congress were bemused when I began to write this book, because they had never heard of a discipline called "military geography." That reaction came as no surprise; after all, members of the Association of American Geographers at their 92nd annual meeting in April 1996 debated heatedly before they finally decided to establish a military geography specialty group. This consolidated guide, designed to fill undesirable gaps, has a threefold purpose:

- To provide a textbook for academic use
- To provide a handbook for use by political-military professionals
- To enhance public appreciation for the impact of geography on military affairs.

Parts One and Two, both of which are primers, view physical and cultural geography from military perspectives. Part Three probes the influence of political-military geography on service roles and missions, geographic causes of conflict, and complex factors that affect military areas of responsibility. Part Four describes analytical techniques that relate geography to sensible courses of military action, then puts principles into practice with two dissimilar case studies—one emphasizes geographic influences on combat operations, while the other stresses logistics. Each chapter terminates with key points, which final reflections reinforce and relate to time-tested Principles of War.

The text at no time tells readers *what* to think. It simply tells them *how,* in jargon-free terms that disregard technical details (neither British Field Marshal Sir Douglas Haig nor corporals who led his squads through Flanders fields in 1917 cared a whit whether Passchendaele Ridge was a product of tectonic upheaval or glacial depositions). Concise historical examples and the probable influence of technological trends help illuminate past, present, and future relationships between geography and military affairs. Notes at the end of each chapter encourage students of the subject to pursue topics of particular interest in greater breadth and depth. Maps and figures are plentiful throughout, but readers nevertheless should keep a world atlas handy.

Military Geography for Professionals and the Public, which considers every form of warfare and every military service at strategic, operational, and tactical levels, is intended for audiences abroad as well as in the United States, and therefore is generally couched in generic terms. Consequently, its contents should be almost as sound at the end of the 21st century as at the beginning, regardless of political, military, economic, social, scientific, technological, and other changes in this volatile world that inevitably will occur during the next ten decades.

MILITARY GEOGRAPHY
FOR PROFESSIONALS AND THE PUBLIC

1. OVERVIEW

When I took a decision, or adopted an alternative, it was after studying every relevant . . . factor. Geography, tribal structure, religion, social customs, language, appetites, standards—all were at my finger-ends.

T. E. Lawrence
Letter to B.H. Liddell Hart, June 1933

WEBSTER'S *THIRD NEW INTERNATIONAL DICTIONARY* DEFINES GEOGRAPHY AS "A SCIENCE THAT DEALS WITH the Earth and its life; especially the description of land, sea, air, and the distribution of plant and animal life including man and his industries with reference to the mutual relations of these diverse elements." The next edition likely will add space to the list. Geography consequently embraces a spectrum of physical and social sciences from agronomy to zoology. In simple terms, it describes what the environment is like at any given place and time.

MILITARY CONSIDERATIONS

Military geography, one of several subsets within those broad confines, concentrates on the influence of physical and cultural environments over political-military policies, plans, programs, and combat/support operations of all types in global, regional, and local contexts. Key factors displayed in table 1 directly (sometimes decisively) affect the full range of military activities: strategies, tactics, and doctrines; command, control, and organizational structures; the optimum mix of land, sea, air, and space forces; intelligence collection; targeting; research and development; the procurement and allocation of weapons, equipment, and clothing; plus supply, maintenance, construction, medical support, education, and training.[1]

PHYSICAL FACTORS

Spatial relationships, arguably the most fundamental of all geographic factors, concern the location, size, and shape of land areas, together with the presence and configuration of intervening waters. Relative positions and modes of transportation determine transit times between any two sites. Total length, width, and area determine the amount of maneuver room available and the relative security or vulnerability of key points within any piece of militarily important property.

Land forms constitute the stage whereon military pageants play ashore. Relief, drainage patterns, geology, and soils are pertinent topics. High-level strategists, airmen, and astronauts see mountains and valleys, plateaus and lowland plains. Frontline soldiers, who

deal with details instead of big pictures, have vastly different viewpoints—hummocks, gullies, river banks and bottoms loom large from their foreshortened perspectives. Bill Mauldin put it best in his book *Up Front* when dogface Willie sitting in a shell crater said to Joe, "Th' hell this ain't the most important hole in th' world. I'm in it."[2]

Table 1. *Geographic Factors*

Physical Factors	*Cultural Factors*
Spatial Relationships	Racial and Ethnic Roots
Topography and Drainage	Population Patterns
Geology and Soils	Social Structures
Vegetation	Languages and Religions
Oceans and Seashores	Industries and Land Use
Weather and Climate	Transportation Networks
Daylight and Darkness	Telecommunications
Gravity and Magnetism	Military Installations

Natural vegetation varies from lush to nearly nonexistent. Treeless tundra, the coniferous taiga that blankets much of Siberia, tropical rain forests, elephant grass, scrub, and cacti create drastically different military environments. Bonneville's salt encrusted flats and Okefenokee Swamp both are basically horizontal, but the former is bare while the latter is luxuriant. The Sahara Desert, sere except for widely scattered oases, bears scant resemblance to the densely wooded Arakan Range in Burma, where the height and spacing of trees, trunk diameters, stem densities, foliage, and duff (rotting materials on the floor) are cogent military considerations.

Mariners properly contend that the importance of oceans is almost impossible to overstate, since water covers almost three-fourths of the Earth's surface—the Pacific Ocean alone exceeds the area of all continents and islands combined. Seas and large lakes, typified by the Caribbean, Caspian, and Mediterranean, separate or subdivide major land masses. Waves, tides, currents, water temperatures, and salinity everywhere limit options open to surface ships and submarines. Straits, channels, reefs, and other topographical features do likewise along littorals.

Earth's atmosphere envelops armed forces everywhere aloft, ashore, and afloat. Temperatures, precipitation in the form of rain, hail, ice, sleet, or snow, winds, and relative humidity, along with daylight and darkness, command close attention because they strongly affect the timing, conduct, and support of peacetime and combat operations. Stiff penalties accompany failure to heed their implications. History has repeatedly witnessed armies mired in mud axle-deep to a ferris wheel, fleets blown off course like the ill-fated Spanish Armada, and bombers as flightless as goonie birds, grounded by gales or fog.

Inner and outer space constitutes a fourth distinctive geographic medium, along with land, sea, and air. Only a tiny fraction thus far has been exploited for military purposes, but operations farther afield for many imaginative purposes are conceivable within a relatively short time frame.

CULTURAL FACTORS

People top the list of cultural considerations that deserve close attention for political-military reasons. Census statistics reveal population size, distribution, age groups, the percentage of males compared with females, and urban versus rural densities. Other militarily important characteristics include native intelligence, languages, dialects, literacy, customs, beliefs, patriotism, attitudes toward "outsiders" (indifference, respect, resentment, hostility), discipline, morale, temperament (passive or aggressive), and the prevalence of endemic diseases. Virgil singled out the will to win with these words in his *Eclogues VII* 2,000 years ago: "It never troubles the wolf how many the sheep be."

Relations among racial, ethnic, tribal, and religious groups merit special attention, because alienation often leads to armed conflict. Immense psychological significance attends some cultural icons, such as shrines, national cemeteries, other hallowed ground, even entire cities. A former Commanding General of NATO's Central Army Group repeatedly told his subordinates, "If we go to war against the Warsaw Pact tomorrow we can't allow the first day's headline to read 'Nürnberg Falls,' because the blow to allied morale would be devastating."

Natural resources, land use, and industries, which underpin combat capabilities and the staying power of friends as well as foes, contribute essentially to national security. Food is the irreducible foundation, followed by raw materials and facilities for converting them to usable goods. Basic ingredients feature, but by no means are confined to, agriculture, animal husbandry, and fisheries; minerals and metals; petroleum, electrical, and nuclear power; water supplies; manufacturing plants; stone, brick, concrete, lumber, and other construction staples. Only a few nations now possess the economic potential for great military power. None is wholly self-sufficient, thus external sources of sustenance and degrees of control over them are geographically consequential.

Transportation networks expedite or impede abilities of statesmen and military commanders to employ armed forces intercontinentally, regionally, or locally. Roads, railways, inland waterways, airfields, and seaports, conveniently located in proper combinations, enable formations of requisite size and type to reach objective areas promptly from distant staging bases, then maneuver effectively. Land, sea, and air lanes that hamper abilities to do so raise the cost of mission accomplishment in terms of time, lives, and money expended. Severe deficiencies may even render requisite military actions infeasible because, as wags are wont to say, "You can't get there from here."

Telecommunication systems (radio, television, telephone, telegraph, space communication satellites, the internet, and submarine cables) facilitate integrated action by uniservice, joint, and multinational armed forces. The type, attributes, and geographic distribution of military and civilian fixed-plant facilities in foreign countries accordingly interest commanders and staffs who hope to use those assets and deny them to enemies. Central offices, substations, transmission lines, repeaters, transfer points, alternative routings, redundant capabilities, power sources, and maintenance installations are prime concerns.

REGIONAL QUIRKS

Geographic regions on Earth and in space are reasonably homogeneous areas containing distinctive topography, climate, vegetation, and cultural features (or lack thereof) that exert

relatively uniform effects on military policies, plans, programs, and operations. Several classification systems are in competition. One accentuates surface configurations that may be hilly or horizontal, smooth or serrated, on land or under the sea. Others attach climatic labels: arctic, subarctic, temperate, and tropical or cold-wet, cold-dry, hot-wet, hot-dry, each accompanied by distinctive fauna and flora.[3]

Geographic regions suitable for military operations sometimes are stacked vertically. Hannibal's army and elephant train traversed cultivated fields at low elevations before they climbed through deciduous forests, a band of evergreens, meadows above the tree line, and expanses of bare rock when they navigated the Alps en route from Gaul to Italia as winter approached in 218 B.C. Temperature gradients were as steep as the slopes, mild near the base but frigid in the Col de la Traversette Pass at 10,000 feet (3,050 meters), where winds were wild and snow already lay deep. The entire entourage, being unacclimated, must have gasped for breath from exertions in thin air near the top.[4] Spacecraft crews become familiar with five geographic regions stacked one above the other as they fly through the troposphere, stratosphere, mesosphere, thermosphere, and exosphere en route to circumterrestrial space about 60 miles (95 kilometers) above Earth, where aerodynamic drag and frictional heat lose most of their significance.[5]

Armed forces expressly prepared for employment in any given environment normally function less well elsewhere until they complete time-consuming and costly transitions. They must become familiar with new topography, climatic conditions, and social systems, modify their techniques, then tailor weapons, equipment, clothing, and supplies to suit the situation. Formations optimized for warfare in rain forests prepare to cope with heat, humidity, leaches, and insects. Dehydration and tropical diseases may cause more casualties than enemy ammunition if troops fail to take proper precautions. Poorly maintained weapons malfunction from rust and molds. Foot soldiers in lightweight uniforms that blend well with surroundings take precedence over tanks and trucks, aerial reconnaissance is severely restricted, small unit tactics predominate. Formations optimized for cold climes in contrast require white parkas, mittens, and insulated boots; lined sleeping bags; skis, snowshoes, snowmobiles, and sleds; tents with stoves; antifreezes; low-viscosity lubricants; hot meals with high caloric contents; and retraining.[6]

Navies fully prepared for "blue water" warfare must modify *modi operandi* along continental shelves, where adversaries ashore as well as afloat can take advantage of short flight times for aircraft and antiship missiles to strike with minimum warning. Mines, minisubmarines, and "frogmen" are other potential menaces. Maneuver room along littorals is often limited. Sensors and communication systems able to work effectively in coastal waters must supplement or replace those designed for use in, on, or over deep seas. Differentiation of friends from foes poses complex problems where civilian and military air and sea traffic mingle.[7]

Military regions and political boundaries seldom coincide. Most nations consequently contain two or more geographic subdivisions that complicate planning, preparations, and operations. Jungles and swamps by no means blanket Vietnam; the Pleiku Plateau, for example, is made to order for armor. Austria is by no means all alpine. Cultural factors often introduce militarily important inconsistencies within regions that are topographically and climatically coherent. Saudi Arabia harbors urban oases in an otherwise nearly empty nation

that is everywhere arid and displays only a handful of prominent physiographic features other than mountains along the Red Sea coast.

AVOIDABLE ABUSES

Policymakers, strategists, and tacticians can expect unpleasant surprises whenever they overlook the fact that many geographic factors fluctuate in response to seasonal, cyclical, or random change. Nuclear combat, however restrained, could instantaneously turn urban battlefields into rubble, transitions from night to day alter radio propagation characteristics, and sunspots periodically cause high frequency blackouts. Viet Cong sanctuaries lost much of their utility when defoliants reduced concealment. Ice transforms unbridgeable bodies of water into arterial highways (trains have crossed bits of the Baltic Sea in wintertime), and wheels are welcome in frozen fens. Forces oriented north to south often find themselves in topographically different worlds than those facing east to west, while switches from defense to attack may cause obstacles to loom where protective barriers stood before. Streams that flood without warning can frustrate even the best laid plans, as U.S. Army engineers in Bosnia discovered in December 1995, when it took a week longer than anticipated to build a pontoon bridge over the raging Sava River, suddenly swollen by melting snow. Rising waters inundated adjacent tent cities occupied by troops waiting to cross from Croatia to Bosnia-Herzegovina. Casualties were confined to those caused by dampness coupled with bone-chilling weather, but only because the tactical situation was benign.[8]

History is replete with prominent commanders who sorrowfully *assumed* that enemy area analyses would mimic their own. New Carthage fell to Rome's Scipio Africanus during the Second Punic War when his vanguard waded a lagoon at low water to reach and scale a city wall that Hannibal's brother, Mago, fecklessly left unprotected.[9] British General Wolfe's forces captured Quebec in 1759 after they climbed cliffs that the French defender, Marquis de Montcalm, guarded too lightly.[10] Japanese columns landed on the Malay Peninsula well north of Singapore in December 1941, then penetrated presumably impassable mangrove swamps to reach the city, which fell the following February, partly because the heavy artillery of British defenders all pointed seaward.[11] German *Panzers* poured through the Ardennes almost unopposed in May 1940, after Marshal Henri Pétain proclaimed that forest "impenetrable," and did so again during the Battle of the Bulge in 1944, because U.S. strategists learned little from Pétain's lesson.[12]

Leaders who flunk elementary map reading courses or lack much feel for clime and terrain are prone to make geographic miscalculations. General Henri Navarre unwisely staked the future of France in Asia on the defense of indefensible Dien Bien Phu (1954), an isolated Indochinese basin that was far from the nearest support base, was sustainable only by air, and was dominated by forbidding terrain.[13] Ill-fated operations at the Bay of Pigs (April 1961) caused repercussions that reached the White House when incompetent U.S. planners put anti-Castro "freedom fighters" ashore in an alligator-filled marsh that had only one major route inland.[14]

It is worth remembering that human factors often may be more cogent than physical geography. Che Guevara, once a guru on guerrilla warfare, almost literally committed suicide in Bolivia, largely because he misread the cultural context. What logic could explain "an Argentinian out of Cuba by way of the Congo in the wilds of the Bolivian jungles

memorizing the verbs of the wrong Indian language in order to convert a people, already possessing land, whose vision for endless centuries had turned inward?"[15] Far from being a fish in a sea of people, as revolutionary warriors advocated, he was a fish out of water. He paid with his life for geographic ignorance.

ANALYTICAL TECHNIQUES

Geographic factors become fully significant politically and militarily only when related to probable effects on friendly and enemy courses of action and assigned missions (attack, defend, delay, withdraw, and so on) during nuclear, conventional, and unconventional conflicts as well as operations other than war typified by shows of force, humanitarian assistance, disaster relief, peacekeeping, search and rescue, counternarcotics, and counterterrorism. Analyses also vary with forces available (combat and support, land, sea, air, amphibious, and space). Countless questions require answers, as the following samples illustrate:

- What offensive strategies and tactics would be most advisable in terrain that favors defenders?
- How far and fast would radioactive fallout from a 2-kiloton nuclear surface burst drift and how wide an area would it afflict?
- Do land forms and vegetation in adjacent countries conceal sanctuaries into which enemy forces retreat to recuperate, then return to the fray?
- What area would be submerged for how long if bombers destroyed a large dam on the River Styx?
- Would sea states, tides, and currents help or hinder combat swimmers and their delivery vehicles?
- Will fog preclude proposed use of night vision devices, battlefield illumination, lasers, and thermal sights?
- How much heavy traffic will the only major highway bear between rear area bases and the combat zone?
- What colors and symbols should psychological operations leaflets avoid because superstitious recipients consider them unlucky?
- Is the water table too high or the soil too friable for troops to dig foxholes?
- Will starving refugees welcome U.S. Meals-Ready-to-Eat or will some contents offend cultural beliefs?

A convenient framework for area analyses fortunately is available. Mnemonic devices line up war fighting factors to form the acronym COCOA:

Critical Terrain
Obstacles
Cover and Concealment
Observation and Fields of Fire
Avenues of Approach

Others prefer OCOKA, in which the K stands for key terrain. Neither sequence seems logical, but all five considerations in either case stand ready for inspection. The area analysis format also addresses geographic effects on logistics, civil affairs, and other relevant matters before relating the whole lot first to options that enemies might adopt, then to friendly courses of action.

Such analyses are perishable. Astute users employ them posthaste or update periodically to guarantee that facts, assumptions, interpretations, and findings remain valid with regard to environmental conditions and ongoing events. Inconsistencies send them back to their drawing boards.

One U.S. four-star officer, after reading the foregoing in first draft, said, "I need to know how the rest of this book will serve as a practical guide." His request was easy to answer. Armed combat and military operations other than war may be games that anyone can play, but they are *not* games that just anyone can play well. Only gifted participants win prizes. Long experience indicates that, all else being equal, military practitioners and their civilian supervisors who purposefully make geography work *for* them are winners more often than not, whereas those who lack sound appreciation for the significance of geography succeed only by accident. There are no hard and fast rules that impose stiff fines for infractions, and universally applicable "school solutions" are scarce, but topic headings and historical examples in each succeeding chapter of this treatise could serve as intellectual checklists and tools to help readers arrive at sound judgments, provided they recognize that no two situations are precisely alike.

NOTES

1. Additional overviews are available in Patrick O'Sullivan, *Terrain and Tactics* (New York: Greenwood Press, 1991); C. Peltier and G. Etzel Pearcy, *Military Geography* (New York: D. Van Nostrand, 1966); Sir Edward S. May, *An Introduction to Military Geography* (London: Hugh Rees, 1909).

2. Bill Mauldin, *Up Front* (Cleveland, OH: World Publishing, 1945), 20.

3. H. M. Forde, "An Introduction to Military Geography, Part I," *Military Review* 28, no. 11 (February 1949): 30-36; "An Introduction to Military Geography, Part II," *Military Review* 28, no. 12 (March 1949): 55-62; Louis C. Peltier, "The Potential of Military Geography," *The Professional Geographer* 13, no. 6 (November 1961).

4. Gavin de Beer, *Alps and Elephants* (New York: E. P. Dutton, 1956).

5. Curtis D. Cochran, Dennis M. Gorman, and Joseph D. Dumoulin, eds., *Space Handbook* (Maxwell Air Force Base, AL: Air University Press, January 1985), 1-3 and 1-4; G. Harry Stine, *Handbook for Space Colonists* (New York: Holt Rinehart and Winston, 1985), 47-63.

6. Field Manual (FM) 90-5, *Jungle Operations* (Washington, DC: Dept. of the Army, August 16, 1982); FM 31-70, *Basic Cold Weather Manual* (Washington, DC: Dept. of the Army, April 1968).

7. Ronald O'Rourke, "The Future of the U.S. Navy," in *Fifty Years of Canada-United States Defense Cooperation*, eds. Joel J. Sokolsky and Joseph T. Jockel (Lewiston, ME: Edwin Mellen Press, 1992), 318-320, and briefing slides from a seminar, "Naval Force Structure Planning: New Environment, Old Habits of Thought" (Washington, DC: Congressional Research Service, June 21, 1993), presentation by Ronald O'Rourke.

8. Dennis Steele, "Spanning the Sava," *Army* 46, no. 2 (February 1996): 16-19.

9. Basil H. Liddell Hart, *Scipio Africanus: Greater Than Napoleon* (Novato, CA: Presidio Press, 1992), 20-43.

10. J. F. C. Fuller, *A Military History of the Western World*, vol. 2 (New York: Funk and Wagnals, 1955), 258-268.

11. Noel Barber, *A Sinister Twilight:The Fall of Singapore* (Boston, MA: Houghton Mifflin, 1968).

12. Alistair Horne, *To Lose a Battle: France 1940* (Boston, MA: Little, Brown, and Co., 1969), 192, 195-198, 211-212, 235-239, 244-268; John S. D. Eisenhower, *The Bitter Woods* (New York: G. P. Putnam's Sons, 1969).

13. Bernard Fall, *Hell in a Very Small Place* (Philadelphia, PA: Lippincott, 1966).

14. Peter Wyden, *Bay of Pigs* (New York: Simon and Schuster, 1979).

15. Daniel James, ed., *The Complete Bolivian Diaries of Che Guevara and Other Captured Documents* (New York: Stein and Day, 1969); the quotation is from J. Bowyer Bell, *The Myth of the Guerrilla: Revolutionary Theory and Malpractice* (New York: Alfred A. Knopf, 1971), 240.

PART ONE: PHYSICAL GEOGRAPHY

2. SPATIAL RELATIONSHIPS

Space *is the integrating factor in geography just as* time *is for history.*

Lucille Carlson
Geography and World Politics

THE LOCATION, SIZE, AND SHAPE OF LAND MASSES AND LARGE BODIES OF WATER HAVE INFLUENCED TO great degrees the capabilities, limitations, and vulnerabilities of armed forces since the Stone Age. It seems safe to predict that the pertinence of spatial relationships will remain undiminished indefinitely.[1]

LOCATION

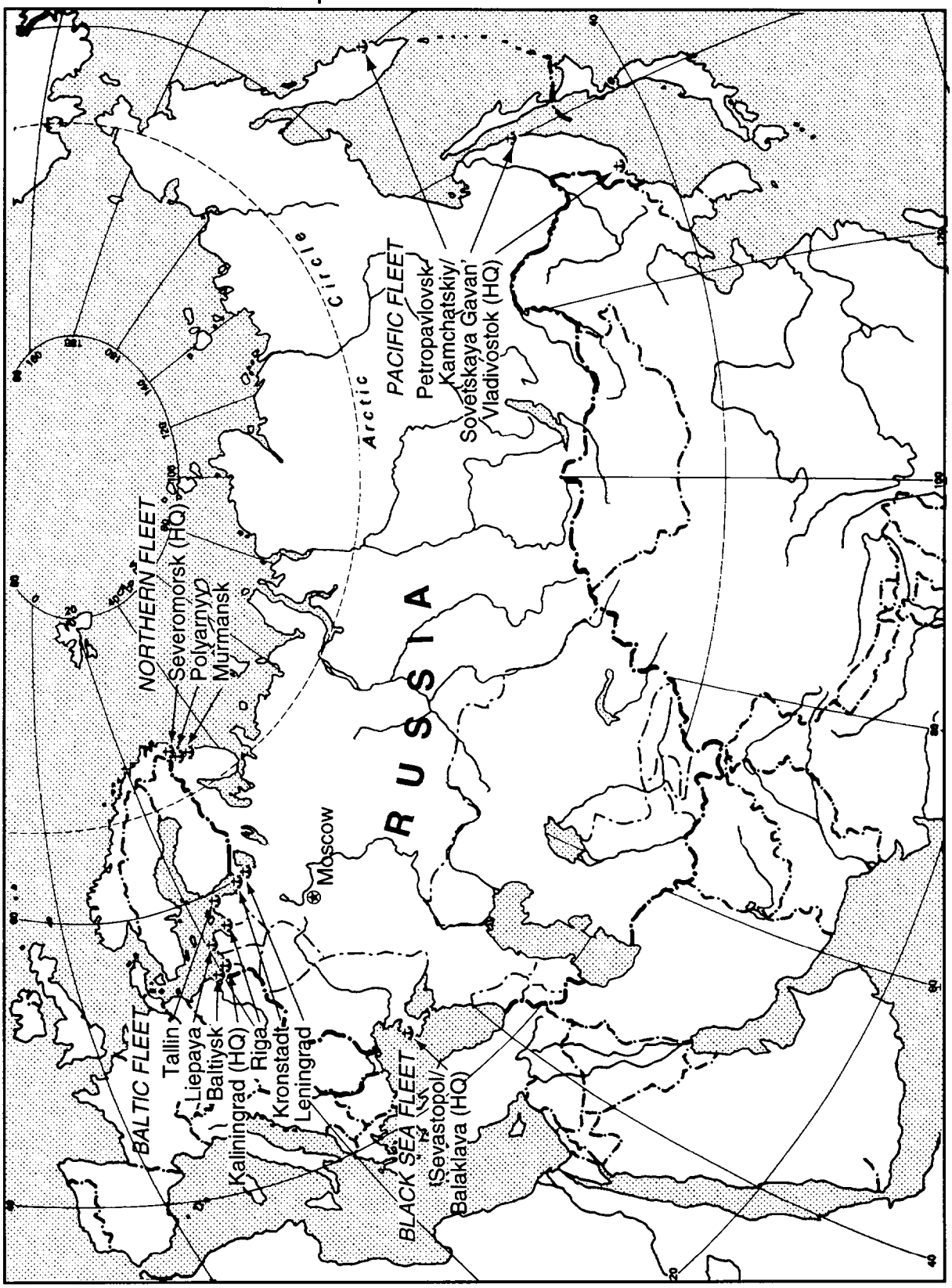
Archimedes, elaborating about the value of levers more than two millenia ago, asserted, "Give me a place to stand and I will move the Earth." Favorable geographic locations confer militarily advantageous leverage, while poor positions foster insecurity.

ACCESS TO OCEANS

No nation that lacks access to any ocean has ever been able to project military power globally. The United States, blessed since 1848 with sheltered ports on ice-free coasts that open on the Atlantic and Pacific Oceans and on every continent, can deploy military power rapidly from one theater to another. No other world power currently enjoys comparable freedom of action. Russia, which fronts on the Atlantic, Pacific, and Arctic Oceans, boasts the world's longest coastline, but its fleets are bottled up in ports that lack convenient outlets to blue water and are ice-bound every winter, except for bases in the Black Sea and near Norway's North Cape, where the Gulf Stream warms frigid waters (maps 1 and 2).[2]

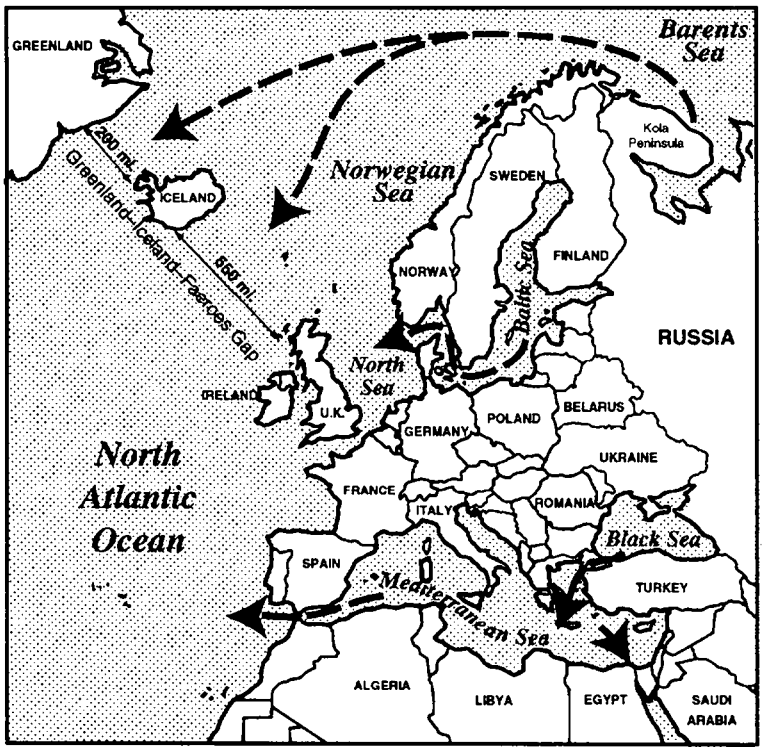
Ocean front property, however, does not *ipso facto* indicate good prospects for sea-going commerce and mighty navies. Unobstructed approaches, sheltered harbors, and convenient

Map 1. *Selected Russian Naval Bases*

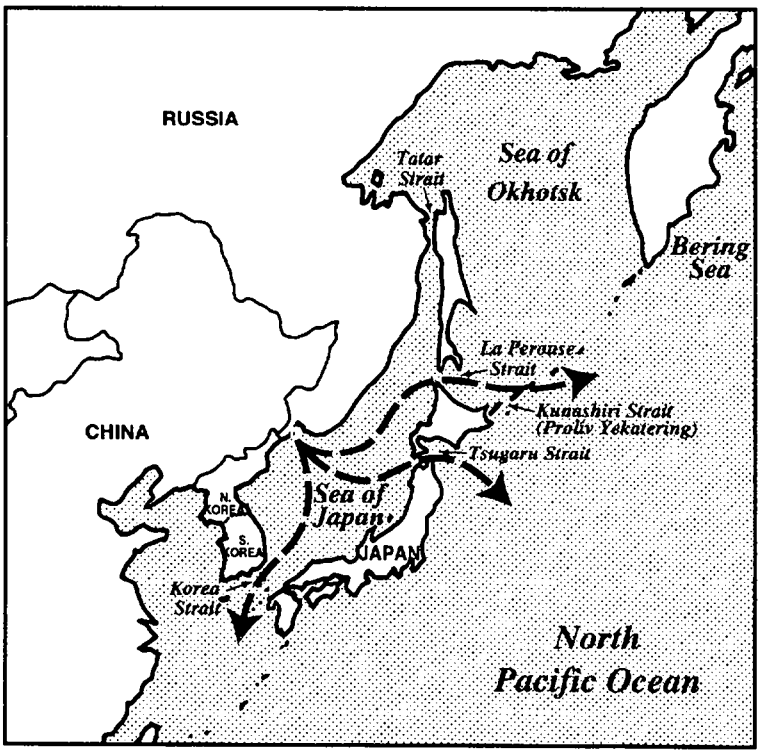


Map 2. *Bottlenecks That Inhibit the Russian Navy*

North Atlantic Choke Points



North Pacific Choke Points



connections with the hinterland must complement maritime locales. Capabilities diminish to some degree if even one of those attributes is deficient or absent.

SECURE LOCATIONS

Secure locations physically separate friends from foes. The British Isles, only 22 miles (35 kilometers) west of continental Europe, last saw successful invaders when William the Conqueror defeated King Harold at Hastings in 1066. Hitler's cross-channel attack plan code-named Operation *Sea Lion* aborted in September 1940.[3] Japan has never been stormed by outsiders. The continental United States has seen no hostile forces on its soil since the War of 1812, when British troops burned the White House and Capitol, bombarded Fort McHenry in Baltimore, and unsuccessfully sought to sack New Orleans. Canada and Mexico have been friends of the United States for more than a century. No nation now has sufficient amphibious assault capabilities to bridge the watery miles that isolate America from its enemies, then seize a foothold on defended U.S. shores. Spaced-based weapons, long-range aircraft, missiles, and transnational terrorists consequently pose the only potentially serious external threats by armed adversaries.

Buffer zones make admirable shields. Joseph Stalin swallowed six European countries in the mid-1940s (East Germany, Poland, Czechoslovakia, Hungary, Romania, and Bulgaria), then rang down an Iron Curtain. Those so-called "satellite states" separated forces in NATO's center sector from the nearest Soviet border by several hundred miles. Demilitarized zones (DMZs) provide variable degrees of protection, depending in large part on geographic circumstances. Incursions across the Korean DMZ, for example, have been restricted to hit-and-run raids since 1953, partly because no overland bypasses are available on that narrow peninsula, whereas enemy troops and supplies consistently circumvented the barrier between North and South Vietnam via the open flank in Laos.

Armed forces that do battle on more than one front at a time must overcome serious strategic, tactical, and logistical problems or risk defeat. Israel found satisfactory solutions during two wars with Egypt and Syria, first in 1967 and again in 1973,[4] but German forces that saw combat on Eastern and Western Fronts during World War I, then on four fronts counting North Africa and Italy during World War II, were spread too thinly during both conflicts and both times they lost. Soviet leaders for that reason understandably feared the possibility of simultaneous wars with NATO and China after the Sino-Soviet split in the early 1960s.[5]

TIME-DISTANCE FACTORS

Time, distance, and modes of transportation not only determine how fast armed forces can move from one place to another but influence abilities to perform most effectively immediately upon arrival. Well-conditioned rifle companies take longer to march 20 miles (32 kilometers) at 2.5 miles per hour (4 kph) than airmobile troops in huge transport aircraft take to cross the Atlantic Ocean, yet the "grunts" may arrive more eager to fight, because jet lag accompanied by fatigue, digestive disorders, and reduced proficiency commonly afflicts flight crews and passengers who swoosh rapidly through several time zones and thereby disrupt their "metabolic clocks" (24-hour circadian rhythms).[6]

Great distances between home bases and operational areas reduce opportunities for timely employment of military power in emergencies. Lengthy lines of supply and

communication increase requirements for long-haul transportation and, if vulnerable to enemy interdiction, make users divert combat forces to protect them. U.S. and British naval surface combatants, for example, had to escort merchant ships and troop convoys from the U.S. east coast and the Gulf of Mexico to Great Britain and the Soviet Union during World War II, while shore-based antisubmarine warfare aircraft conducted search and destroy patrols at both ends and from Iceland.[7]

Forward deployments on friendly territory, best typified by globally distributed U.S. bases and facilities, alleviate but cannot eliminate quick-reaction problems, because requirements may arise in locations where no concentrations exist. Most of the half million U.S. forces that helped drive Iraq from Kuwait in 1991 were stationed in the United States and Germany when that crisis erupted. Equipment and supplies prepositioned at Diego Garcia in the middle of the Indian Ocean were more than 2,000 miles from transfer points in the Persian Gulf, where custodians issued them to personnel airlifted from far distant bases.[8]

Neither the United States nor the Soviet Union was consistently well situated during the Cold War. NATO's armed forces watched impotently while Soviet troops crushed the 1956 uprising in Hungary, partly because their access routes ran through Communist Czechoslovakia and neutral Austria, whereas the Soviets were in position to generate great combat power rapidly and sustain it over short, internal lines under their control.[9] Nikita Khruschchev conversely backed down during the Cuban missile crisis of 1962, partly because most Soviet armed forces were remote from the Caribbean.[10] Like his predecessors and successors, he furnished money, materiel, and ideological assistance to pro-Communist regimes in distant places, but avoided large-scale military involvement for similar reasons. Mutual force reductions in Europe, an arms-control goal established well before the Cold War wound down, succeeded in 1990 only after negotiators overcame critics who correctly claimed that Soviet forces could withdraw a few hundred miles overland, then return on short notice if relations soured, whereas U.S. counterparts would have to be airlifted and sealifted from remote bases.[11]

Distance may also discombobulate alliances. Japan concluded a security pact with Germany in November 1940, but that aggressive pair never were able to form a combined high command, seldom coordinated policies, plans, or programs, never shared bases, and never conducted mutually supporting operations in widely separated theaters that at their zenith remained more than 3,500 straight-line miles (5,630 kilometers) apart.

DOMINANT GEOGRAPHICAL POSITIONS

Dominant geographical locations anywhere on Earth or in space best enable occupants to achieve present or anticipated objectives of any kind. The most desirable positions may be as large as a country or as small as spots plotted on large-scale tactical maps. The leverage available from any given point or area usually varies with missions, situations, forces on tap, terrain, available time, and political restrictions. Attackers and defenders view each site from different perspectives. So do armies, navies, and air forces which strive to gain geographic advantage for themselves and deny it to adversaries.

Strategic, operational, and tactical positions take many forms and serve many purposes. Great Britain originally acquired Gibraltar, Malta, Cyprus, Suez, Aden, and Socotra to help protect lifelines of empire to the Middle East and South Asia. The Soviets, with transitory success, sought influence and footholds along the Horn of Africa and in India from which

they could threaten sea lines of communication that linked the United States and its allies with petroleum producers astride the Persian Gulf. The North American Air Defense Command (NORAD) in the early 1960s draped 81 Distant Early Warning (DEW) stations across the arctic from the Aleutians to the Atlantic as safeguards against a Soviet surprise air attack over the North Pole. A generous group of gap-filler radars and picket ships augmented the Mid-Canada and Pine Tree Lines farther south. Three huge Ballistic Missile Early Warning Sites (BMEWS) located in Clear, Alaska, Thule, Greenland, and Fylingdales Moor, England kept a sharp lookout for Soviet intercontinental ballistic missile (ICBM) shots, with assistance from surveillance satellites that scanned for submarine-launched ballistic missiles as well as ICBMs.[12]

Appropriately located islands often make ideal stepping stones. Propeller-driven transport aircraft that spanned the Pacific during the Korean War hopped from Travis AFB near San Francisco to Honolulu, Midway, and Wake Island (which looked like a postage stamp from the air), then on to Tokyo. Flights over the Atlantic at that time called at Goose Bay, Labrador and Keflavik, Iceland. U.S. weapons, equipment, and supplies bound for Tel Aviv during the 1973 Arab-Israeli conflict arrived rapidly only because Portugal granted refueling rights in the Azores.

POLITICAL INHIBITIONS

Manmade boundaries, which are merely lines on maps, impose political obstacles that sometimes inhibit military operations as much as physical barriers when allies or neutrals forbid the armed forces of outsiders to violate their land or territorial waters. Transgressors who nevertheless choose to do so may pay political, economic, or military prices, the nature and intensity of which are not always obvious beforehand.

High stakes coupled with low risks in relation to likely gains encourage aggressors to ignore political boundaries. Hitler clearly felt free to ride roughshod over neutral Belgium, Luxembourg, and the Netherlands on his way to France in 1940. Low stakes coupled with high risks in relation to likely gains contrariwise encourage caution. British-based U.S. bombers on April 15, 1986, made long dog-legs over the Bay of Biscay and back through Gibraltar en route to hit Tripoli and Benghazi because the French Government denied them overflight rights when President Ronald Reagan directed retaliation for a Libyan-backed terrorist attack in Berlin.[12]

Privileged sanctuaries behind sacrosanct boundaries, which permit adversaries to fight when they wish and then run away, also impose political inhibitions, although such asylums seem to survive only if probable penalties for disturbing them surpass potential benefits. Manchuria comprised such a shelter throughout the Korean War, first as a Chinese supply base for North Korea, then as a haven for defeated North Korean troops who fled across the Yalu River on floating footbridges and, after October, 1950, as a springboard for Chinese Communist offensives. The U.N. Command could have lanced that boil if so directed but declined to do so for fear that such action would precipitate "the wrong war, at the wrong place, at the wrong time, and with the wrong enemy." [14] Communist sanctuaries inside Cambodia fared less well after President Nixon authorized U. S. armed forces to conduct cross-border raids in 1970 and again in 1971.[15] The United States maintained sanctuaries in Japan, Okinawa, Thailand, and the Philippines throughout the Vietnam War, although many observers overlooked that fact.

SIZE

The square miles or square kilometers encompassed by any operational area furnish room for armed forces to maneuver offensively or defensively and to disperse command centers, military formations, ports, airfields, logistic installations, and other static or mobile targets. Total size, however, is only one relevant criterion. *Usable* space is equally important.

LARGE AREA AS AN OFFENSIVE ASSET

Areas that are large in proportion to forces employed therein offer a greater range of offensive options and facilitate greater freedom of action than crowded spaces afford. Envelopments and turning movements become feasible on the ground, whereas cramped quarters commonly compel frontal assaults accompanied by increased casualties (picture assault forces trying to puncture enemy defenses from exposed positions on beachheads or bridgeheads). The U.S. 503rd Parachute Infantry Regiment established a world's record for microsized regimental drop zones (DZs) in February 1945, when it leaped onto Corregidor: the larger DZ had been a parade ground that measured 325 by 250 yards (297 by 229 meters), the smaller was once a nine-hole golf course, and both were bounded on the south by a cliff. Each C-47 transport completed multiple passes that lasted 6 seconds apiece, barely long enough for jumpmasters to push eight paratroopers out the door.[16]

Offensive naval flotillas as well as land forces need a lot of maneuver room in this high-tech age, which renders close combat excessively risky. No modern admiral, for example, would be enthusiastic about battle in closed bodies of water such as Salamis, where Themistocles defeated the Persian Navy in 480 B.C., Aboukir Bay, where Lord Nelson blasted Napoleon Bonaparte's fleet to win the Battle of the Nile in 1798, or Lake Erie, where Captain Oliver Hazard Perry beat the British in 1813, then announced, " We have met the enemy and they are ours!"

LARGE AREA AS A DEFENSIVE ASSET

Defenders on land and at sea prefer arenas that contain enough room to maneuver laterally and in depth, trade space for time if necessary, then regroup, reinforce, and redeploy for offensive action when enemy spearheads at the end of extended supply lines lose momentum. Tiny Luxembourg plays poor games of cat and mouse, whereas Tsarist Russia used defenses-in-depth to frustrate Napoleonic invaders, who briefly occupied and burned Mosow in 1812 but fell back under pressure when winter approached. Retreat, coupled with scorched earth policies, paid off for the Soviet Union after Hitler launched Operation *Barbarossa* in June 1941. Communist defenders ceded ground grudgingly, left communes in ruins, torched crops, and systematically shifted essential industries from war zones to interior sites—desperate workers dismantled nearly a quarter of the nation's manufacturing capacity and carted it east of the Ural Mountains before temporarily victorious Germans overran the rest.[17]

Evasion and escape artists in most countries envy the vast space available to Nez Percé Chief Joseph, who led 300 warriors along with 400 women and children on a 4-month trek that totaled nearly 2,000 miles (3,220 kilometers) through parts of Oregon, Idaho, Wyoming, and Montana before the U.S. Army finally brought his starving tribe to bay in October, 1877.[18] Mao Zedong's classic Long March (map 3), in much the same mold, departed his base camp with about 100,000 men in October 1934. Six thousand miles (9,655 kilometers)

and 366 days later 20,000 survivors slipped into northern Shaanxi Province, short on provisions but long on professional pride, after leading Chiang Kai-Shek's Kuomintang troops on a roundabout chase through half of China.[19]

Open water can add great depth to holdings on land, as Japan demonstrated during World War II. Its four home islands cover an area approximately equal to North and South Dakota, but outpost lines that ran from the Aleutian Islands through Pacific Trust Territories, New Hebrides, the Solomon Islands, and the Netherlands East Indies afforded several million more square miles within which to conduct delaying actions (see map 25, page 160).

Finally, it is worth emphasizing that any nation may brandish nuclear weapons for deterrent purposes, but policies that contemplate even limited use against similarly armed opponents appear excessively imprudent for all save those that possess a redundant (preferably well- protected) power base. Only a few very large countries fit that description. Most of the remainder, which concentrate likely targets in a handful of cities or in the capital, could not survive small-scale nuclear attacks.

LARGE AREA AS A MILITARY LIABILITY

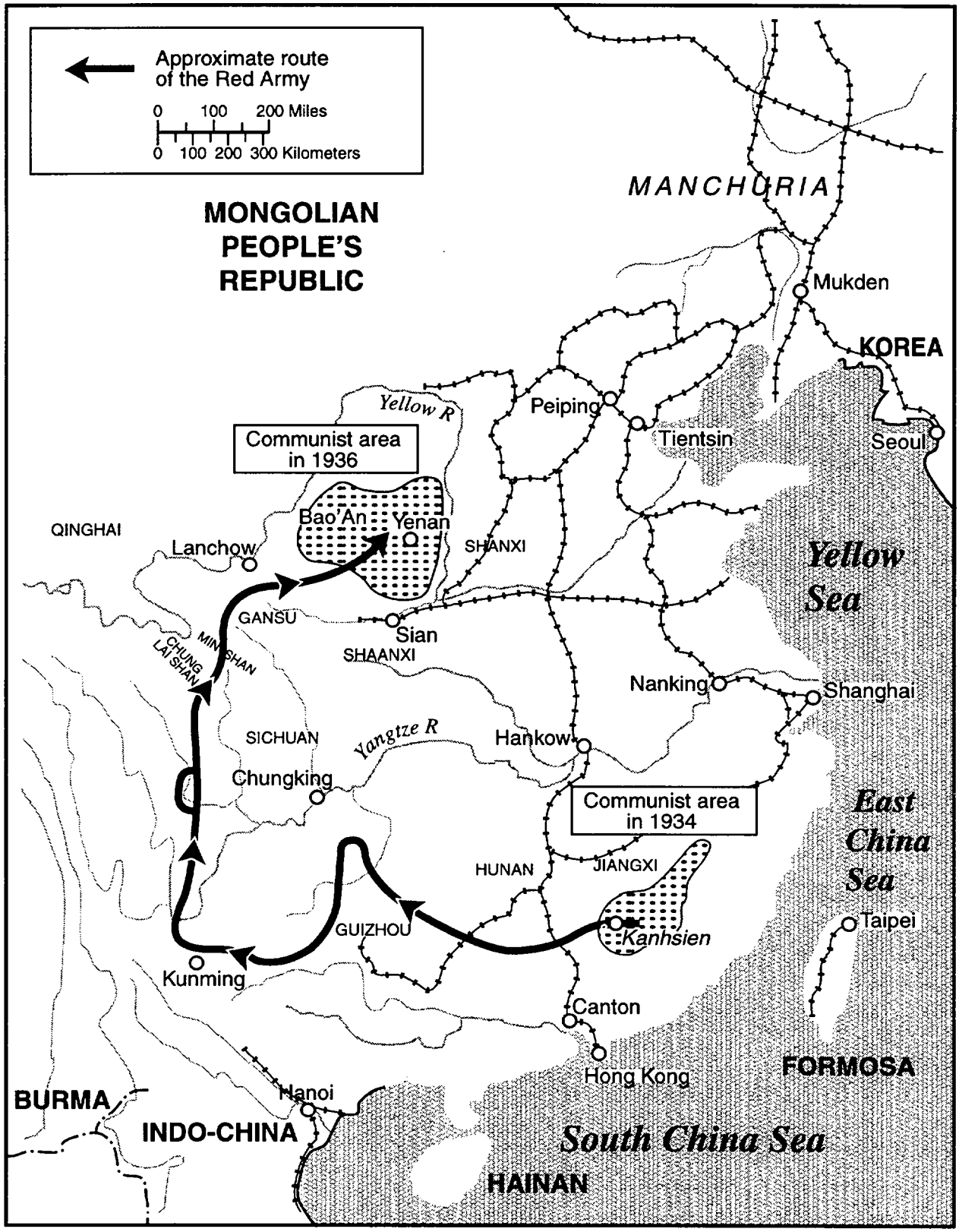
Large operational areas sometimes are mixed blessings. Continent-sized Australia, which concentrates most elements of political, economic, and military power along its periphery, is fortunate that potential targets are mainly on its southern shores far from potential enemies. Canada's principal assets, which hug the United States, are safe because those two countries remain partners. The capital cities and other "crown jewels" of many medium-sized states, however, run high risks. Saudi Arabia and Syria typify largely empty lands wherein core assets are close to insecure borders, while Seoul, Korea is barely 25 straight-line miles (40 kilometers) south of the demilitarized zone that separates it from sworn enemies.

Gigantic size clearly can be a military liability rather than an asset. Territorial infinity was illusionary in the U.S.S.R., a colossus that spanned 7,000 miles (11,230 kilometers) and nine time zones between the Baltic Sea and Bering Strait. Approximately 80 percent of the population, along with a high proportion of industrial capacity, were west of the Ural Mountains when Nazi Germany invaded. Connections between European Russia and the Soviet Far East depended almost entirely on the ribbonlike Trans-Siberian Railroad, a condition that compelled Soviet Armed Forces to operate in two widely separated and only slightly synchronized theaters. Long Soviet boundaries were so hard to defend and recalcitrants so hard to control throughout the Cold War that heavily armed Border Guards and Internal Security Troops peaked in the 1980s at a combined personnel strength that approximated 600,000 (more than most national armies).[20] Other huge nations, such as China and India, have experienced similar internal problems.

SHAPE

Favorable configurations generally confer military advantages, whereas awkward shapes do not. A circle with prized possessions dispersed well back from its rim would be perfect. Some countries or operational areas approach that ideal, but a good many are elongated, discontinuous, or fragmented.[21]

Map 3. *Mao's Long March*



Adapted from Robert Payne, *Portrait of a Revolutionary: Mao Tse-Tung* (London: Abeland-Schuman, 1961), 150.

ELONGATED SHAPES

Spindly Chile, 2,650 miles long and nowhere more than 250 miles wide (4,265 by 400 kilometers), is lucky, because the towering Andes Mountains guard most of its land borders. Israel, in contrast, had a waistline only 8 miles wide (<13 kilometers) before it seized and retained West Bank territories during the 1967 war—the Mediterranean was a 3-hour march for Jordanian foot troops, 15 minutes in medium tanks, and less than artillery range from the nearest enemy positions. Opportunities to trade space for time were nil. President Charles de Gaulle greatly increased NATO's military vulnerability when he evicted its armed forces from France in 1967; his action crammed U.S. combat and support formations into the narrowest part of West Germany where that nation is barely 150 miles wide (240 kilometers).[22]

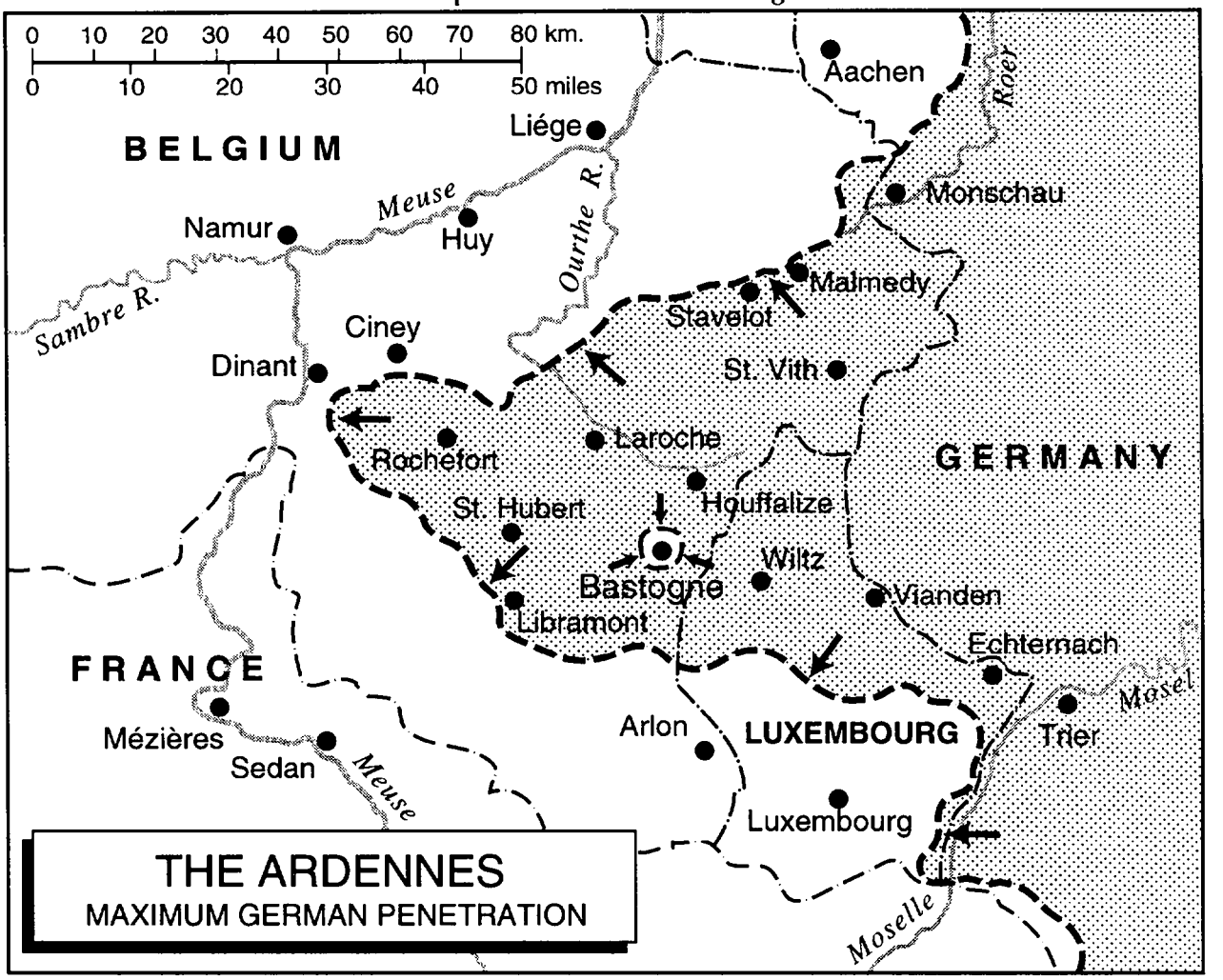
Military salients, a less exaggerated form of elongation, extend into enemy territory. Problems accompany those that penetrate deeply whenever hostile armed forces remain strong enough to hit one or both flanks. Iraqi divisions that captured Kuwait in 1990, for example, were dangerously exposed. General Colin L. Powell publicly announced, "Our strategy in going after this army is very simple. First we are going to cut it off, and then we are going to kill it."[23] Allied counteroffensives during the Battle of the Bulge (December 16, 1944 to mid-January 1945) similarly pinched a German salient that, at its zenith, drove a wedge almost 50 miles (80 kilometers) into Belgium, as map 4 depicts.[24]

Peninsulas, unlike salients, tend to isolate conflicts. Allied campaigners obtained positive results in Italy, a "sideshow" theater, where economy of force operations in 1943-1945 pinned down many German divisions that otherwise might have bolstered the Atlantic Wall or have reinforced German defensive capabilities in Normandy after Anglo-American armed forces landed. Armed combat lasted three years in Korea (1950-1953) without spreading to the mainland. Defensive actions against superior foes on peninsulas from which there is no escape, however, seldom have happy endings, as U.S. forces in the Philippines found after Japanese invaders backed them onto minuscule Bataan Peninsula hard by Manila Bay. A 90-mile "Death March" followed their surrender on April 9, 1942.[25]

DISCONTINUOUS SHAPES

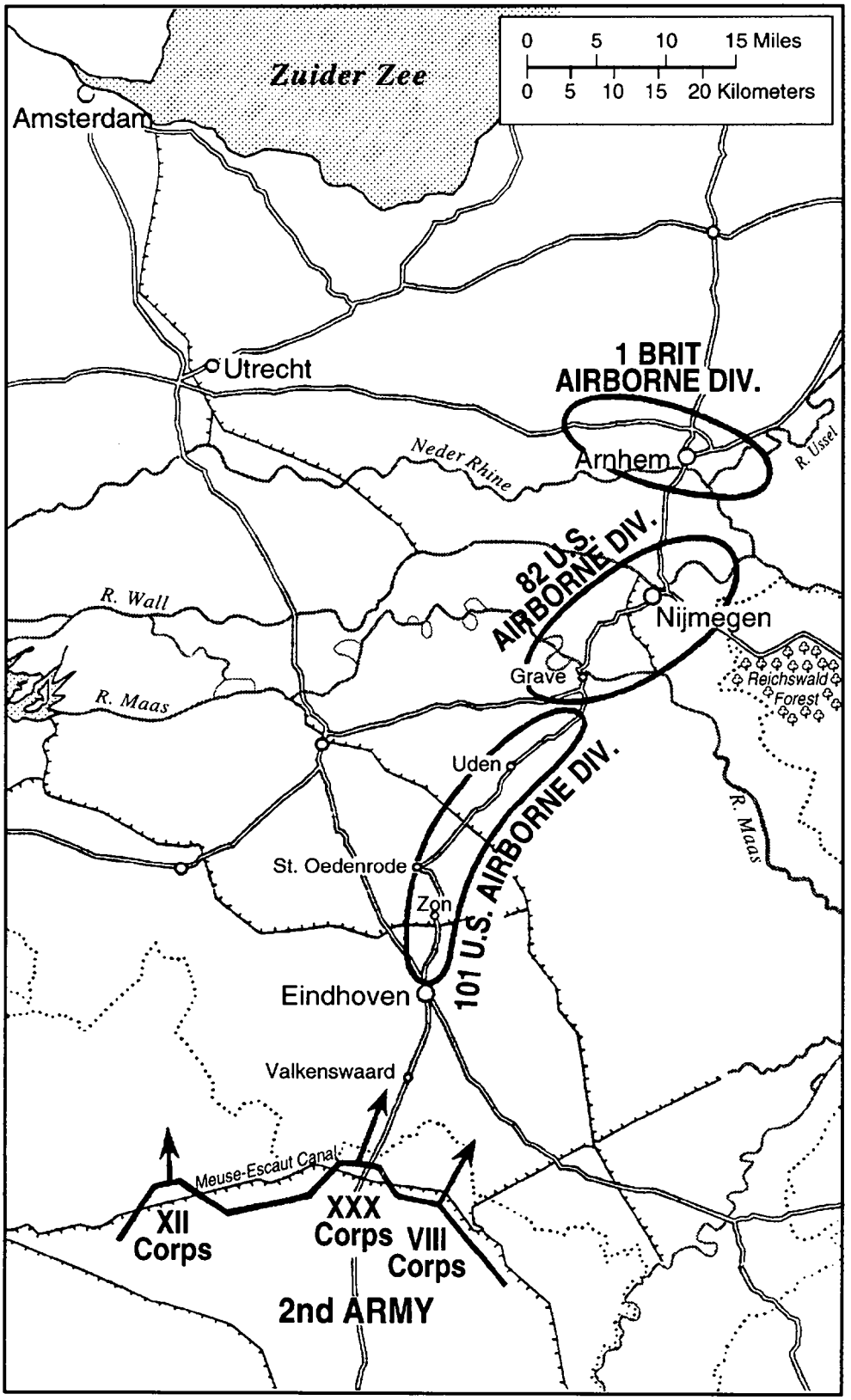
Discontinuous shapes of military significance come in assorted sizes and degrees of permanence. The smallest are parachute drop zones and helicopter landing zones in enemy territory. None can survive long unless it is reinforced rapidly, friendly forces advancing overland link up expeditiously, or surrounded units withdraw. Operation *Market Garden* decisively demonstrated that point in September 1944, when two U.S. and one British airborne divisions strove to secure five bridges over large rivers and canals in Holland so armored columns could scoot 64 miles (103 kilometers) up a narrow corridor, cross the Rhine at Arnhem, outflank the Siegfried Line, then head for the Ruhr, which was Nazi Germany's industrial heartland (map 5). British Lieutenant General Frederick (Boy) Browning, who feared that the plan was overly ambitious, said to Field Marshal Bernard Montgomery, its architect, "I think we might be going a bridge too far." He was right. The British 1st Airborne Division held out heroically at Arnhem for 10 days waiting in vain for a linkup, then disintegrated. Fewer than one-fourth of its 10,000 men made it safely back across the Rhine; the rest were killed, captured, or missing.[26]

Map 4. *The Battle of the Bulge*

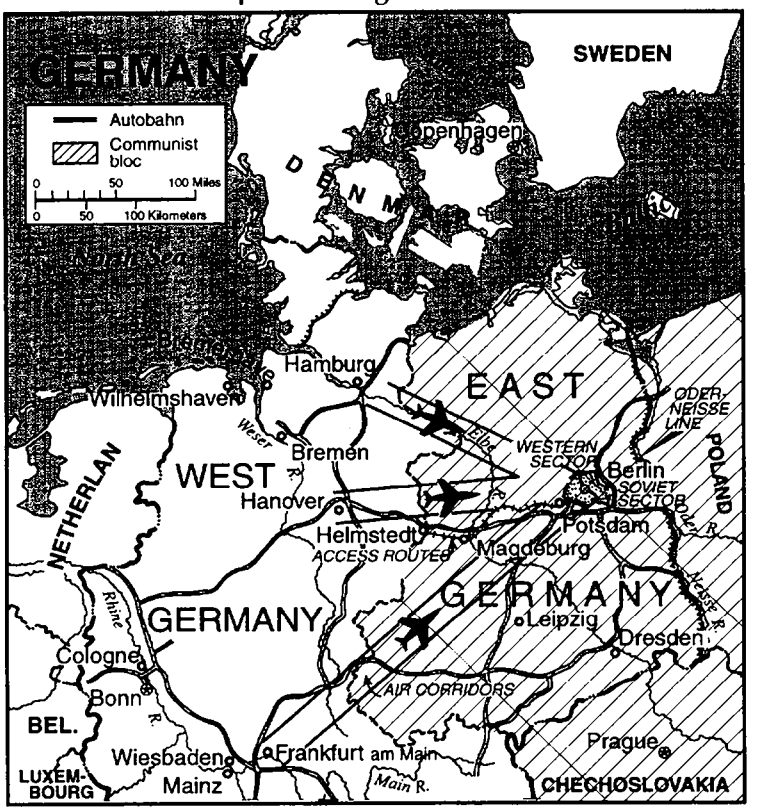


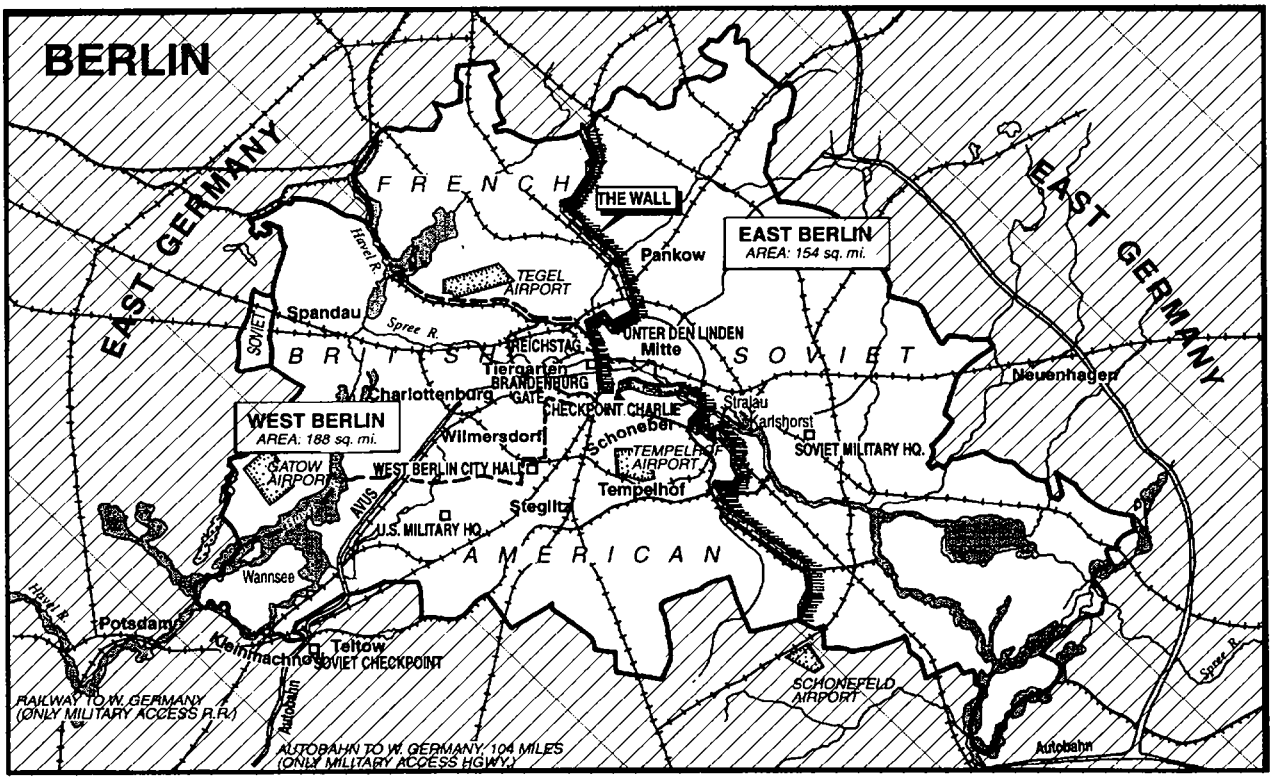
Forward bases and facilities, which are semipermanent enclaves on foreign soil, constitute a second subcategory under the rubric of disconnected shapes. Those in enemy territory, such as the U.S. Naval Base at Guantanamo, Cuba, and (from time to time) the Panama Canal Zone, are noteworthy because they demand stringent security. Exclaves on a grander scale primarily are political entities that frequently become flash points. Adolf Hitler, who hungered for East Prussia, which the Treaty of Versailles had separated from Germany proper in 1920, first requested from Poland (but never received) a connecting corridor through the free city of Danzig, then reclaimed those lands and much more by force of arms in September, 1939. Pakistan comprised east and west sectors 1,000 land miles apart (1,610 kilometers) from 1947 until 1971 when East Pakistan, with Indian assistance, gained independence as Bangladesh after a bloody civil war. Beleaguered Berlin (map 6), a Free World exclave and potential powder keg 100 miles (160 kilometers) east of the Iron Curtain, had huge symbolic as well as practical importance. Its position was tactically untenable, because Soviet and East German forces could seal off or swallow the city at their pleasure if

Map 5. *Operation* Market Garden



Map 6. *Beleagured Berlin*





willing to risk a nuclear war. Only the massive Berlin Airlift kept the population alive during a prolonged blockade that lasted from June 1948 until May 1949.[27]

FRAGMENTED SHAPES

Fragmented shapes mainly pertain to island nations such as Japan and the Philippines, which are open to defeat in detail. Indonesia, the most noteworthy, consists of several thousand islands, many uninhabited, that festoon off the coast of Southeast Asia for 3,000 miles (4,825 kilometers), a distance comparable to that between the U.S. Atlantic and Pacific coasts. Isolation discourages coordinated offensive or defensive military campaigns in widely separated places and, in some cases (such as Timor), encourages separatist movements.

KEY POINTS

- The location, size, and shape of land masses and large bodies of water strongly influence military capabilities, limitations, and vulnerabilities.
- No nation that lacks access to any ocean has ever been able to project great military power globally.
- Geographical isolation offers countries considerable protection against invasion.
- Even very large armed forces that battle strong adversaries on more than one front may be seriously disadvantaged.
- Time, distance, and modes of transportation determine how rapidly armed forces can respond to remotely-located contingencies.
- Armed forces spread thinly throughout large countries and operational areas are offensively and defensively disadvantaged.
- Armed forces deployed throughout archipelagos and other discontinuous operational areas may be subject to defeat in detail.

NOTES

1. Many political geography textbooks discuss spatial relationships in an international context. See, for example, Paul Buckholts, *Political Geography* (New York: Ronald Press, 1966), 73-93, and Lucille Carlson, *Geography and World Politics* (Englewood Cliffs, NJ: Prentice Hall, 1958), 24-39.
2. Russia's maritime deficiencies following the demise of the U.S.S.R. duplicate those that confronted the Soviet Navy. See John M. Collins, *The U.S.-Soviet Military Balance: Concepts and Capabilities, 1960-1980* (Washington, DC: McGraw-Hill Publications, 1980), 239-244.
3. J. F. C. Fuller, *A Military History of the Western World*, vol. 1 (New York: Funk and Wagnals, 1955), 360-384; Peter Fleming, *Operation Sea Lion* (New York: Simon and Schuster, 1957).
4. Trevor N. Dupuy, *Elusive Victory* (Dubuque, IA: Kendall/Hunt, 1992).
5. Donald S. Zagoria, *The Sino-Soviet Conflict, 1956-1961* (Princeton, NJ: Princeton University Press, 1962).
6. Arthur N. Strahler, *Physical Geography*, 2d ed. (New York: John Wiley and Sons, 1963), chapter 5; Richard D. Lee, "Metabolic Clock," *Aerospace Safety Review* 3, no. 3 (Winter 1966): 3-5.

7. *The War Reports of General of the Army George C. Marshall, General of the Army H.H. Arnold, and Fleet Admiral Ernest J. King* (New York: J. B. Lippincott., 1947), 557-563; Barry Pitt, *The Battle of the Atlantic* (New York: Time-Life Books, 1977).

8. Leonard Bushkoff, "Hungary (October-November 1956)," in *Challenge and Response in International Conflict*, vol. 2, *The Experience in Europe and the Middle East*, eds. Doris M. Condit, Bert H. Cooper, Jr., et al. (Washington, DC: Center for Research in Social Systems, American University, March 1967), 529-578.

9. Peter David, *Triumph in the Desert* (New York: Random House, 1991).

10. James A. Nathan, ed., *The Cuban Missile Crisis Revisited* (New York: St. Martin's Press, 1992); Robert Smith Thompson, *The Missiles of October: The Declassified Story of John F. Kennedy and the Cuban Missile Crisis* (New York: Simon and Schuster,1992); Raymond L. Garthoff, *Reflections on the Cuban Missile Crisis*, rev. ed. (Washington, DC: Brookings Institution, 1989).

11. Richard M. Nixon, *U.S. Foreign Policy for the 1970's: The Emerging Structure of Peace* (Washington: February 9, 1972), 177; Mark M. Lowenthal, *The CFE Treaty: Verification and Compliance Issues*, Issue Brief 91009 (Washington, DC: Congressional Research Service, 1991).

12. Collins, 159-167.

13. For background, see Daniel P. Bolger, *Americans at War: An Era of Violent Peace, 1975-1986* (Novato, CA: Presidio Press, 1988), 169-189, 383-441.

14. J. Lawton Collins, *War in Peacetime: The History and Lessons of Korea* (Boston, MA: Houghton Mifflin, 1969), 19, 82, 183, 200, 217, 291-292, 296. The quotation is by General of the Army Omar N. Bradley, Chairman of the Joint Chiefs of Staff, and is reproduced in testimony before the Senate Committees on Armed Services and Foreign Relations on *The Military Situation in the Far East*, 82^{d} Congress, 1st sess., part 2, May 15, 1951, 732, 753.

15. Keith William Nolan, *Into Cambodia: Spring Campaign, Summer Offensive, 1970* (Novato, CA: Presidio Press, 1990).

16. Gerard M. Devlin, *Back to Corregidor* (New York: St. Martin's Press, 1992); see especially 37-39, 44-61, 76-85.

17. Alexander Werth, *Russia at War, 1941-1945* (New York: E. P. Dutton and Co., 1964), 144-260.

18. S.L.A. Marshall, *Crimsoned Prairie* (New York: Charles Schribner's Sons, 1972), 191-237.

19. Robert Payne, *Portrait of Revolutionary: Mao Tse-Tung* (New York: Ablard-Schuman, 1961), chapter 6.

20. James T. Reitz, "The Soviet Security Troops: The Kremlin's Other Armies," in part 5, *Soviet Union: What Lies Ahead?* vol. 6, *Studies in Communist Affairs* (Washington, DC: Government Printing Office, 1985), 549-580.

21. See, for example, Buckholts, *Political Geography*, 73-78.

22. Gordon A. Moon, II, "Invasion in Reverse," *Army* 17, no. 2 (February 1967): 24-30 and "Uncertain Future," March 1967, 38-42.

23. Colin L. Powell with Joseph E. Persico, *My American Journey* (New York: Random House, 1995), 509-510.

24. John S. D. Eisenhower, *The Bitter Woods* (New York: G. P. Putnam's Sons, 1969).

25. John W. Whitman, *Bataan Our Last Ditch* (New York: Hippocrene Books, 1990); John Tolland, *But Not in Shame: The Six Months After Pearl Harbor* (New York: Random House, 1961), 265-366.

26. Cornelius Ryan, *A Bridge Too Far* (New York: Simon and Schuster, 1974).

27. Ann and John Tusa, *The Berlin Airlift* (New York: Athenium Press, 1988); James M. Schick, *The Berlin Crisis,1958-1962* (Philadelphia, PA: University of Pennsylvania Press, 1971).

3. LAY OF THE LAND

In peace, soldiers must learn the nature of the land, how steep the mountains are, how the valleys debouch, where the plains lie, and understand the nature of rivers and swamps—then by means of the knowledge and experience gained in one locality, one can easily understand any other.

Niccolo Machiavelli
Discorsi

A U.S. ARMY MAJOR GENERAL WHO ADDRESSED THE NAVAL WAR COLLEGE DURING THE COLD WAR DECLARED without cracking a smile, "Young men of all services must learn terrain or learn Russian." No one will ever know for sure whether he overstated his case, because the United States and the Soviet Union never went to war with each other, but the lay of the land was militarily important long before Rennaissance Man Machiavelli made his pronouncement more than 500 years ago and likely will remain so.

LAND FORMS

Land forms comprise the foundation upon which all other terrestrial features are superimposed (figure 1 is illustrative).[1] They occupy three militarily significant categories, which table 2 lists with the highest, largest, or deepest first. High ground, level land, and depressions each uniquely influence the abilities of air and ground forces to maneuver freely, locate targets, deliver firepower effectively, conduct non-combat operations, coordinate actions, and furnish essential support at strategic, operational, and tactical levels.

HIGH GROUND

"Mountains" and "hills" are imprecise terms, the definitions of which depend on circumstantial interpretations. High spots in southern India's Palmi Hills are equal in elevation to those of the U.S. Appalachian Mountains which, in turn, are small compared with the Alps or Andes. Some summits are saw-toothed, others are smooth. Little correlation may be evident between total elevation, measured from mean sea level to any point on land, and local relief, which measures topographic features from base to top (figure 2). Pike's Peak in Colorado, for example, is 4,000 feet (1,220 meters) higher than the loftiest pinnacle along Lebanon's coastal range, yet local relief is less because its climb begins more than a mile above sea level. Airmen, who set their altimeters according to elevation, view local relief

Figure 1. ***Land Forms Displayed Schematically***

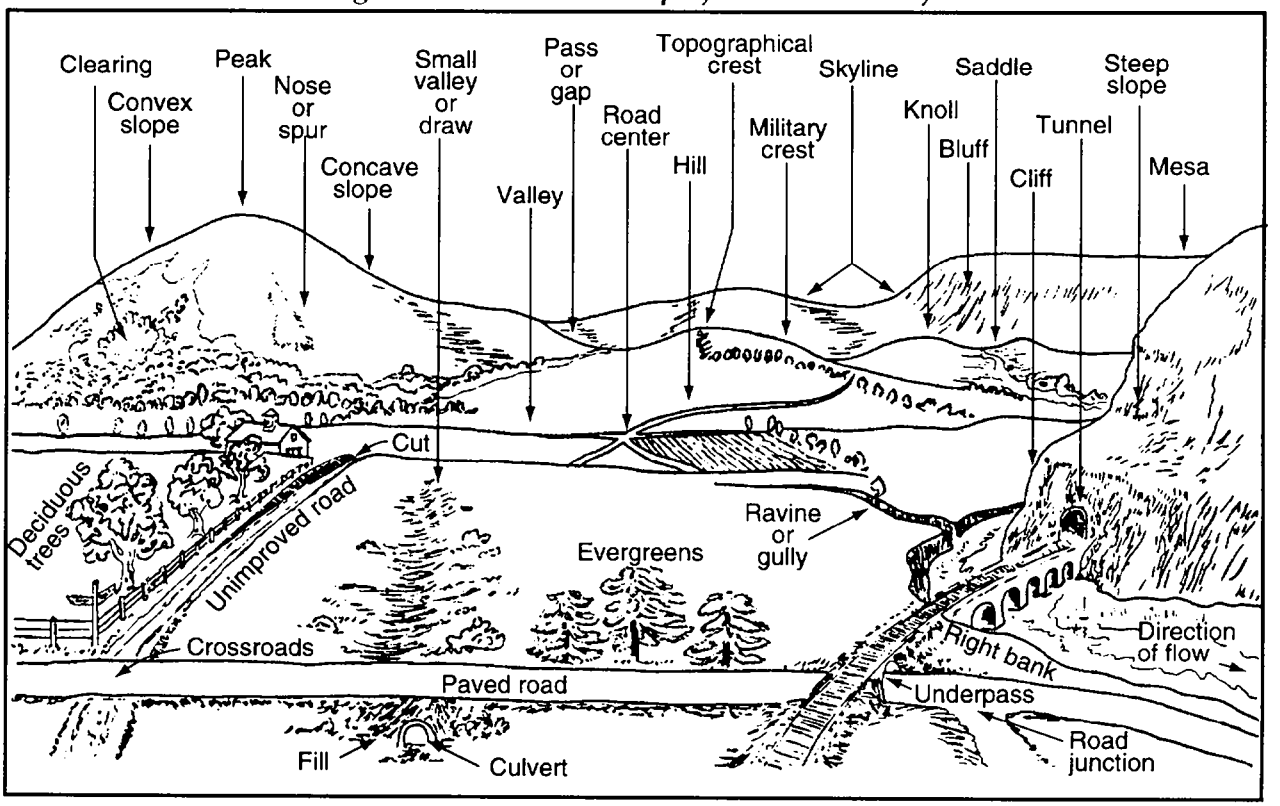


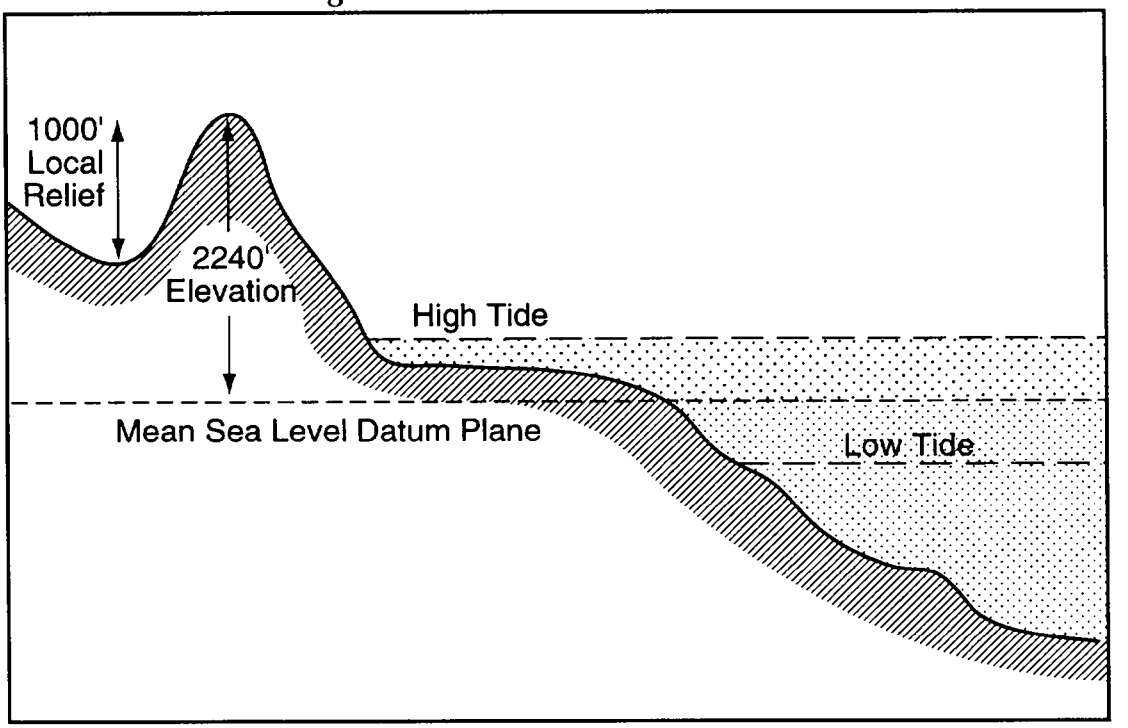
Table 2. ***Land Forms Listed***

High Ground	*Relatively Level Land*	*Depressions*
Mountains Hills Hummocks Cliffs Bluffs	Plains Plateaus Mesa Tops Butte Tops	Valleys Basins Canyons Gorges Ravines Caverns Caves Craters

from different perspectives than land forces, whose front-line troops may consider hummocks to be high ground. Gradients, which measure how rapidly the ground rises or falls vertically over given horizontal distances, generally are expressed as plus or minus percentage figures, depending on direction of movement (figure 3 shows a +23 percent ascending grade from A to B and -23 percent descending from B to A).

Very steep slopes severely limit military flexibility. Helicopter pilots, for example, must take care that rotor blades don't hit the ground on the uphill side while they hover or decapitate troops when they debark and ensure that the skids will hold instead of sliding

Figure 2. ***Elevation and Local Relief***



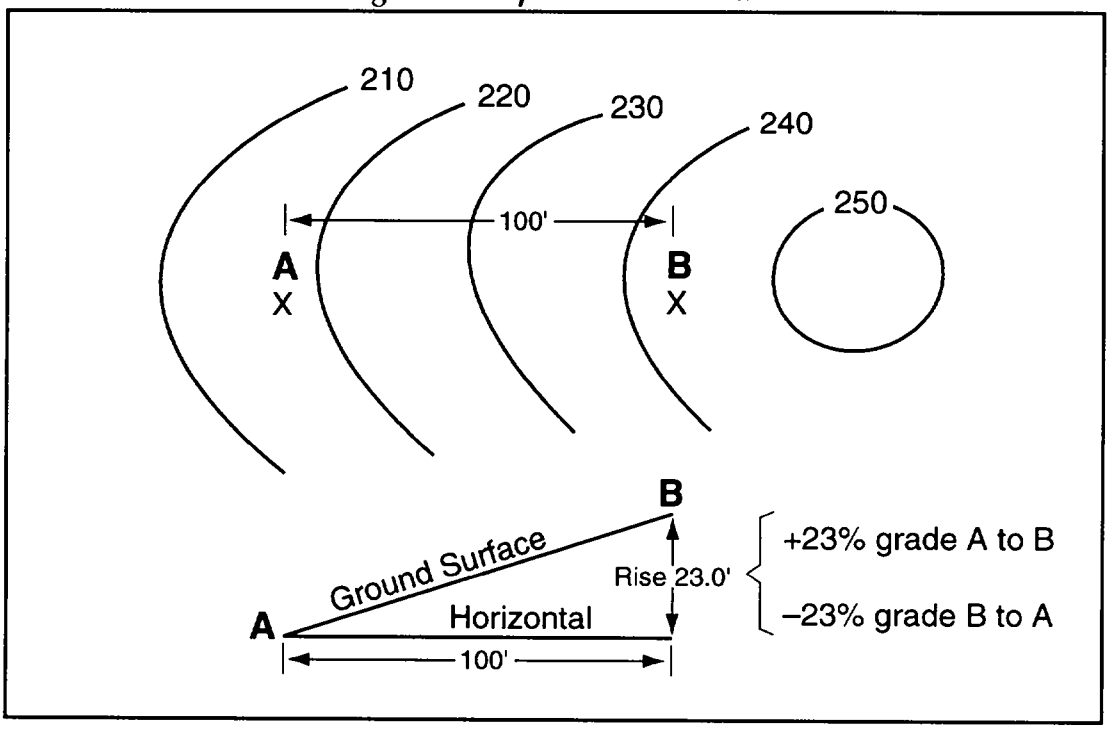
downhill if they have to land. The proficiency with which ground forces negotiate steep terrain depends on professional skills, types of transportation, and loads. Mountaineers can scale walls that would stop standard infantry; tracked vehicles can negotiate steeper ground than trucks; railway locomotives can tow longer trains up sharper grades if flatcars are laden with tents instead of tanks. Aerial observers and high-flying bombers are hard pressed to identify and hit targets concealed by rugged terrain where closely-spaced ridges make close air support a perilous proposition even in perfect weather.

Points and areas on bare slopes are visible from the top to the bottom of any hill only if the topographical crest (the highest elevation) and the military crest (the highest point from which terrain all the way to the base is visible) happen to coincide. Convex slopes and other surface irregularities commonly create "blind spots"—masks or defilades in military parlance—that protect enemy positions from flat-trajectory weapons, such as rifles and machine guns (see figure 4). Terrain masks also degrade the performance of Very High Frequency (VHF) radios, which likewise depend on line-of-sight. Surface-to-surface missile and field artillery batteries emplaced along steep, narrow valleys cannot elevate launchers or tubes high enough to clear nearby crests.

RELATIVELY LEVEL LAND

Flat to rolling surfaces include relatively small mesas and buttes as well as the gargantuan U.S. Great Plains, Russian steppes, and high plateaus such as the Tibetan Tableland, which, at 16,000 feet (4,875 meters), is higher than most mountains. Slopes nowhere exceed 5-15 degrees on large plains and plateaus, except for isolated protuberances that rise abruptly above otherwise horizontal terrain.

Figure 3. *Slopes and Gradients*

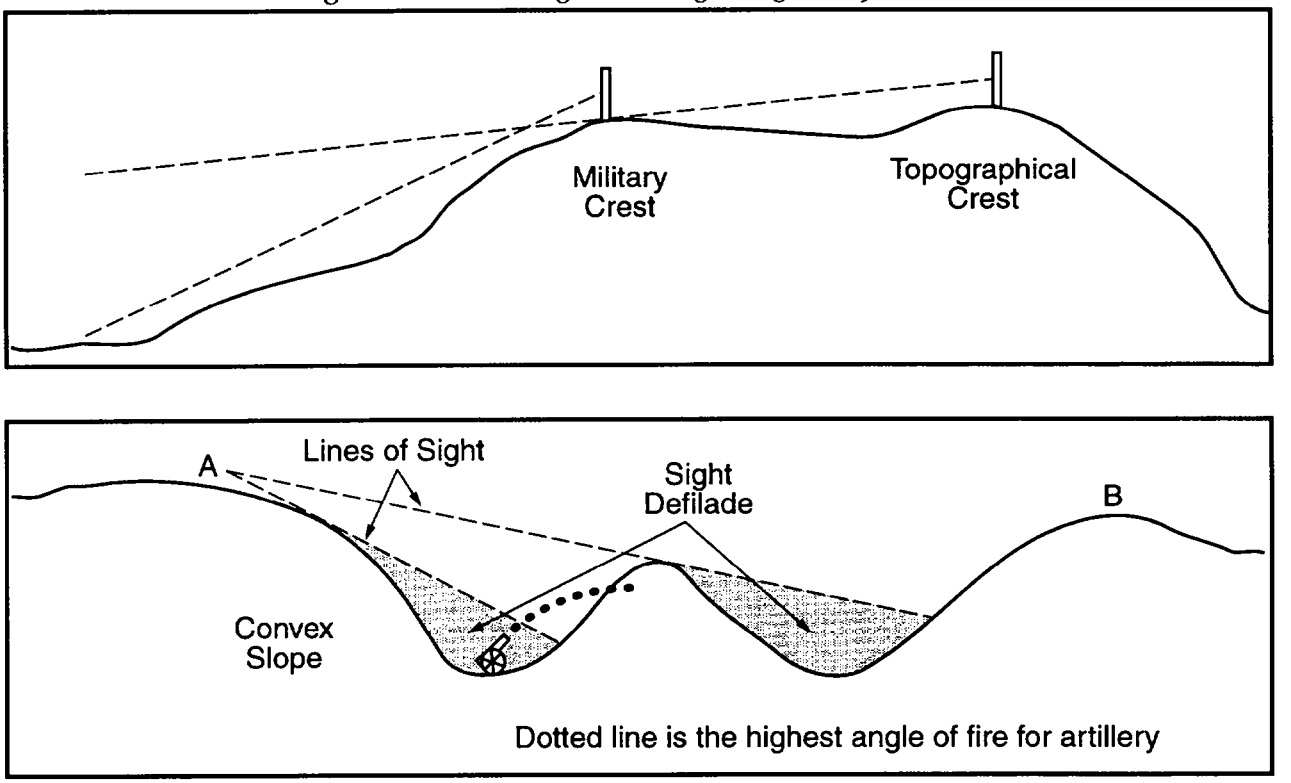


Relatively level lands throughout history have witnessed major military operations. One of the first confrontations between pastoral and agricultural societies occurred in the 18th century B.C, when Hyksos horsemen overran Lower Egypt, which, then as now, mainly occupied the Nile Delta. Roman luminaries Actius and Theodoric stopped Attila the Hun on the Mauriac Plain near what now is Chalôns-sur-Marne, France, in 451 A.D. Charles Martel, a Frank, defeated Moorish invaders in the Loire Valley close by Tours (732 A.D.) to stem the Islamic tidal wave that was sweeping northward from Africa. Washington defeated Cornwallis on rolling lands around Yorktown, Virginia, in 1781 and thereby assured eventual victory for the infant United States, while Napoleon met Wellington and his Waterloo on Belgian lowlands in 1815.[2] It should come as no surprise that the most expansive military campaigns in modern times took place on vast Soviet flatlands that allow gigantic armed forces to maneuver fluidly and conduct air-land combat on a grand scale. Operation *Zitadelle,* the epic clash at Kursk, reportedly culminated in 70,000 Germans killed or wounded (not counting captured or missing in action) and the destruction of 3,000 tanks, 1,400 aircraft, 1,000 artillery pieces, and 5,000 trucks. Soviet loses in that largest of all armored battles were only slightly less.[3]

TOPOGRAPHICAL DEPRESSIONS

Canyons and gorges make awesome obstacles, but are fewer than caverns and caves, which come in many sizes and serve many military purposes. Mao's strategic concepts, for example, took shape in a Shaanxi cave where he had ample time for reflection after the Long March. Natural shelters, perhaps further hollowed out and refined, need not be nearly as large as the cliff side cavity that hid the fictional Guns of Navaronne. Tenacious Japanese troops on Peleliu, Saipan, Iwo Jima, Okinawa, and other contested Pacific islands that were

Figure 4. ***Line-of-Sight and High-Angle Trajectories***



honeycombed with comparatively small caves made U.S. forces root them out at the expense of frightful casualties on both sides, because air strikes and heavy naval artillery left those sanctuaries virtually intact.[4] Yugloslav guerrillas who took refuge in caverns and caves from 1941 through 1944 gave fits to a sizable number of German divisions that might have been profitably employed on other fronts.[5] Weapons, equipment, and supplies stockpiled deeply beneath bedrock generally are safe from direct hits by conventional bombardment. Subterranean facilities used by enemies to store nuclear, biological, or chemical munitions cause concern for identical reasons, because actions to neutralize them by frontal assaults would be costly and outcomes uncertain. An 11-man sabotage team, following surreptitiously acquired floor plans, hit Hitler's heavy water plant at Vermork, Norway, and with one small explosion crippled Nazi Germany's nuclear weapons program,[6] but that spectacular achievement has proved to be an exception instead of a rule.

Basins surrounded by steep terrain expose forces on the bottom to murderous fire if opponents occupy commanding heights, as French paratroopers in Vietnam found at Dien Bien Phu (1954) and U.S. Marines discovered at Khe Sanh during the next decade (1967-1968). Alfred, Lord Tennyson immortalized the Charge of the Light Brigade during the battle of Balaclava in 1853 with these heart-wrenching words:

> Cannon to the right of them,
> Cannon to the left of them,
> Cannon in front of them
> Volley'd and thunder'd . . .
> Into the jaws of death,

Into the mouth of hell
Rode the six hundred.

Shocked onlookers became so hushed when the Light Brigade entered the "Valley of Death" that the jingle of bits and accouterments could clearly be heard. Twenty minutes later almost 250 men and twice that many horses were dead.[7]

RIVERS AND RESERVOIRS

Fast-moving offensive ground forces that lack sufficient air assault capabilities must swim, ford, ferry across, or build bridges over large streams without breaking stride or forfeit forward momentum while defenders on the far bank hold in place.[8] All military services routinely require adequate water for drinking, cooking, and sanitation, plus special purposes such as decontamination during chemical combat. Drainage systems, river crossing sites, and militarily useful reservoirs thus are relevant topics. (Chapter 11 covers inland waterways.)

DRAINAGE SYSTEMS

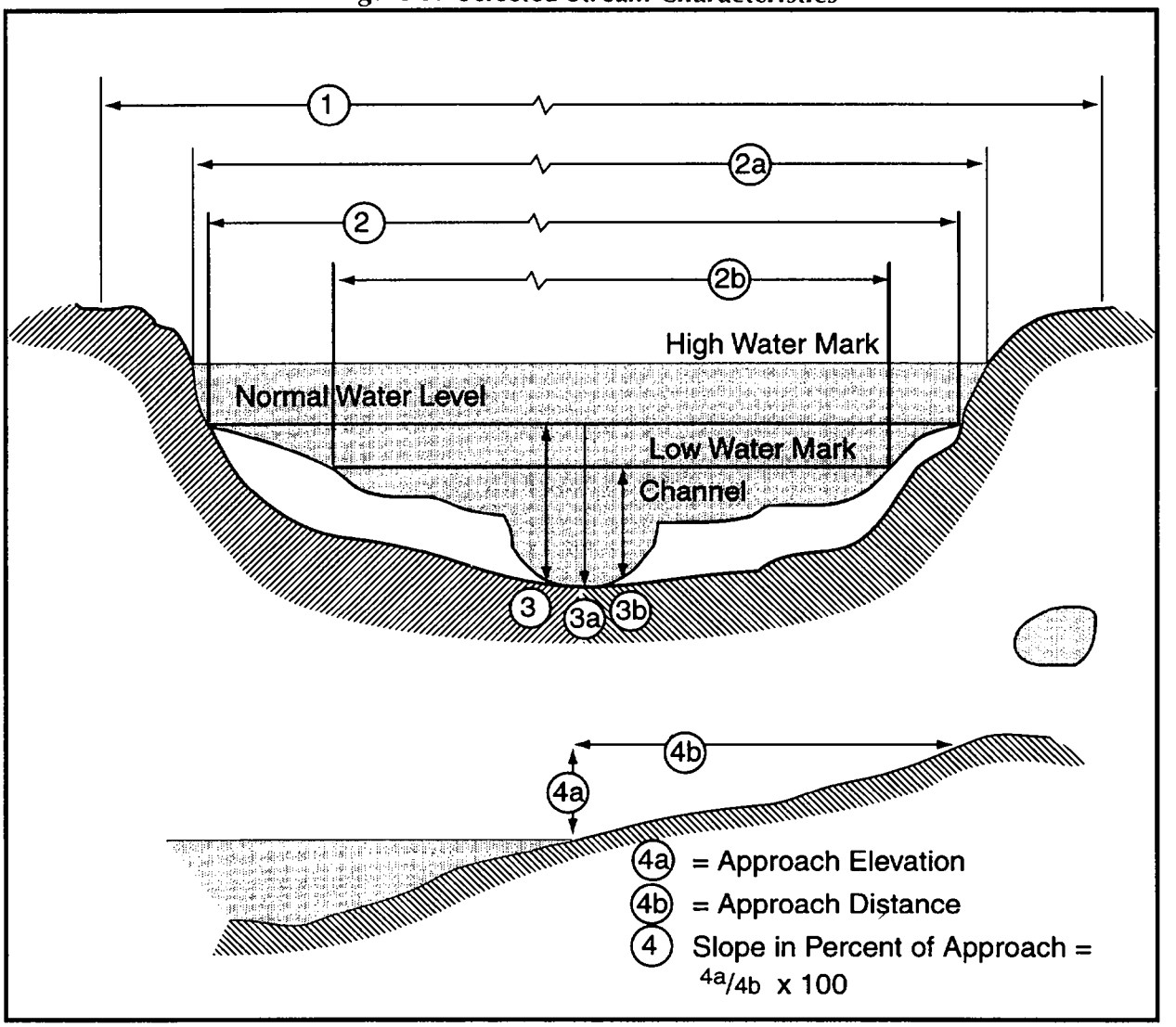
Drainage systems generally are shaped like asymmetrical trees, each branch of which empties its contents into a larger stream until the biggest tributaries connect with the trunk. Immense systems such as the Amazon and Mississippi funnel runoff from several million square miles, while minor systems service much smaller areas. Great rivers that arise and remain in well-watered regions have many tributaries. Streams 30 to 60 feet wide (9 to 18 meters), for example, lace Western Europe every 6 miles (9+ kilometers) or so, while rivers up to 300 feet across occur on the average at 30-mile intervals. Relatively few branches in contrast feed the Tigris, Euphrates, and Nile, which arise where water is plentiful but traverse dry lands thereafter.[9]

Militarily important riverine characteristics begin with widths, measured in feet, yards, or meters from bank to bank, and with depths which indicate the distance from surface to bottom (figure 5). Current velocities, usually stated in feet or meters per second, depend primarily on the steepness of the stream bed. Twenty-five to 30 feet (7-9 meters) per second or 17 to 20 miles an hour is considered quite fast, whereas 1 or 2 feet per second or less is sluggish. The deepest, fastest flow normally follows the main channel well above the bottom, because stream banks and beds function as friction brakes. Currents accelerate along outside curves, where they figuratively play "crack the whip."

Widths, depths, velocities, and volumes measured in cubic feet, yards, or meters past particular points are by no means constant. Military planners and operators anticipate seasonal fluctuations, typified by annual inundations along the Nile Valley, and are fully aware that tidal rivers rise and fall twice daily in response to lunar cycles. Not all destructive floods, however, are predictable nor are they all from natural causes: Germans defenders in November1944 blew dams on the Roer River at Schmidt to delay advancing Allied armies; Chinese "volunteers" at Hwachon Reservoir in Korea (1951) threatened to release a wall of water that could have washed away command posts, supply dumps, and bridges and split U.S. IX Corps.[10]

Sand bars, mud banks, and rock outcroppings impose natural obstacles close to shore, especially along outside curves. Floating debris and ice floes in stream can be destructive

Figure 5. *Selected Stream Characteristics*



1. The *width of stream bed* from bank to bank.
2. The actual *width of the water* measured at normal stage. In addition, maximum width 2a and minimum width 2b are estimated, based on local observations or records of high water and low water, and then recorded.
3. The actual *depth of the stream* at normal water level.

3a. Estimated *maximum water depth* based on local observations or records.

3b. Estimated *minimum water depth* based on local observations or records.

4. The *slope of the approaches* is the slope of the stream banks through which the approach roads are cut.

to river craft and bridges, but solid ice is beneficial when thick enough to bear the weight of troops, trucks, and tanks.

CROSSING SITES

River crossings at many places on broad fronts minimize enemy abilities to concentrate decisive defensive power against vulnerable targets, perhaps employing weapons of mass destruction. Ideal locations exhibit the following attributes:[11]

- Good roads closely parallel the river so that offensive forces can easily reach the best crossing sites.
- Well-protected areas are ample to hold follow-on forces waiting to reinforce assault waves.
- Easily negotiable slopes lead to water on the near shore and to land on the far side.
- Narrows facilitate fast assault crossings, round trips by rafts and ferries that support subsequent buildups, and combat bridge construction.
- Current velocities less than 5 feet per second (3.5 miles per hour) limit down-stream drift.
- Fording sites are consistently shallow, their bottoms are firm enough to bear heavy traffic, and selected routes are free from militarily significant obstacles.
- Unfordable streams are consistently deep enough to float swimming vehicles, inflatable boats, rafts, and ferries.
- Rapids, shoals, sandbars, snags, debris, and icy obstructions are conspicuously absent.
- Conveniently located islands that act as stepping stones reduce combat bridging requirements.

The best crossing sites unfortunately are apt to be staunchly defended and actual conditions seldom are ideal. German *panzer* divisions in Russia during World War II, for example, frequently found that marshy lowlands abutted both banks of large streams, floods loaded with sediment clogged inboard engines, ice floes each spring bombarded expedient bridges, and vehicles became toboggans on moderate slopes after torrential summer rains.[12] Skilled tacticians nevertheless overcame such adversities and learned that landings at unexpected spots improve prospects for low-cost success.

WATER SUPPLIES

Large armed forces demand enormous quantities of water in peacetime as well as war, whether active or passive, at fixed installations or in the field. Requirements are most difficult to satisfy in arid regions, especially when division-sized ground elements and air wings move frequently. Drinking water must be palatable (color, odor, and taste all count) and be unpolluted by pathogenic bacteria that spread contagious diseases such as typhoid fever, cholera, and amoebic dysentery. Time-consuming and expensive purification processes become obligatory when water for use as coolants is corrosive. Surface and subsurface sources are complementary, because neither suffices under all conditions. Both contribute supplies that differ quantitatively as well as qualitatively from time-to-time and place-to-place with varying degrees of convenience.[13]

Surface Water. Rivers, lakes, and some inland seas are large sources of fresh water on Earth's surface. Lesser repositories include ponds, small streams, and springs. Some sources are consistently reliable, whereas floods and droughts elsewhere seasonably reduce usable water supplies below required amounts. Unpredictable depletions caused by nature or enemy actions may do likewise with little or no notice. Prudent commanders consequently try to identify alternative sources before water crises occur.

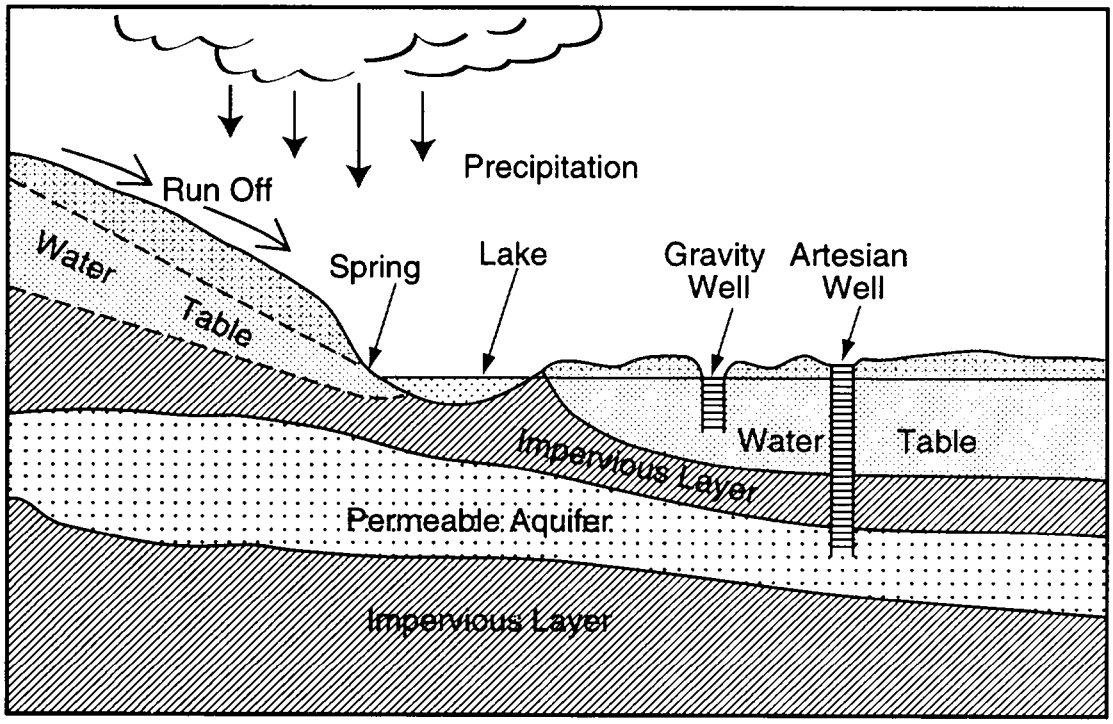
Perennial flows of sweet, cool spring water usually are low in organic impurities but tend to be widely scattered, high in mineral content, and output seldom is enough to satisfy large military formations which most often must establish, operate, and maintain water supply points at locations that are easily accessible and facilitate distribution by road. Large quantities of good quality surface water are commonly available on plains and plateaus where rainfall annually exceeds 25 inches (60 centimeters), but ample sources are hard to find in mountains where runoff starts, in frigid climes where sources are ice-bound many months each year, in the tropics where pollution frequently is rampant, and near small towns and urban centers where raw or incompletely treated sewage and toxic chemicals sometimes contaminate running water and reservoirs.

Naval vessels and some coastal countries distill brine to produce fresh water. The world's largest desalinization plant, located in Saudi Arabia, siphons more than 5 million gallons per day from the Persian Gulf (nearly 19 million liters) and, after purification, pipes fresh water as far inland as Riyadh. Allied missile defense batteries took special precautions to protect that facility against Iraqi Scud attacks during Operations *Desert Shield* and *Desert Storm* in 1990-1991.[14] The U.S. Marine garrison at Guantanamo Bay, Cuba, which is isolated from the rest of Oriente Province by minefields and other man-made obstacles, routinely requires about 1.2 million gallons (4.5 million liters) of desalinated sea water per month. Surplus capacity and barges, plus 15 million gallons in storage, made it possible to accommodate 55,000 Cuban and Haitian refugees who inflated peak consumption to more than 73 million gallons in October 1995 (27.6 million liters).[15]

Subsurface Water. Not all precipitation and melt water empties directly into surface drainage systems. A good deal seeps into subterranean reservoirs instead. How much depends on total accumulations, slopes, soil compositions, and the permeability of underlying rocks. Moisture first percolates through an aerated zone that alternately dampens and dries, then reaches the water table, a saturated layer of variable thickness and depths that may be shallow or deep (figure 6). Some water continues to trickle down through cracks and crannies until contained by aquifers encased in nearly impervious rock formations. Artesian springs that rise to the surface under hydrostatic pressures along fissures and fault lines are little affected by seasonal fluctuations or by pollution, but often are too mineralized for human consumption or cooling systems. Relatively shallow wells sunk into the water table generally are preferable with two prominent exceptions: well water along littorals tends to be brackish; supplies drawn from arctic sources above permafrost are only briefly productive each year.[16]

Mobile ground forces seldom sit still long enough to tap subsurface reservoirs, but ports, airfields, supply depots, major maintenance shops, and other static installations frequently benefit. So do Civil Affairs well-digging teams whose humanitarian mission is to improve the quality of life for impoverished people. Subterranean repositories furnish the *only* reliable source of water inland wherever lands are parched, a fact of particular importance when

Figure 6. *Water Tables, Acquifers, and Wells*



summer heat heightens routine requirements and demands soar under stressful conditions. Conservative estimates, for example, indicate that it would take approximately 200,000 gallons of wash water to decontaminate the personnel, weapons, equipment, and facilities (such as aid stations and field hospitals) of just one U.S. Army or Marine division hard hit by persistent chemical warfare (CW) agents.[17] That would be a tall order even if fire hydrants were handy, and perhaps impossible in the desert, where the employment of CW munitions could entail unconscionable risks for *both* sides if reprisals in kind drenched aggressors.

GEOLOGY AND SOILS

Commanders, staffs, and subordinates from the highest to the lowest echelons of every armed service need to know how geology and soils affect combat and support operations, but most are bored to tears by those technical subjects. This brief section, which seeks to stimulate interest, first characterizes Earth's mantle, then explains important military implications in simple terms.

SURFACE CHARACTERISTICS

Soil covers Earth's land surface in layers that vary from several hundred feet thick on some alluvial plains to an inch or so on steep mountain slopes. Various grades of gravel, sand, silt, and clay, classified in descending order of particle size, occasionally appear in pure form but more often in a mix (silty gravel, sandy clay, and so on), each with distinctive properties such as texture, compactness, porosity, and consistency that affect military utility (table 3).[18]

Table 3. *Selected Soil Characteristics*

	Predominantly Gravel	*Predominantly Sand*	*Predominantly Silt*	*Predominantly Clay*
Dry	Solid Stable	Loose Unstable	Compact Dusty	Hard Dusty
Wet	Solid Stable	Compact Stable	Spongy Slippery Dries Fast	Sticky Slippery Dries Slowly
Frost	Unaffected	Unaffected	Heaves	Heaves

Gravel consists of coarse and smooth rocks, rounded or angular, that range from about 1/4 inch to 3 inches (2.5 to 7.6 centimeters) in diameter and are unaffected by weather conditions. Smaller grains constitute sand, which is unconsolidated when dry yet compact when wet. Dry silt is finer still, but solid except for the surface, which raises dust clouds under windy conditions, whereas wet silt constitutes soft, slippery mud until sunshine, warmth, or wind re-solidify it. Plasticity and adhesiveness are salient characteristics of microscopic (almost poreless) clay particles, which are hard and often brittle when dry. Clay sheds water well but, once saturated, combines the worst attributes of slime and glue. Clay also takes a long time to dry and, like silt, heaves in response to alternating freezes and thaws. Combinations modify each basic soil type, depending on the mix.

Top soils heavy in humus (decomposed vegetation) are several feet thick in peat bogs, somewhat less in marshes and meadows. Humus invariably is thin in deserts where scanty precipitation supports little plant life, in the arctic where cold retards decay, and wherever tropical heat and humidity disintegrate organic waste.

Bedrock beneath all soil sometimes lies at or near the surface, but often is deeply buried. Structures (laminated or solid), textures (coarse or smooth), and fracture patterns (clean or jagged breaks) are notable attributes. "Rock of Ages" like granites and quartzites are exceedingly hard, but all conglomerates, sandstones, siltstones, even splintery shales are more durable than their basic constituents, which were gravel, sand, silt, and clay before being cemented together under great pressures. Calcium-rich limestones range from very hard construction material to very soft chalk, the latter typified by the white cliffs of Dover.[19]

CROSS-COUNTRY TRAFFICABILITY

Load-bearing capacities, traction, and stability despite sustained use characterize the abilities of particular soils to tolerate traffic by wheeled and tracked vehicles as light as snowmobiles and as heavy as tractor-trailers or tanks. Cross-country mobility over gravelly ground is consistently feasible, whereas bogs and swamps are impassable to all but small amphibians. Off-the-road movement, however, most often depends on weather conditions. Frozen fields generally are conducive. So are dry soils other than sand, which in its loose state immobilizes trucks that lack low-pressure tires. Saturated silt, in contrast, churns into soft mud after the first few vehicles pass, faster than usual when loosened by cultivation. Wet clay is worse: deep ruts rapidly appear; stickiness gums drive trains, degrades speed, and

complicates steering; modest inclines become too slippery to climb; and after soaking rains tanks and armored fighting vehicles slide down slopes like Olympic-class luges.[20]

Terrain strewn with boulders also inhibits free movement, as British Brigadier John Bagot Glubb discovered in 1931, when he took an Arab Legion patrol into Trans-Jordan's panhandle to suppress rambunctious Bedouins. Blocks of black lava so littered the landscape that progress on horseback was painfully slow and dismounted legionnaires took 10 days to clear a path that was barely wide enough for a column of trucks to proceed 6 miles (9.6 kilometers), then turn around.[21]

WEAPON PERFORMANCE

Soil conditions and rock affect the performance of many conventional weapons and delivery vehicles. Rocky outcroppings and gravel magnify the lethal radius of conventional munitions, which ricochet on impact and scatter stone splinters like shrapnel, whereas mushy soil smothers high explosives that burrow before they detonate. Even light artillery pieces leave fairly heavy "footprints" in saturated earth, a peculiarity that limits (sometimes eliminates) desirable firing positions. Gunners struggled to keep towed artillery pieces on targets when they worked at or near maximum tube elevations on wet ground in Vietnam where it didn't take many rounds to drive 155-mm howitzer trails so deeply into the mire that recoil mechanisms malfunctioned. Each piece consequently had to be shifted several times each night, a grueling proposition that caused trucks to snap winch cables when soil suction exceeded their capacities. Howitzer trails proved impossible to seat permanently at lower angles of fire, which caused whole batteries to slide after one or two volleys. No amount of shoring solved those problems, but resourceful artillerymen in the Mekong Delta improvised long-legged heliborne platforms that rested on solid foundations that gave their guns acceptable stability.

Surface conditions likewise amplify or mute nuclear weapon effects. The diameters and depths of craters are less when soil is dry than when soaked, nuclear shock waves transmitted through wet clay are perhaps 50 times more powerful than those through loose sand, and the intensities as well as decay rates of nuclear radiation reflect soil compositions and densities. Research and development specialists at underground test sites use related data to determine how deeply they must bury nuclear devices of specified yields to prevent radiation from venting in open air. Massive beds of volcanic ash called "tuff" seem best.[22]

MILITARY CONSTRUCTION MATERIALS

Engineers whose mission is to build, repair, and maintain military roads, airstrips, vehicle parks, bridge foundations, and field fortifications routinely use bulldozers, front loaders, dump trucks, and shovels to scoop, prepare, and redeposit surface soils. Some materials, however, are much better suited than others for such purposes..

Excavations in granite and other hard rock require demolitions and power tools, whereas most sandstones, limestones, and shales are easier to extract, provided the earthen overburden allows easy access. Amalgams of gravel with silt or sand make good material for fill, stable embankments, and foundations, but no mix of silt or clay is suitable for aircraft runways, taxi strips, or road surfaces, even with palliatives to keep dust down during dry seasons. Weathered basalt, which forms a hard crust when dry but develops deep ruts after rains, also is undesirable.[23] Laterite, a common deposit in tropical alluviums, was the

construction material of choice for main supply routes and C-130-capable airfields in Vietnam, because its iron and aluminum oxide concretions harden irreversibly and withstand tremendous abuse. Peneprime, oil, or some other asphaltic compound waterproofed and controlled dust.[24]

VEGETATION

Paleolithic foot soldiers armed with stone axes and wooden clubs discovered that dense vegetation limits land mobility and observation to front, flanks, and rear. Problems multiplied when warriors began to employ "standoff" weapons that required clear fields of fire (spears, javelins, slingshots, bows and arrows), formed cavalry squadrons, and devised "mechanized" modes of transportation (mainly horse-drawn chariots). Technological innovations that include armor, aircraft, and thermonuclear weapons have profoundly altered the significance of vegetative cover since then, but none has neutralized its effects. Bare ground still favors offensive forces; forests still favor defense.

GLOBAL DISTRIBUTION

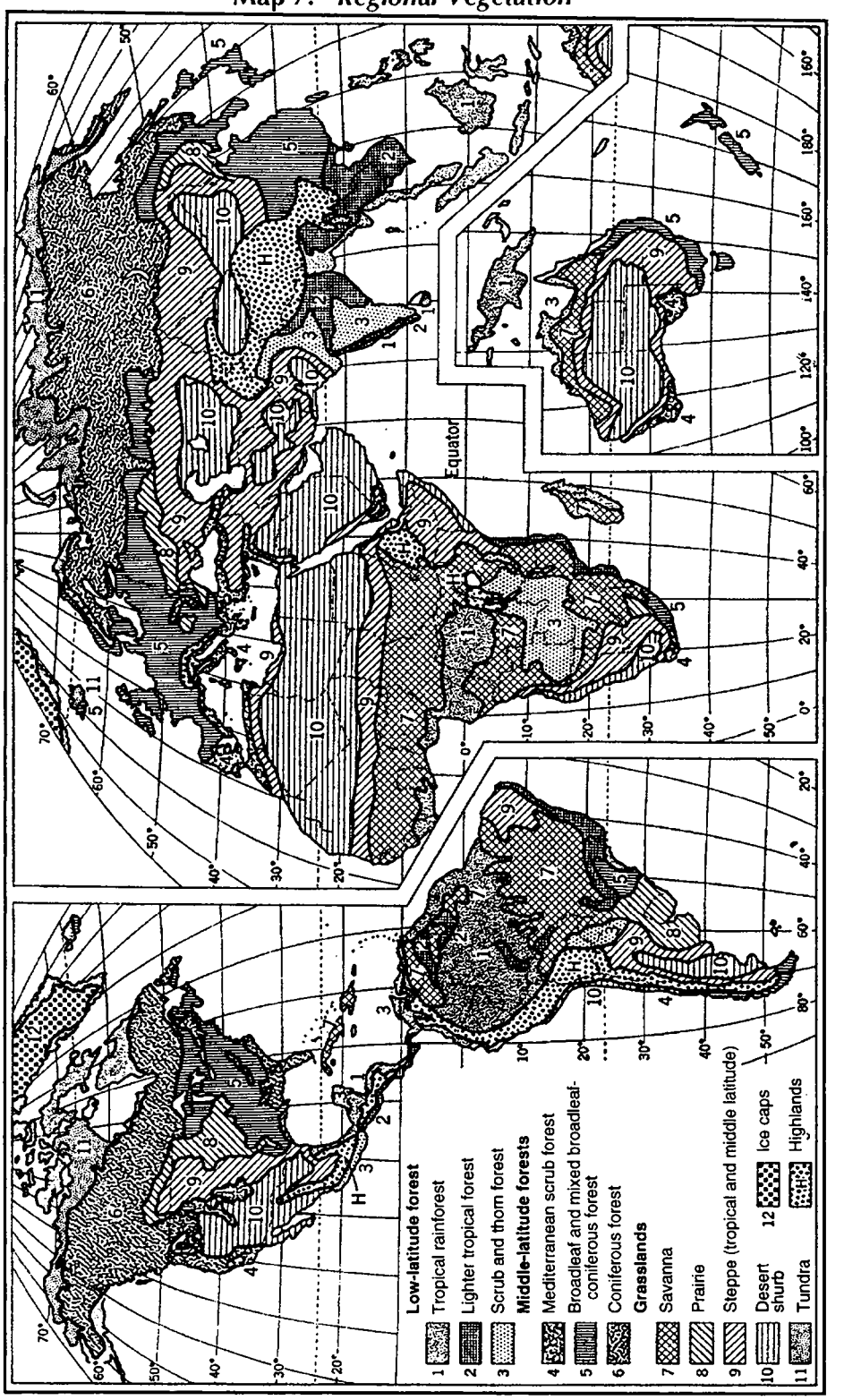
Arctic and Antarctic barrens girdle the globe around the North and South Poles, but the Earth is covered thickly or sparsely with some sort of vegetation in most other places (map 7).[25] Several distinctive belts, one below the other from high to low latitudes, are observable in the Northern Hemisphere where huge land masses predominate.

Tundra, a bleak zone that begins where perpetual ice caps terminate, supports a mat of mosses, lichens, summer flowers, and a few grotesquely twisted dwarf trees that hug the ground. A great band of evergreens, commonly called the "taiga," replaces tundra somewhat farther south in response to a longer growing season. Spruce, pine, hemlock, and fir forests intermingled with deciduous birch, alders, larch, and willow trees sweep across subarctic Alaska, Canada, European Russia, and Siberia. Moss-covered swamps cover level, poorly drained lands.

Broadleaf woodlands, once typified by Sherwood Forest in England, Germany's *Schwartzwald* (Black Forest), and the northern United States east of the Mississippi River, replace the taiga in middle latitudes (some say a squirrel could cross the State of Pennsylvania in colonial times without touching ground). Cultivated fields and pastures, however, have long since supplanted primeval stands of oak, ash, maple, hickory, elm, walnut, and beech trees. Natural grasslands originally covered much of mid-western Canada and the United States as well as Eurasian steppes from Ukraine to the Orient, where the climate is too dry for trees. A good deal of that land also is agricultural today.

Mediterranean borders, southern California, central Chile, and South Africa's Cape Province furnish conditions conducive to squat cork oaks, olive trees, vineyards, and scrubs that prefer cool, wet winters and long summer droughts. Prickly, leathery-leaved plants such as cacti, mesquite, creosote bushes, and chaparral favor deserts and their fringes that are more or less centered along the Tropics of Cancer and Capricorn. Neither of those discontinuous strips dips closer to the Equator than 15 degrees or much farther away than 40, but individual deserts very considerably. The 3.5-million-square-mile Sahara (6.3 million square kilometers) occupies almost as much space as all 50 United States, and the Great Australian Desert constitutes almost half of its parent continent, whereas the Lut Desert in

Map 7. *Regional Vegetation*



Source: U.S. Dept. Agriculture Yearbook, 1941, "Climate and Man." Aitoff's equal-area projection adapted by V.C. Finch.

Iran, at 155,000 square miles (401,000 square kilometers), is relatively small. Some stretches of sand and bare stone are devoid of vegetation, although even the driest soils by and large support some struggling plant life.

Tropical forests ring the world at its midriff, most notably in the Amazon Basin, West-Central Africa, parts of India, Southeast Asia, Indonesia, and nearby Pacific Islands where abundant rainfall and an endless growing season encourage exuberant vegetation. Jungle giants that include teak, mahogany, and ebony trees commonly form double, triple, even quadruple canopies that exclude sunshine from forest floors. Undergrowth, contrary to popular misconception, is dense only where light filters through. Mangrove thickets that straddle the Equator flourish best along salt water coasts, but those botanical flying buttresses take root as far upstream as tidal influences are felt.

Vegetation varies with altitude as well as latitude. Each 1,000-foot ascent (305 meters) is roughly equivalent to a trip 300 miles (480 kilometers) north or south of the Equator. Sage brush and short grass, for example, greet back-packers at the eastern base of the Colorado Rockies a mile above sea level. Routes to the top enter woods with widely-spaced ponderosa pines, then thick stands of Douglas fir before they reach the timber line at about 11,500 feet (3,500 meters). Landscapes thereafter consist of alpine pastures, then a crust of lichens well below wind-swept peaks where the environment is too hostile for the hardiest plants.

OPERATIONAL IMPORTANCE

Each type of vegetation significantly influences military operations in unique ways. Varieties that are offensively advantageous almost always frustrate defense and vice versa, as the following vignettes indicate.

Forests. Fairy tales fantasize about ogres who wait for unwary travelers in gloomy forests. Legitimate terrors confront warriors in dark woods, where armed forces battle like blindfolded boxers who cannot see their opponents, small-unit actions by foot troops predominate, control is uncertain, and fluid maneuvers are infeasible. State-of-the-art technologies confer few advantages regardless of the day and age:

- Vehicles of any kind are virtually useless, except on beaten paths.
- Tree trunks deflect flat-trajectory projectiles.
- Nuclear blasts that topple timber could create impassable abatis that benefit nobody.
- Tanks can bulldoze small trees, but the vegetative pileups impede or stop progress.
- The lethal radius of conventional bombs and artillery shells is much less than in open terrain, although the "bonus" effect of flying wood splinters can be considerable.
- Hand grenades bounce aimlessly unless rolled at short ranges that sometimes endanger the senders.
- Napalm burns out rapidly in moist greenery; flares illuminate very little; and dense foliage deadens radio communications.

Winners and losers are hard to predict when combat takes place in forests. Publius Quintilius Varus lost three well-armed, well-trained Roman legions when beset by teutonic barbarians near what now is Münster during the battle of Teutoburgerwald in 9 A.D. He and his senior henchmen committed suicide to avoid capture after that defeat, while survivors were crucified, buried alive, or sacrificed to pagan gods. Caesar Augustus shaped the political

outline of Europe in many respects when, as a result, he abandoned plans to colonize lands that have become Germany.[26] Forest campaigns ever since have often been costly to belligerents on both sides. Wilderness (U.S. Civil War, May 1864), Belleau Wood and Argonne Forest (World War I), Guadalcanal, Burma, and New Guinea (World War II), Vietnam, and Laos typify a few among many unhappy experiences that involved the United States.

Scantily Clad Landscapes. Brush, high grass, tall crops typified by sorghum and corn (maize), orchards, and widely spaced plantation trees do little to limit aerial or spaceborne sensors and weapon systems. Such vegetation hinders vehicular movement very little, but it slows foot soldiers, reduces their visibility, and restricts fields of fire for land-based line-of-sight weapons. Wire-guided missiles that require clear ground between gunners and targets are useless in thickets and other entanglements. Dense herbage deflects thermal radiation caused by nuclear blasts, yet amplifies the persistence of chemical warfare agents. Immense steppes sparingly carpeted with short grass and deserts devoid of vegetation afford little cover or concealment for armed forces or military installations, but favor long-range observation and clear fields of fire. Air superiority and technological prowess count a lot under those conditions, as Iraq's President Saddam Hussein discovered during Operation *Desert Storm* (1991), which took place on the geographic equivalent of a sand-colored pool table. His army, which was tactically and technologically deficient, lacked an air umbrella. Allied forces, aided by satellite intelligence, thus were able to bombard and maneuver at will while Iraqi formations risked destruction whether they moved or stayed still. One U.S. Marine Corps pilot quipped, "It was like being in the Super Bowl, but the other team didn't show up."[27]

MILITARY MODIFICATIONS

Military men have long sought to modify vegetative cover whenever it interferes with observation, fire lanes, cross-country trafficability, or affords adversaries convenient ambush sites. Roman legionaires in hostile territory often stripped brush and trees a bow-shot distance on both sides of dangerous roads. Clearing processes eliminate offensive verdure, while grubbing removes roots and stumps. Techniques employed depend on the type and thickness of vegetation, the acreage involved, perceived urgency, troops on hand, and available implements that range from heavy engineer equipment to hand tools.

Land Clearing. Bulldozers, which are used for most large-scale land clearing operations, can upend small trees and stumps up to 6 inches in diameter (15 centimeters), tree dozers (commonly called "Rome plows") shear off somewhat larger trunks at ground level, leaving chain saws to fell timber of almost unlimited diameters and cut forest giants into manageable segments. Tractor-mounted units pull stumps; rippers reduce root systems; and graders windrow debris for disposal. Carefully controlled brush fires sometimes assist. Explosives occasionally may prove indispensable, but it takes additional time and energy to fill resultant craters.[28]

U.S. Army engineers in Vietnam used 30 bulldozers and Rome plows per team to remove dense vegetation around base camp perimeters, enemy infiltration routes, and potential ambush sites. Each team could create a helicopter landing zone in a matter of minutes or clear 150 to 250 forested acres a day on reasonably level terrain, although rough ground and thick secondary growth reduced output by half. Amphibious tree crushers, which weighed

in at 97 tons, could churn through bogs and hack out wide swaths on dry land at a steady 3 miles (4 kilometers) an hour, but welders and radiator repairmen had to work round-the-clock on all vehicles to patch up punctured cooling systems and replace hydraulic lines that heavy brush ripped off.[29]

Defoliation. The U.S. Air Force, with permission from the Republic of Vietnam, began to spray chemical defoliants over the Cau Mau Peninsula in the Mekong Delta during 1962. That practice spread to the Rung Sat Special Zone, a mangrove swamp along shipping channels into Saigon, then countrywide, including the southern half of the demilitarized zone. Herbicides thus deposited produced desired results, but accompanying ecological and health problems sparked controversies that remained unresolved decades after the last load was released.[30]

KEY POINTS

- High ground, level land, valleys, and depressions each influence armies and air forces in unique ways.
- The proficiency with which ground forces can negotiate steep terrain depends on professional skills, types of transportation, and loads.
- Rugged topography drastically reduces observation, the value of flat-trajectory weapons, and line-of-sight communication systems performance.
- Ground forces find dominant terrain advantageous despite the proliferation of high-technology sensors and weapon systems.
- Combat assaults across broad streams in hostile territory demand suitable sites, plus special tactics, techniques, equipment, and training.
- Surface materials strongly influence the lethality of nuclear as well as conventional explosives, cross-country movement by motor vehicles, and military construction capabilities.
- Dense vegetation benefits defensive operations, whereas sparsely covered, level terrain favors offensive maneuvers.
- Armed forces in the field must be able to tap, purify, store, and distribute water supplies in adequate quantities for assorted purposes even in arid climes.

NOTES

1. Norman A. E. Hinds, *Geomorphology: The Evolution of the Landscape* (New York: Prentice-Hall, 1943); Arthur N. Strahler, *Physical Geography*, 2d ed. (New York: John Wiley and Sons, 1963), part 4, Land Forms.

2. R. Ernest and Trevor N. Dupuy, *The Harper Encyclopedia of Military History: From 3,500 B.C. to the Present*, 4th ed. (New York: Harper Collins, 1993), a monumental work of 1,654 pages.

3. Ibid., 1203; Earl F. Ziemke, *Stalingrad to Berlin: The German Defeat in the East*, Army Historical Series (Washington, DC: U.S. Army, Office of the Chief of Military History, 1968), chapter VII, "Operation *Zitadelle*."

4. Henry L. Shaw, Jr., et al., *Central Pacific Drive, History of Marine Corps Operations in World War II*, vol. 3 (Washington, DC: Historical Branch, U.S. Marine Corps, 1966) (see page 680 for pertinent pages); George W. Garand and Thurman R. Strobridge, vol. 4, *Western Pacific Operations*,1971 (see page 843 for pertinent pages); Roy E. Appleman et al., *Okinawa: The Last*

Battle, United States Army in World War II (Washington, DC: U.S. Army Center of Military History, 1984) (see page 515 for pertinent pages).

5. Earl F. Ziemke, "Yugoslavia 1941-1944," in *Challenge and Response in International Conflict*, eds. Doris M. Condit and Bert H. Cooper, Jr., et al., vol. 2 (Washington, DC: Center for Research in Social Systems, American University, March 1967), 321-351; *Antiguerrilla Operations in the Balkans (1941-1944)*, DA Pamphlet 20-243 (Washington, DC: Dept. of the Army, August 1954).

6. Dan Kurtzman, *Blood and Water: Sabotaging Hitler's Bomb* (New York: Henry Holt, 1997).

7. Alfred, Lord Tennyson, *The Charge of the Light Brigade*, 1854, Stanza 3. For elaboration, read Cecil Woodham-Smith, *The Reason Why* (New York: McGraw-Hill, 1954), especially 197-249.

8. Carl von Clausewitz addressed the military significance of river lines early in the 19th century. See *On War*, eds. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 433-446, 532-534.

9. Leon Bertin, *Larousse Encyclopedia of the Earth*, 2d ed. (New York: Prometheus Press, 1965), 68-91; Arthur N. Strahler, *Physical Geography*, chapter 23.

10. Edward G. Miller, *A Dark and Bloody Ground: The Hürtgen Forest and the Roer River Dams* (Texas Station, TX: Texas A&M Press, 1995); Martin Blumenson, "The Rangers at Hwachon Dam," *Army*, no. 3 (December 1967): 36-53. See also, "Look for Safer Crossing Places," *Army Digest* 25 (March 1970): 1.

11. For overviews, refer to Field Manual 90-13/Fleet Marine Force Manual 7-26: *River Crossing Operations* (Washington, DC: Dept. of the Army and Commandant, U.S. Marine Corps, September 30, 1992), especially chapters 2 and 7; FM 5-36: *Route Reconnaissance and Classification* (Washington, DC: Dept. of the Army, March 1988), 2-36 through 2-47; Charles Huie, "Soviet Army Bids for River Crossing Mobility," *Army* 18 (December 1968): 41-44

12. DA Pamphlet 20-290: *Terrain Factors in the Russian Campaign* (Washington, DC: Dept. of the Army, July 1951, 16-27.

13. FM 30-10: *Terrain Analysis* (Washington, DC: Dept. of the Army, March 27, 1972, 127-130 (superseded by FM 5-33, same title, July 1990, but contains more detailed information about water supplies).

14. Arthur P. Clark et al., ed., *ARAMCO and Its World: Arabia and the Middle East*, rev. ed. (Dhahran, Saudi Arabia: Saudi Arabian Oil Co.,1995), 166; Abdulaziz Al-Sweel, ed., *Saudi Arabia: A Kingdom* in Transition (Washington, DC: Saudi Arabian Cultural Ministry to the United States, 1995).

15. Mark Sullivan, specialist in Latin American Affairs, interview by author, Congressional Research Service, March 21, 1996, Washington, DC; correspondence from Plans Division, U.S. Marine Corps, March 29, 1996.

16. FM 5-484: *Navy Facilities Engineering Command Pamphlet P-1065*, and Air Force Manual 32-1072: *Multiservice Procedures for Well-Drilling Operations* (Washington, DC: Depts. of the Army, Navy, and Air Force, March 8, 1994).

17. Conversations with Army chemical warfare specialists in February 1996.

18. FM 30-10: *Terrain Analysis*, 82-83, 145; FM 5-33: *Terrain Analysis* (Washington, DC: Dept. of the Army, July 1990), 1-4 and 1-5.

19. Technical Manual 5-545: *Geology* (Washington, DC: Dept. of the Army, July 1971), chapter 2; Chester R. Longwell, Adolph Knopf, and Richard F. Flint, *Outlines of Physical Geology*, 2d ed. (New York: John Wiley and Sons, 1946), 24-42.

20. Daniel O. Graham, Jr., "Soils and Slopes," *Armor* (September-October 1977): 41-44; FM 30-10: *Terrain Analysis*, 80-82,142-147.

21. John Bagot Glubb, *The Story of the Arab Legion* (London, Hoddler and Stoughton, 1952), 106-109.

22. Samuel Glasstone, ed., *The Effects of Nuclear Weapons*, DA Pamphlet 39-3 (Washington, DC: Government Printing Office, February 1964), 267-27, 289-296, 300-301; FM 30-10: *Terrain Analysis*, 82-83.

23. Working papers, Combat Intelligence Center Vietnam (CICV), 1968; James A. Wilson, Jr., "The Fourth Dimension of Terrain," *Military Review* 26, no. 6 (September 1946): 52-53; Glenn R. Locke, "Dust," *U.S. Army Aviation Digest* (August 1970): 34-35.

24. *Laterite and Its Engineering Properties: A Geology/Soils Survey*, Combat Intelligence Center Vietnam, March 10, 1967, 1, 3, 5,7.

25. Peter Farb, *The Forest*, rev. ed. (New York: Time-Life Books, 1969), 57-80, and A. Starker Leopold, *In the Desert of the Earth* (New York: Harcourt, Brace, Janonovich, 1961), 9-15, 53-67.

26. J. F. C. Fuller, *A Military History of the Western World*, vol. 1 (New York: Funk and Wagnals, 1955), chapter 8.

27. Williamson Murray, *Gulf War Air Power Survey*, vol. 2, *Operations and Effects and Effectiveness* (Washington, DC: Government Printing Office, 1993); Frank N. Schubert and Theresa L. Kraus, eds., *The Whirlwind War* (Washington, DC: U.S. Army Center of Military History, 1995). The quotation is from "Stray Voltage," *Armed Forces Journal* (March 1991): 58.

28. FM 5-430-00.1/Air Force Joint Pamphlet 32-8013, vol. 1: *Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations—Road Design* (Washington, DC: Dept. of the Army and Dept. of the Air Force, August 26, 1994), chapter 4.

29. Robert R. Ploger, " 'Different' War—Same Old Ingenuity," *Army* 18, no. 9 (September 1968): 71-72; Joseph M. Kiernan, "Combat Engineers in the Iron Triangle," *Army* 17, no. 6 (June 1967): 42-45; Richard Duke, "Rooting Out Charlie," *Army Digest* (November 1967): 56; "Tree Eater Tested in Vietnam," *Army Digest* (December 1967): 14.

30. Arthur F. McConnell, Jr., "Mission: Ranch Hand," *Air University Review* 21, no. 2 (January-February 1970): 89-94; *Veterans and Agent Orange: Health Effects of Herbicides Used in Vietnam*, Institute of Medicine, National Academy of Science (Washington, DC: National Academy Press, 1994); "Agent Orange Linked to Diabetes," *Army Times*, May 19, 1997, 2.

4. OCEANS AND SEASHORES

Our planet has the wrong name. Our ancestors named it Earth, after the land they found all around them. . . . If the ancients had known what the earth is really like they undoubtedly would have named it Ocean after the tremendous areas of water that cover 70.8 percent of its surface.

Leonard Engel
The Sea

GENERAL GEORGE C. MARSHALL, SPEAKING AS CHIEF OF STAFF, U.S. ARMY IN 1943, REVEALED, "MY MILITARY education and experience in the First World War [was] based on roads, rivers, and railroads. During the past two years, however, I have been acquiring an education based on oceans and I've had to learn all over again."[1] That made him a member of a very large club whose membership has not diminished.

Oceanography emerged as a distinctive field of military study in 1855, when U.S. Navy Lieutenant Matthew F. Maury published the first treatise on that subject, *The Physical Geography of the Sea*.[2] Findings since then have affected every naval activity from ship design to employment practices above, below, and on open waters of the Atlantic, Pacific, Indian, Arctic, and Antarctic Oceans, as well as along their littorals.

SEA WATER ATTRIBUTES

Water is one of the few substances on Earth that exists in solid, vaporous, and fluid forms, although most remains liquid. Four basic attributes of sea water are militarily important: salinity, density, stratification from surface to sea bottom, and permeability to light and sound All four are interconnected.[3]

SALINITY

Sea water, best described as brine, is not uniformly salty. The proportion of sodium chloride and other chemicals in solution determines salinity which, as a rule, is highest in the Horse Latitudes, which straddle 30 degrees north and 30 degrees south where dry winds encourage evaporation; less in the Doldrums astride Earth's Equator, where rainfall is abundant; and least near both poles, where melting glaciers and pack ice provide a stream of fresh water. Large river systems like the Amazon, Congo, and Mississippi also dilute the salt contents far offshore. Air temperatures and terrestrial streams condition the salinity of relatively small

inland seas that directly or indirectly connect with oceans, as exemplified by the cool Baltic Sea (especially the Gulf of Bothnia near Finland), which is abnormally fresh, while the Red Sea in a torrid zone is exceptionally salty. Few major rivers feed the brackish Mediterranean, whereas the Danube, Dneister, Dneiper, and Don empty into the Black Sea.

DENSITY

High salinity increases the density (weight and mass) of sea water. So do water temperatures down to the freezing point, which approximates 28.5 °F (-2 °C). Surface temperatures, which average about 80 °F (26.7 °C) near the Equator, generally decrease 0.5 °F with every degree of latitude north or south, but many anomalies obtain. Thermometers dipped in the Persian Gulf, for example, commonly register as much as 85 °F (29 °C), somewhat warmer than open waters around Diego Garcia 2,000 miles to the south. Pressures, which also contribute to water density, increase about 2 pounds per square foot for every 100 feet (30 meters) of descent until the weight of waters above exerts an astonishing 15 tons per square inch in the abyss.

STRATIFICATION

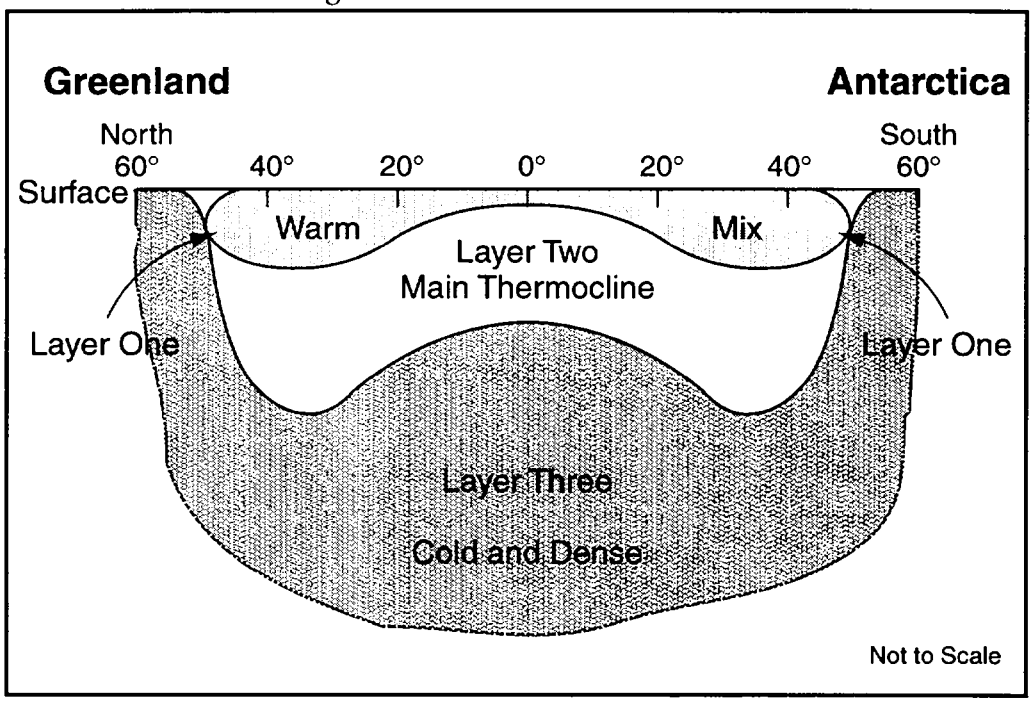
A much simplified representation of sea water reveals three remarkably different horizontal laminations between the ocean surface and the floor. Layer One, a watery mix well stirred by wind and waves, covers the top few hundred feet in temperate climes up to 50 degrees north and 50 degrees south latitude, although a thinner cover of warm, light water prevails in the tropics. Temperatures and salinity plummet in Layer Two, a thermocline where densities increase correspondingly until they stabilize at a depth of 5,000 to 6,000 feet (2,000 or so meters). The coldest, saltiest, and therefore the heaviest waters little influenced by seasonal change lie in Layer Three below, because the intervening thermocline acts as a barrier between top and bottom. A modified pattern exists near both poles, where cold water and low salinity dominate on the surface as well as the seabed and the absence of a permanent thermocline allows upwelling from ocean depths, as figure 7 indicates.

PERMEABILITY

Few electromagnetic emanations can penetrate sea water at great depths. Extremely low frequency (ELF) radios, the principal exception, take 15 minutes or more to transmit a three-letter message, which means that some other mode must be found to keep submarine crews abreast of football, baseball, and basketball scores. The limit of visible light is slightly more than 600 feet (200 meters) under ideal conditions, but plankton, organic debris, silt, and other suspended materials commonly reduce illumination to 50 feet (15 meters) or less along coastlines. Radar, infrared, and most radio signals rebound from the surface.

Sounds, in sharp contrast, may transmit thousands of miles under water, but directions and intensities depend on available power, geographic locations, seasonal variations, and time of day. Inorganic particles, schools of fish, gas bubbles, ship traffic, and offshore drilling scatter or absorb signals. Sounds that travel swiftly along any given duct may bounce about when they try to cross boundaries between the three horizontal sea water layers or penetrate upwelling water columns and may bend or refract as much as 15 degrees toward more favorable channels. Shadow zones that exclude sounds and convergence zones where amplifications occur further complicate sound propagation.[4]

Figure 7. *Sea Water Stratification*



SEA SURFACE BEHAVIOR

The uppermost layer of sea water is eternally dynamic in response to Earth's rotation, the pull of sun and moon, winds, water densities, temperatures, seismic activities, and geomagnetic influences. Currents, tides, waves, swell, and sea ice are manifestations of intense interest to military mariners and civilian policymakers who plan, prepare for, conduct, or depend upon naval operations.[5]

CURRENTS

Ocean currents, unlike waves and tides, transfer sea water long distances in endless redistribution cycles. Together with prevailing winds, they carried Christopher Columbus and his flagship the *Santa Maria* across the Atlantic from Europe to the New World in 1492 and took Thor Heyerdahl and the *Kon-Tiki* on a grand ride from Peru to the South Pacific archipelago of Tuamotu in 1947. Most naval operations have taken place in the Northern Hemisphere since Greece defeated a Persian fleet at Salamis during the Pelopponesian War in 480 B.C,[6] but currents south of the Equator may become militarily important when least expected.

Temperature differentials set up primary circulation patterns with light, warm waters near the surface floating poleward in the Northern and Southern Hemispheres, while cold, salty waters head toward the Equator through the abyss. The direction of movement, or "set," is the course currents steer, whereas current velocities constitute "drift." Prevailing winds, which push surface water before them, start to shape a circular pattern. Earth's rotation deflects currents clockwise north of the Equator and counterclockwise to the south, with three prominent exceptions: Equatorial currents set almost due west; an underlying countercurrent

sets in the opposite direction; and the Antarctic Circumpolar Current takes an easterly course around the globe unobstructed by any large land masses (map 8).

Relatively fast, narrow currents parallel the western rim of the Atlantic, Pacific, and Indian Oceans, whereas counterparts off east coasts are comparatively wide, shallow, and slow. The Gulf Stream, which is 50 miles wide (80 kilometers) and 1,500 feet deep (457 meters) near Miami, FL, drifts northward at 3 to 4 nautical miles an hour. The North Atlantic Drift, a prolongation of the Gulf Stream, spreads abnormally warm water north of the Arctic Circle past Spitzbergen and the ice-free Russian port of Murmansk until it touches Novaya Zemlya in much diluted form. Solid coastlines prevent any drift on such a scale in the North Pacific, but the cold Kamchatka Current, like the Labrador and Greenland Currents which also originate in polar regions, creates billowing fog banks on its way south when it collides with warm water headed north.

TIDES

Tides rock the oceans daily, about 12.5 hours apart, in response to gravitational tugs primarily by the moon. Spring tides about 20 percent greater than average arise twice a month when the sun reinforces lunar pull at the time of new and full moons and the Earth, moon, and sun are directly in line. Neap tides about 20 percent below average occur when the sun offsets the moon's pull at the time of lunar first and third quarters and the sun and moon are at right angles (figure 8).

Elaborate tables forecast daily tides for principal ports, beaches, and many lesser locales. Calculations are complex, because high and low waters everywhere arrive about 50 minutes later each day, while high and low water readings persist longer than rise and fall. Successive tides for specific spots north and south of the Equator are unequal, although alternate levels are identical. That phenomenon, oddly enough, disappears twice a month when the moon passes over the Equator. Tides register 15 to 20 percent higher than normal once a month when lunar orbits bring the moon closest to Earth (at perigee) and about 20 percent below normal once a month when the moon is farthest away (at apogee). Extreme heights occur when perigee and spring tides coincide. Tidal ranges also differ from place to place. The rise and fall of a foot or less is common along some straight line or sheltered coasts, but 50 feet (15 meters) have been recorded in New Brunswick's Bay of Fundy, a funnel-shaped basin that confines incoming slosh and rockets a 4-foot wall of water up narrow inlets at 10 to 15 miles an hour (16 to 24 kilometers per hour).

WAVES

Waves, unlike currents and tides, are whipped up entirely by winds. When winds abate, long, low, parallel waves called swell continue indefinitely, but transfer very little water from one place to another (figure 9 shows a bobbing cork that ascends each approaching wave, then slides down the reverse slope without moving far from its point of origin.) The vertical distance between the crest and trough determines wave height, the distance between successive peaks or depressions determines wave length, the speed at which each wave advances determines its velocity expressed in feet per second or nautical miles per hour, and the time it takes one crest to succeed another determines the wave period. Wave trains occasionally appear as parallel crests and troughs, but those driven by stiff breezes often

Map 8. *Ocean Currents*

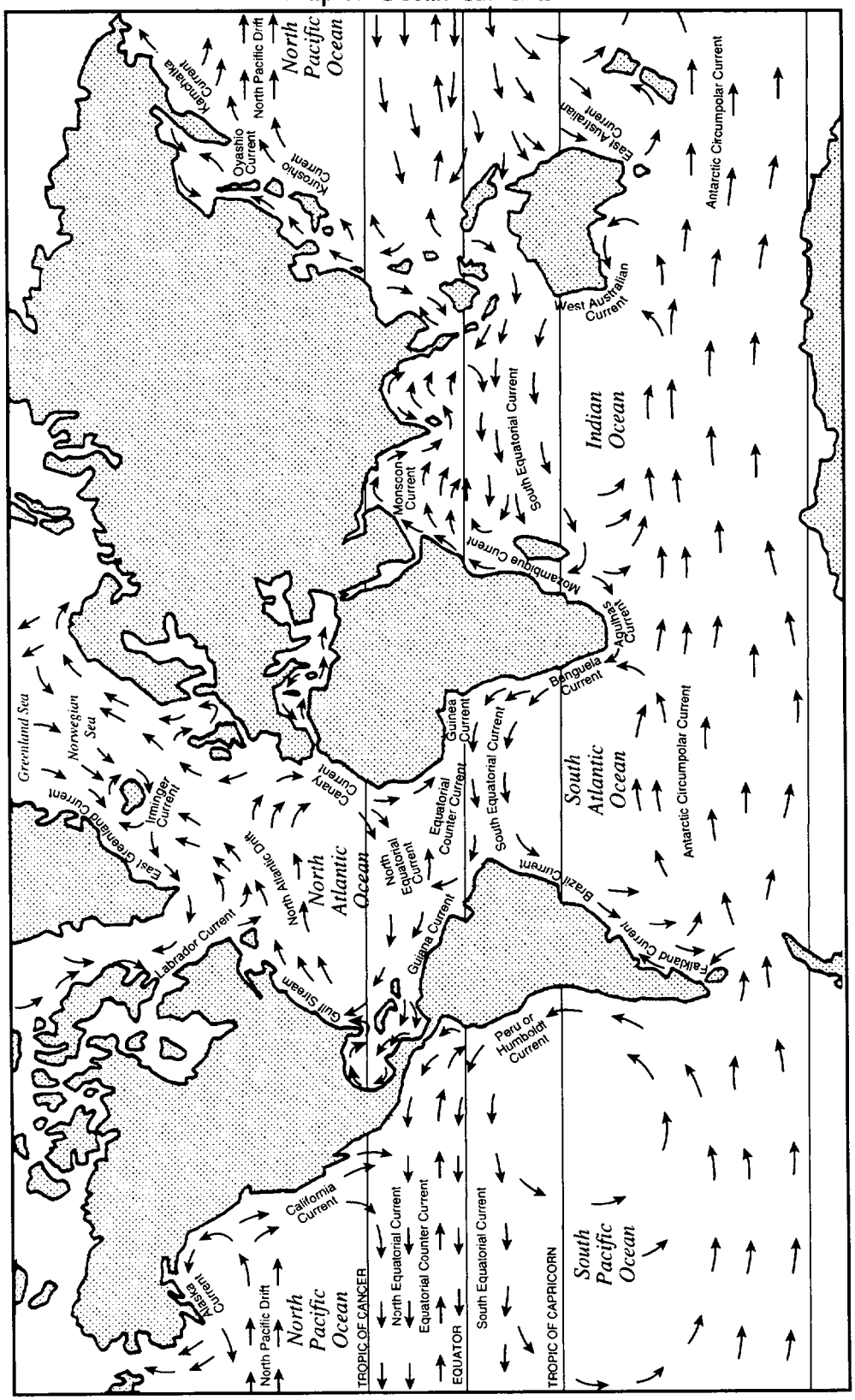
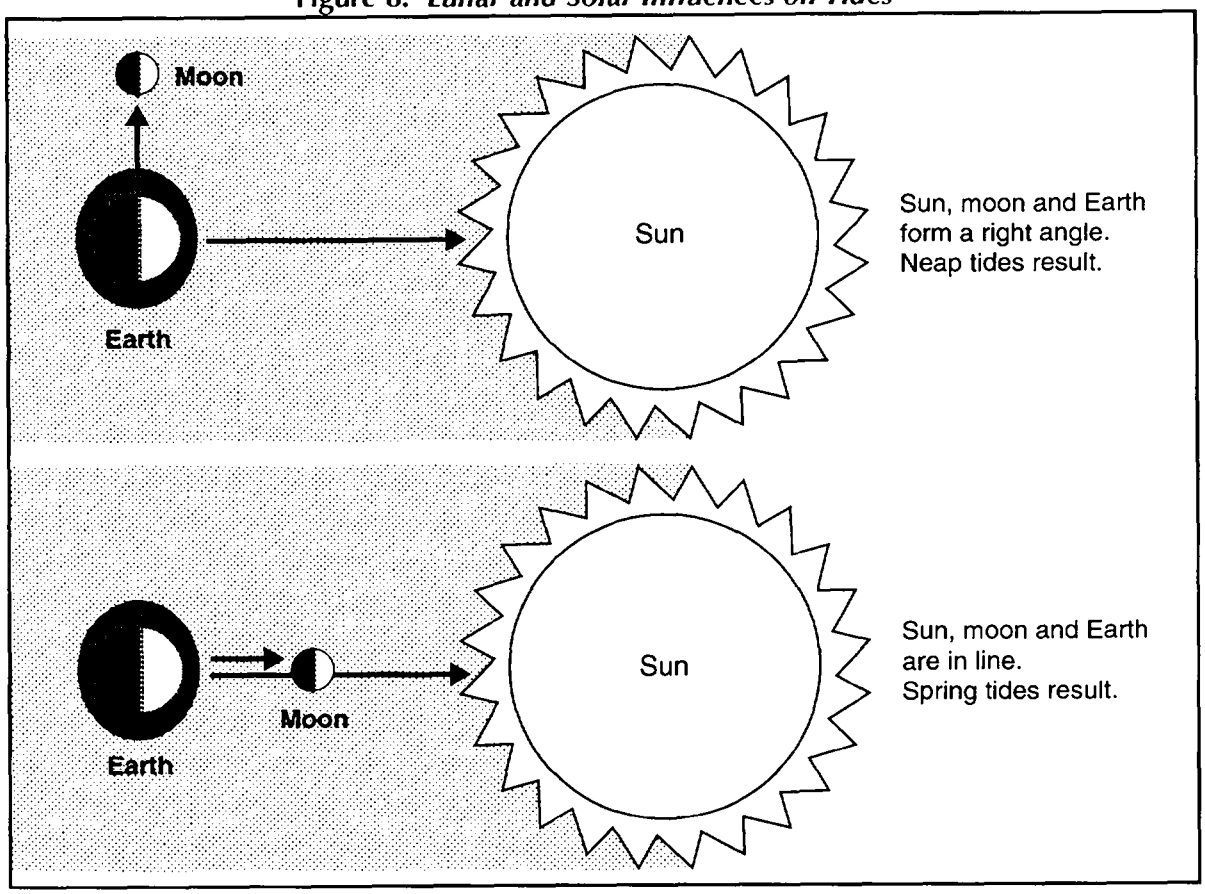


Figure 8. *Lunar and Solar Influences on Tides*



Adapted from Leonard Engel, *The Sea.*

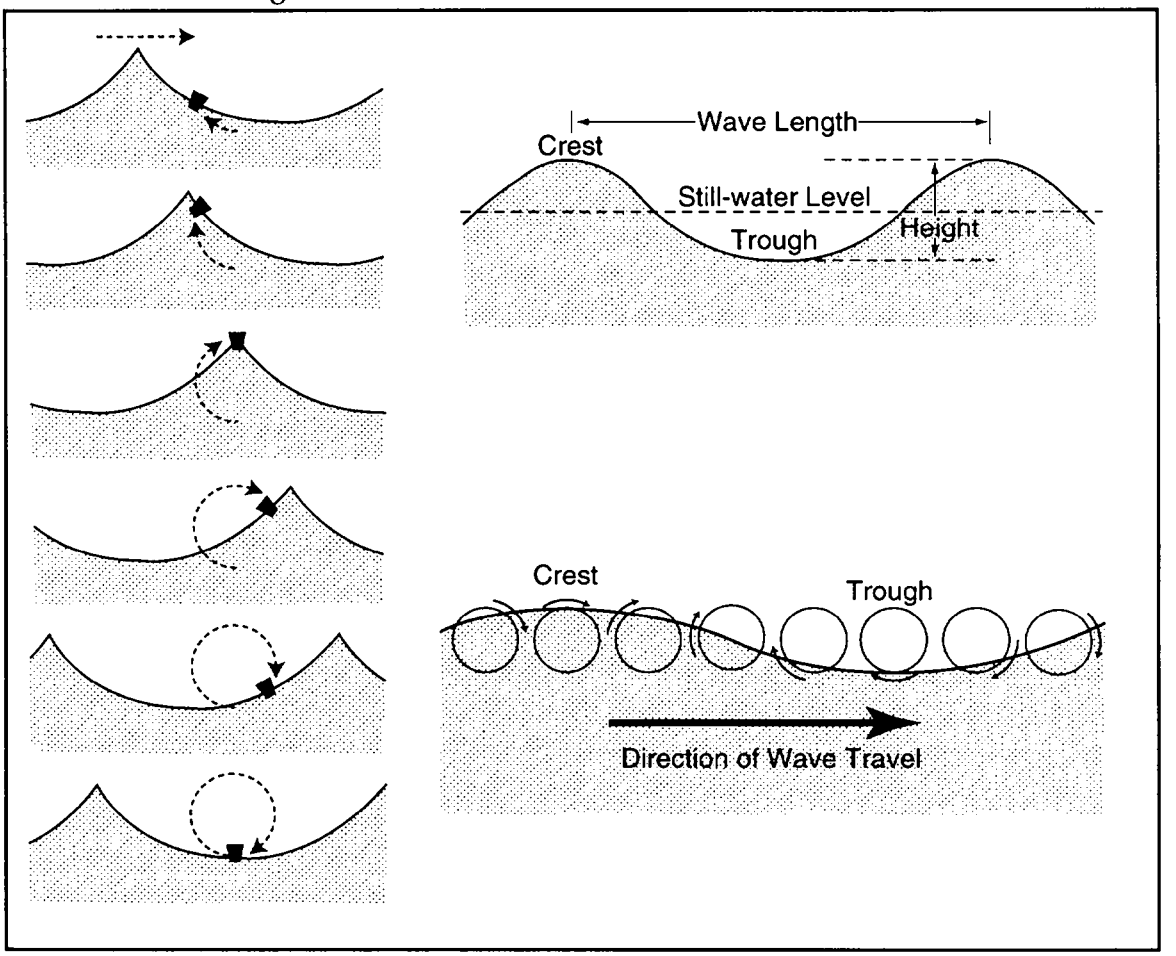
overtake, pass, or overwhelm each other to form a choppy sea checkered with foam (table 4 connects wind velocities with sea states). Waves grow largest in deep water when lashed by strong steady winds over long distances—a "fetch" of 500 to 1,000 miles (800 to 1,600 kilometers) or more. Those generated in large bays never exceed a few feet no matter how hard the wind blows, whereas hurricanes and typhoons over open oceans develop superwaves that routinely top 50 feet (15 meters). A watch officer on the U.S. Navy tanker *Ramapo* en route from Manila to San Diego on February 7, 1933, reportedly saw a great sea rising astern "at a level above the mainmast crow's nest," and calculated its height at a record 112 feet (34 meters).[7]

Ocean waves and swell begin to slow when they reach shallow water that is about half as deep as the distance between crests (figure 10). Bottom drag then reduces spacing between waves, which rapidly increase in height and steepness until crests roll forward as breakers that pound cliffs or wash sheets of brine over flat shores where some seeps in while the rest pours back. Longshore currents slip sideways when waves strike coasts at sharp angles.

ICEBERGS AND FLOES

Icebergs can cripple or sink surface ships and submarines whose skippers are unwary, as passengers and crew of the *Titanic* discovered on a clear, calm night in April 1912, when that "unsinkable" luxury liner took a one-way trip to Davy Jones' locker. Glacial tongues of

Figure 9. *Ocean Wave Motions and Measurements*



Adapted from Leonard Engel, *The Sea.*

Figure 10. *Conditions Conducive to Surf*

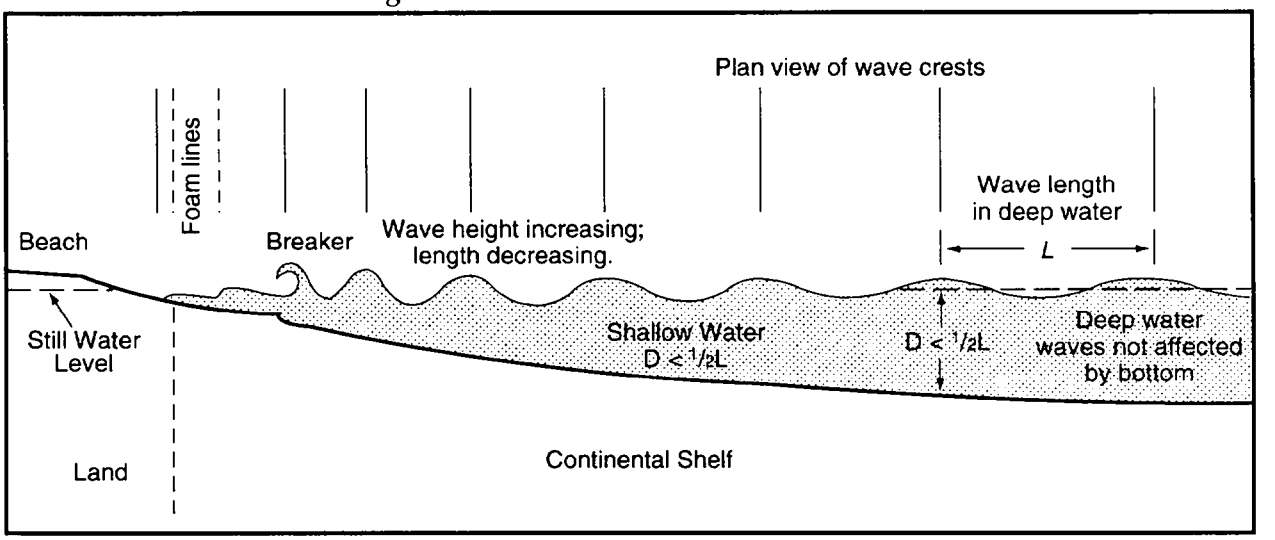


Table 4. ***Beaufort Wind Scale Related to Sea States***

Beaufort Number	*Wind Type*	*Wind Speed (knots)*	*Sea Surface*	*Wave Height (feet)*	*Sea State*
0	Calm	<1	Mirrorlike	0	1
1	Light Airs	1-3	Ripples	<1	1
2	Light Breeze	4-6	Wavelets	1-2	1
3	Gentle Breeze	7-10	Scattered Whitecaps	2-3	2
4	Moderate Breeze	11-16	Many Whitecaps	4.5	3
5	Fresh Breeze	17-21	Moderate Waves	6	4
6	Strong Breeze	22-27	Large Waves Develop	12	5
7	Moderate Gale	28-33	White Foam Begins	16	6
8	Fresh Gale	34-40	Foam Streaks	24	6
9	Strong Gale	41-47	Seas Roll	30	6
10	Whole Gale	48-55	Heavy Seas, Hanging Crests	40	7
11	Storm	56-64	Medium Ships Lost Behind Huge Waves	50	8
12	Hurricane	>64	Great Danger	>50	8

Greenland's gigantic ice cap are the source of most icebergs in the North Atlantic. Huge blocks with sharp peaks and jagged bellies break off in springtime, a process called "calving," then drift southward with ocean currents. Icebergs float, because ice is less dense than sea water, but about nine-tenths of their mass are concealed. Many tower 250 feet (76 meters) or more above the surface and spread a quarter of a mile (400 meters) or so below. *Titanic's* catastrophe occurred at 41° 46′ North Latitude, on a line with Madrid, Spain, although most icebergs in the Atlantic melt before they float that far south. Fewer bergs appear in the North Pacific, because "breeding" grounds are restricted, but those that break off the Antarctic ice shelf are immense, numerous, and drift farther toward the Equator than those from Greenland. Associated hazards, however, are less owing to lighter seagoing traffic.

Pack ice, which perennially covers most of the Arctic Ocean, produces flat-topped, steep-sided, tabular floes of which all proceed independently before dominant winds with narrow

strips of water known as "leads" in between. Some such floes are sufficiently large and smooth enough to accommodate medium-range cargo aircraft equipped with skis while others, buckled together by vagrant winds, feature rough surfaces that impede foot travel. Truckers at Thule Air Base, Greenland regularly drive across North Star Bay from late autumn until late spring on sea ice, which freezes 5 to 10 feet thick (2 to 3 meters) and thaws annually on the fringe of the permanent ice pack. Most floes that separate from Antarctic ice shelves in summer are much larger than any counterparts in the Northern Hemisphere; many are miles wide and 2,000 feet (600 meters) or so thick, with spectacular cliffs that tower 200 to 300 feet (60 to 90 meters) above the water.

MARINE TOPOGRAPHY

Marine topography above and below any ocean includes continental shelves, continental slopes, islands, and the abyss. Amphibious forces are essentially concerned with littorals, especially beaches, their seaward approaches, and straits, whereas "blue water" sailors factor in mountain ranges, troughs, and plains concealed under the seas.[8]

BEACHES AND APPROACHES

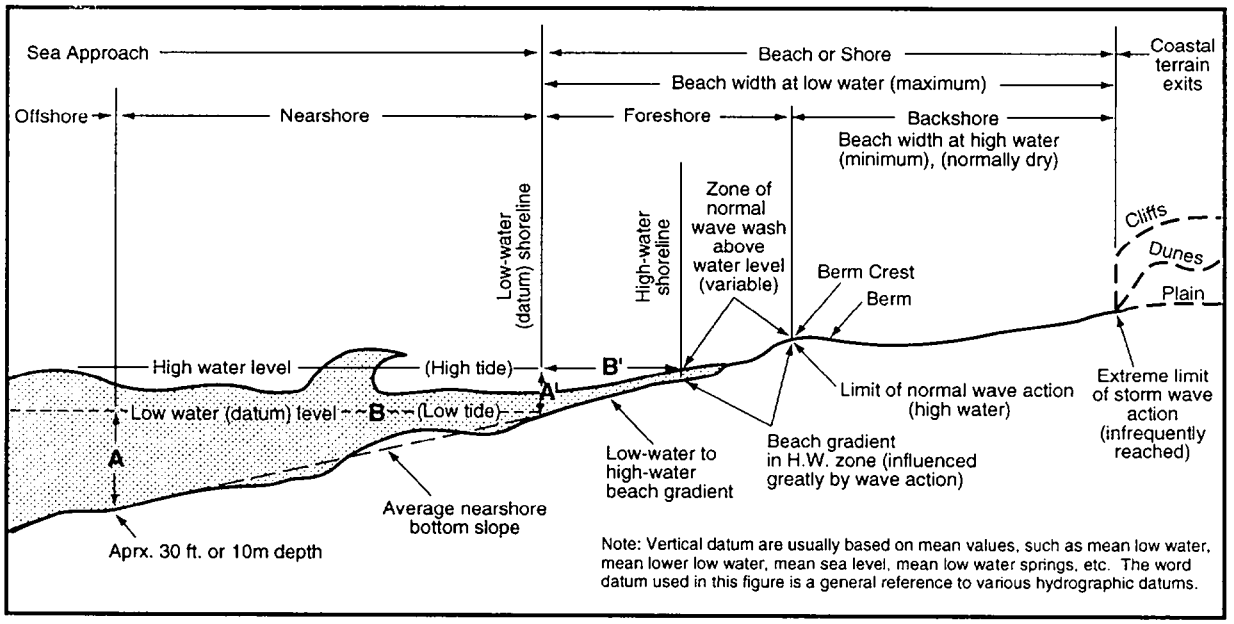
Beaches, which start at the shoreline and extend inland to the first marked change in topography, come in all sizes, shapes, colors, and descriptions. Those found along low-lying coasts generally are wide, long, and continuous, while others are interrupted by headlands, are confined to tiny strips by towering cliffs, or are displaced completely where mountains meet the sea. Vacationers prefer broad expanses of soft, white sand, but beaches are black on infamous Iwo Jima and some places along the Kona coast of Hawaii. Narrow strands at Nice, France, and other ritzy resorts on the Côte d'Azur are strewn with pebbles, cobblestones, and boulders. Mud deposits are by no means unusual.

Militarily useful beach studies address offshore conditions and exits inland, with particular attention to water depths, bottom gradients, obstructions, tides, currents, surf, and dominant terrain ashore (figure 11). Lengths must be adequate for amphibious forces of appropriate size, normally a battalion landing team, although tactical situations may demand larger or smaller formations. Task force commanders regularly subdivide very long beaches into segments code-named, for example, Red, White, and Blue, even Red 1, Red 2, Red 3 if necessary. Widths should afford ample room for essential command/control and logistical shore parties on dry ground above the high water mark. Beyond that, beaches ideally display the following characteristics:

- Water offshore is deep enough for transport ships to operate as near the beach as tactical situations prudently allow.
- Final approaches are free of sandbars, banks, shoals, reefs, offshore islands, rocky outcroppings, and other obstacles..
- Channel configurations discourage mining.
- Beach gradients allow amphibious landing ships and craft to discharge troops and loads on dry ground near the high water mark.
- The sea bottom and beach both are firm enough to support wheeled and tracked vehicles where dry landings are infeasible.

- Adequate landing zones are available ashore for helicopters.
- Defenders lack dominating terrain that overlooks landing beaches.
- Multiple exits of ample capacity lead from the beach to initial military objectives inland.

Figure 11. ***A Typical Beach Profile***



Seaward approaches generally are gentle wherever shores are sandy and flat, whereas rocky coastlines tend to drop off more sharply. Beaches backed by high ground almost always abut deep water, but those at the base of cliffs habitually are littered with boulders visible only at low tide, if at all. Trucks fight for traction in dry, shifting sands on level shores; pebble and cobblestone beaches bear heavy loads, but roll so freely that tanks and other tracked vehicles slide; mud beaches often seem bottomless. Damp sand, in contrast, provides the best surface for amphibious operations. Dunes formed from fine to medium-sized wind-blown sand rarely rise more than 20 to 100 feet (5 to 30 meters) above high water, although some measure three times that high. Those that are even partly covered with vegetation are relatively firm and therefore trafficable. So are low ridges that storms create when they wash debris and driftwood ashore. Broad coastal plains behind beaches afford ample maneuver room and alternative avenues inland, provided the footing is solid, but boundaries that troops on the ground can easily find are hard to draw. Featureless terrain also affords few prominent registration points for artillery or naval gunfire, and flanks remain open. Rough topography alleviates some of those problems, but may restrict access to the hinterland.[9]

On-the-spot reconnaissance, which calls for clandestine infiltration and exfiltration capabilities along with a lengthy list of specialized skills,[10] is performed whenever possible to ascertain precise characteristics of beaches, approaches, and exits before amphibious commanders approve landing plans. Superbly trained Sea-Air-Land (SEAL) teams equipped

with state-of-the-art technologies most often implement such missions for the U.S. Department of Defense. Enemy armed forces are not their only adversaries—dense sea weed, sharks, barracudas, venomous sea snakes, and various fish with poisonous spines await the unwary under water.[11]

STRAITS AND OTHER NAVAL NARROWS

Control over key straits and other natural or manmade narrows has been a basic military objective since naval warfare came into vogue well over two millennia ago, because unfriendly armed forces on one or both sides of any naval choke point may try to deny free passage to opponents.[12] Several such bottlenecks have made bold headlines in the 20th century (map 9). The Panama and Suez Canals, Gibraltar, the Red Sea's southern gate at Bab-el-Mandeb, the strait that separates Taiwan from mainland China, and the Strait of Hormuz astride sea lines of communication (SLOCs) to and from Persian Gulf oil producers are among those that have been (or still are) bones of contention.

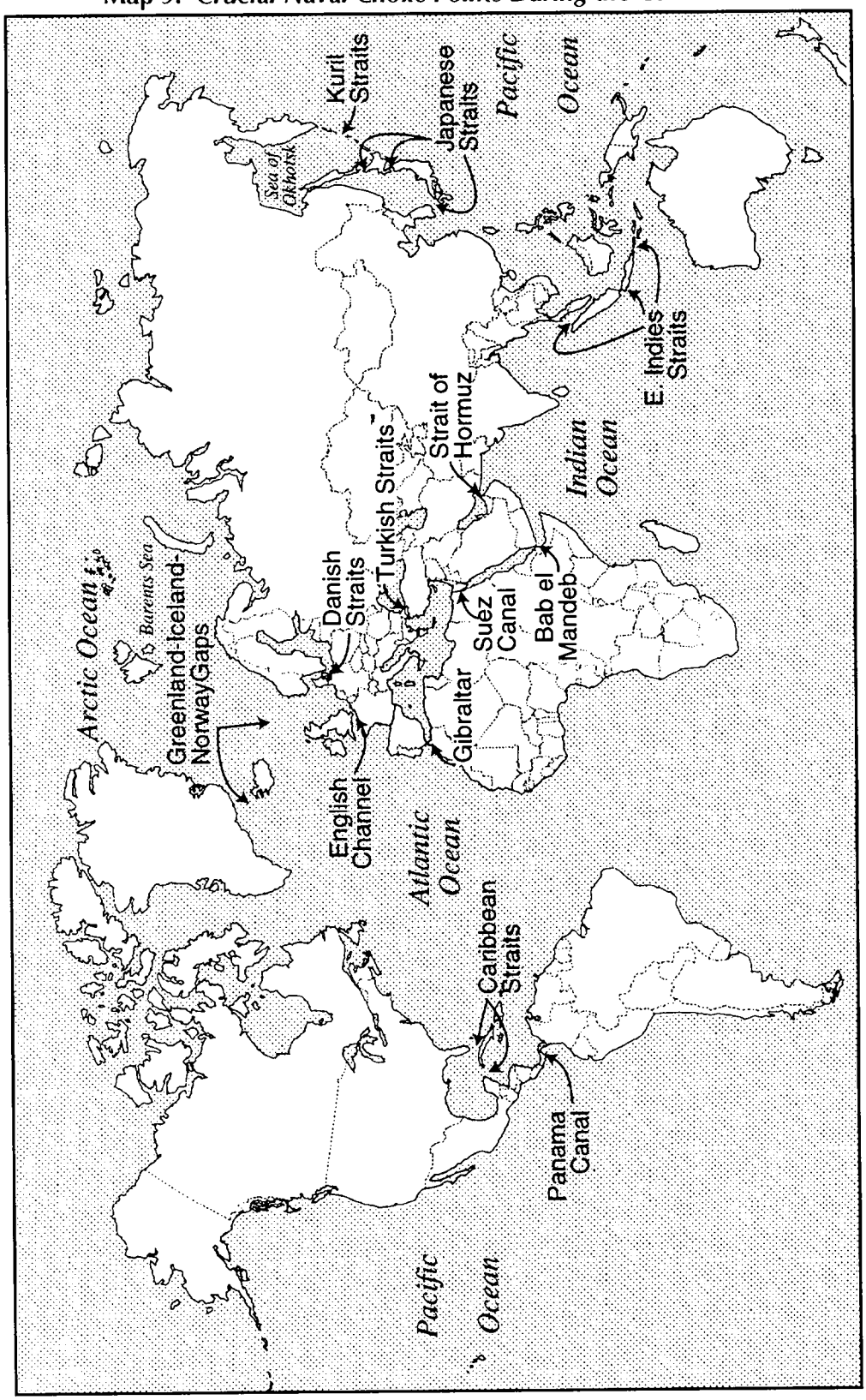
The British Commonwealth expended 250,000 men in unsuccessful attempts to wrest the Dardanelles from the Ottoman Empire during World War I; Turkish casualties were comparable.[13] Chechen separatists seized a ferry in the Black Sea eighty years later and threatened to blow it up in the Bosporus if Russian President Boris Yeltsin refused to lift a siege in their homeland.[14] Inspiration for that audacious act may have come from former Egyptian President Gamal Abdel Nasser, who ordered subordinates to load ships with cement, then sink them in the Suez Canal during the 1967 Arab-Israeli war. Results from his standpoint were rewarding: the main channel remained closed until 1975.[15]

Choke points identified on map 9 helped shape U.S. and Soviet military strategy throughout the Cold War. Hunts for lone *Red Octobers*[16] were commonplace until the Soviet Union armed its strategic nuclear submarines with long-range ballistic missiles that could attack targets from sanctuaries close to Russian coasts. Those in the Northern Fleet took cover in the Barents Sea beyond the Greenland-Iceland-Norway (G-I-N) Gaps. Counterparts with the Soviet Pacific Fleet hid in the Okhotsk bastion. Advantages, however, were by no means one sided. Soviet attack submarines and surface ships could not reach the Atlantic Ocean en masse without a fight, because NATO navies and shore-based aircraft blocked the G-I-N Gaps. Soviet Baltic and Black Sea Fleets were respectively bottled up by the Danish and Turkish Straits, which remained in NATO's hands. Occupants of the Kremlin consistently sought (but never were able) to neutralize Japan, use adjacent straits to reach open water, and close them to the U.S. Navy, which would have frustrated emergency efforts to reinforce and resupply U.N. forces in the Republic of Korea.[17]

CONTINENTAL SHELVES AND SLOPES

Continental shelves lie between low tide and depths of 500 to 600 feet (85 to 100 fathoms). They include shallow embayments and inland seas such as the Gulf of Mexico, Hudson Bay, the Yellow Sea, Black Sea, and the Baltic. Regions rich in food fish, oil, and mineral deposits stimulate intense economic competition, often with military overtones, because some countries press extravagant territorial claims—up to 200 miles (325 kilometers)—that international conventions have not yet negated.

Map 9. *Crucial Naval Choke Points During the Cold War*



Shelf widths range from 800 miles (1,300 kilometers) under arctic ice north of Siberia to narrow (even nonexistent) strips where rough terrain crowds the coast or swift currents keep sheves from forming. Most shelves are undulating plains, but low spots and protuberances are common. The Aleutian Islands festoon across the North Pacific for 1,000 miles (1,600 kilometers), while the Indonesian Archipelago stretches more than twice that far. Fringing reefs, which are coral formations attached to shore, often form in tropical climes. Like barrier reefs farther out on the shelf, they are partly submerged, parallel to the coast, and frequently block easy access from high seas to the beach, even for flat-bottomed boats. Continental slopes 10 to 20 miles wide (16-32 kilometers) begin where shelves leave off, then plunge at sharp angles until they reach the bottom which is miles below sea level in some locales. The most spectacular dropoff on Earth is located along the coast of Chile, where more than 8 vertical miles (13 kilometers) separate the Andean peak of Cerro Aconcaqua from the deepest spot in the Peru-Chile Trench fewer than 250 horizontal miles (400 kilometers) away. Undersea avalanches of stone and soupy silt occasionally race at express train speed down submerged gorges and canyons that characteristically cut into continental slopes.[18]

THE ABYSS AND ABOVE

Cold, dark abyssal plains covered with a thick carpet of sediments under tremendous pressure lie 15,000 to 20,000 feet (4,570-6,095 meters) below sea level. Not all of the ocean floor, however, is level. Challenger Deep, south of Guam, the most awesome of many trenches, could swallow Mount Everest without a trace. The world's longest mountain chain, known as the Mid-Ocean Ridge, winds through the Atlantic, Pacific, and Indian Oceans for 40,000 miles (64,375 kilometers) at elevations that average 5,000 to 6,000 feet (1,525-18,285 meters). Those eminances break the surface only in Iceland, but volcanic seamounts project above water in Hawaii, the Azores, and 10,000 other places large and small. Low-lying atolls that feature coral reefs around quiet lagoons are widely distributed in warm Pacific waters. Breaks in such reefs afford the only convenient avenues of arrival and departure when flats are exposed at low tide.

REPRESENTATIVE NAVAL RAMIFICATIONS

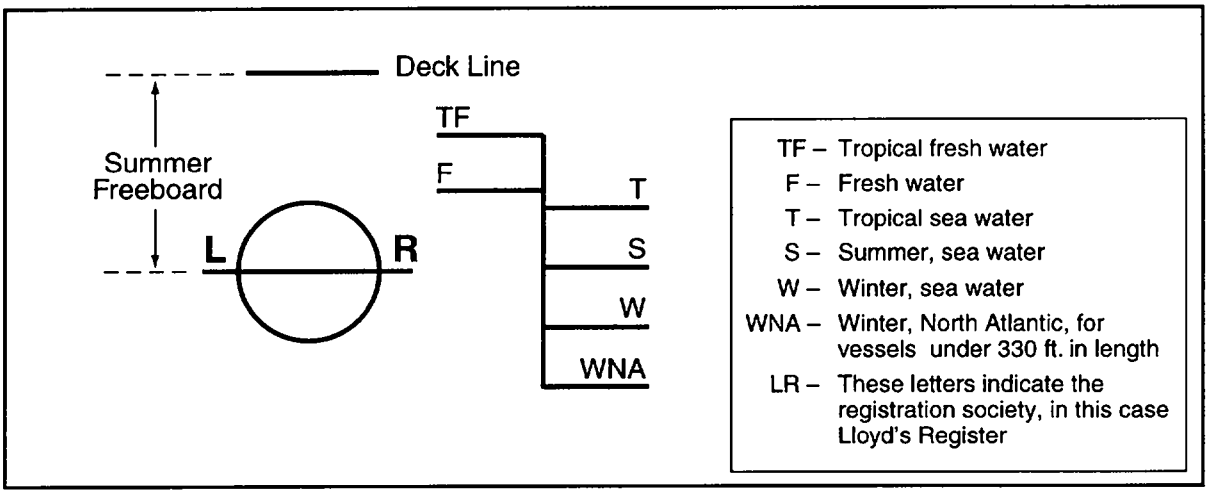
The oceans, their contents, underwater topography, and shorelines shape naval plans, programs, and operations on, above, and below the surface along the littoral as well as on high seas. This synopsis singles out three ramifications: ship designs; amphibious landings; submarine and antisubmarine warfare.

SURFACE SHIP AND SUBMARINE DESIGNS

Flotation, buoyancy, stability, and speed were essential properties of every man-of-war in olden times and will remain so eternally. Seaworthiness in the presence of ocean waves, swell, and buffeting winds was relatively easy to attain when wooden warships were fashionable, but design problems have multiplied and magnified manyfold since the first two steam-driven ironclads, the Federal ship USS *Monitor* and the Confederate ship CSS *Virginia* (originally christened the *Merrimac*) did battle inconclusively on March 9, 1862, in Chesapeake Bay.[19]

Hull dimensions, shapes, volumes, weights, and centers of gravity must be in proper proportion; performance suffers if even one of those factors is out of kilter. Surface ships float only if the submerged hull displaces a weight of water equal to the vessel's total weight, including crew, weapons, munitions, water, fuel, and other stores. Plimsoll lines drawn on cargo ships at the maximum allowable draft indicate whether they are safely loaded in tepid sea water of average salinity. Subsidiary marks account for difference in water densities, because ships ride higher or lower regardless of load when water temperatures and salt contents change (figure 12).

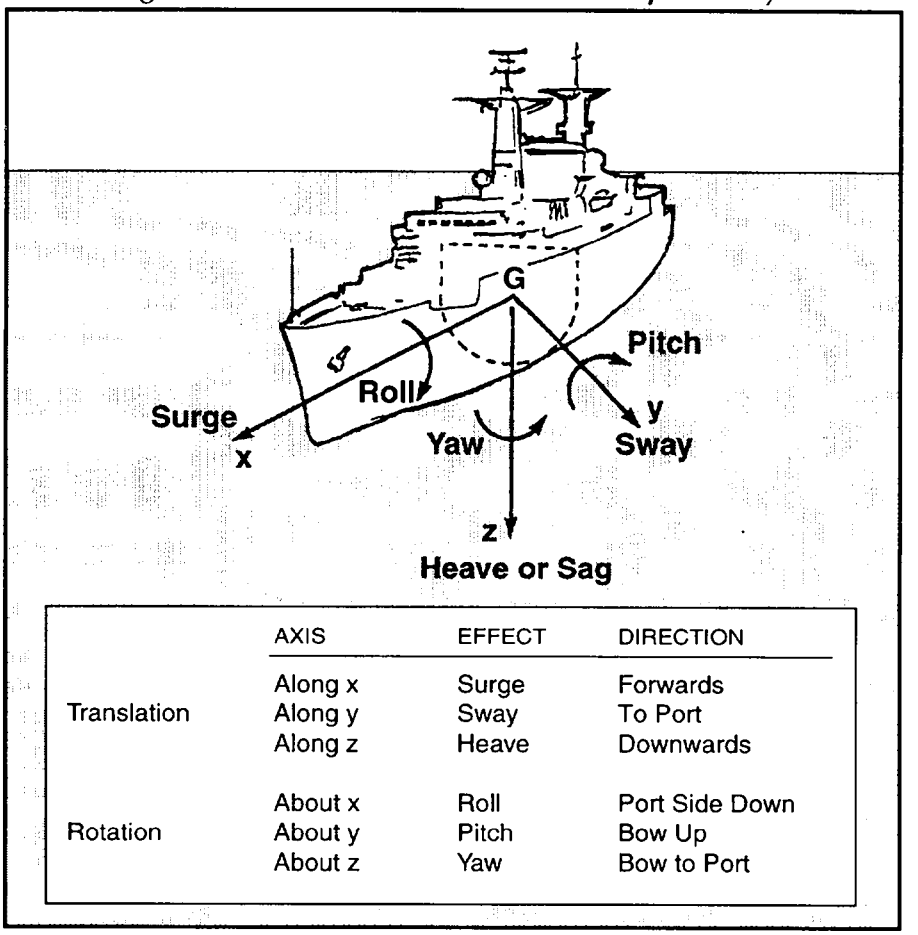
Figure 12. ***Plimsoll Line Markings***



Ships underway tip up, down, and sideways around the center of flotation, which seldom coincides with centers of gravity or buoyancy. Stable hull shapes thus are the Holy Grail of every naval architect, because waves and winds not only make warships surge, sway, heave, roll, pitch, and yaw in heavy seas (figure 13), but introduce great structural stress. Ice that forms on upper decks during freezing weather also degrades stability to such an extent that poorly designed ships respond sluggishly, founder, or sink.

Surface ships must be sturdy enough to withstand slamming when flat-plated bows meet huge waves at acute angles. Forward momentum stops momentarily, the ship shudders, and vibrations from stem to stern adversely affect weapons systems. So do extreme rolling and pitching. Walls of water can damage deck-mounted equipment, wave crests that scatter electronic signals sometimes cause spurious echoes to appear on radar screens, fixed-wing and helicopter operations become impossible, and underway replenishment must be deferred regardless of need. Instability induced by winds and waves moreover may encourage motion sickness among the hardiest crew members and passengers when really foul weather strikes—Colonel Lewis B. "Chesty" Puller, a legendary U.S. Marine, turned green in 1950 when the tail end of a typhoon rocked the ship upon which he was embarked. Mental acuity and manual dexterity suffer so greatly at such times that simple tasks become difficult. Designers consequently locate operations and control centers as well as quarters amidships, where turbulence is least pronounced.

Figure 13. ***Effects of Wave Action on Ship Stability***



	AXIS	EFFECT	DIRECTION
Translation	Along x	Surge	Forwards
	Along y	Sway	To Port
	Along z	Heave	Downwards
Rotation	About x	Roll	Port Side Down
	About y	Pitch	Bow Up
	About z	Yaw	Bow to Port

Adapted from P. G. Gates and N. M. Lynn, *Ships, Submarines, and the Sea* (New York: Brassey's (UK), 1990), 67

Submarines constitute a separate case, for they *must* sink or remain neutrally buoyant at required levels beneath the sea. Excessive buoyancy in fact would prevent rapid submersion in emergency. Crewmen pump water into ballast tanks to dive, pump part of it out to slow or terminate descent, and restore compressed air when they want to rise. Tanks fore and aft maintain submarines on an even keel, which is particularly important when they employ weapon systems or loiter at periscope depth where waters often are turbulent. Compromise designs are required to ensure effective performance, because streamlined shapes that are well suited under water are less efficient on the surface.

The corrosive effects of sea water and salt air on surface ships and submarines are pervasive and pernicious, the curse of every "swabbie" who spent most of his or her first cruise chipping paint. Superstructures and immersed hulls are under ceaseless attack. Unsightliness is the least serious problem, because metals eventually lose strength, electrical shorts occur, bolts seize up, and accretions on launch tracks cause missiles to malfunction if untended for long. Not even stainless steel is immune, so the search for antidotes and rust-resistant materials continues.

Sea weeds that foul screws and barnacles that encrust keels along with immersed instruments (such as surveillance devices) can be just as destructive as rust. Antifouling paints that slowly leach copper, tin, or mercury into sea water are somewhat protective, but

their poisonous emissions are envionmentally inadvisable and hazardous to handlers. Frequent repainting with less objectionable substances must suffice until acceptable substitutes such as co-polymers become widely available.

AMPHIBIOUS LANDINGS

Amphibious warriors who wait for picture perfect beaches and approaches are apt to miss golden opportunities, while those who take calculated risks after making sound terrain analyses sometimes reap rich rewards. Island hoppers in the Pacific during World War II, for example, took fewer than 3 years to leapfrog from Guadalcanal (August 1942) to Okinawa (March 1945), even though Japanese resistance was tenacious and precious few landings took place under ideal conditions.[20]

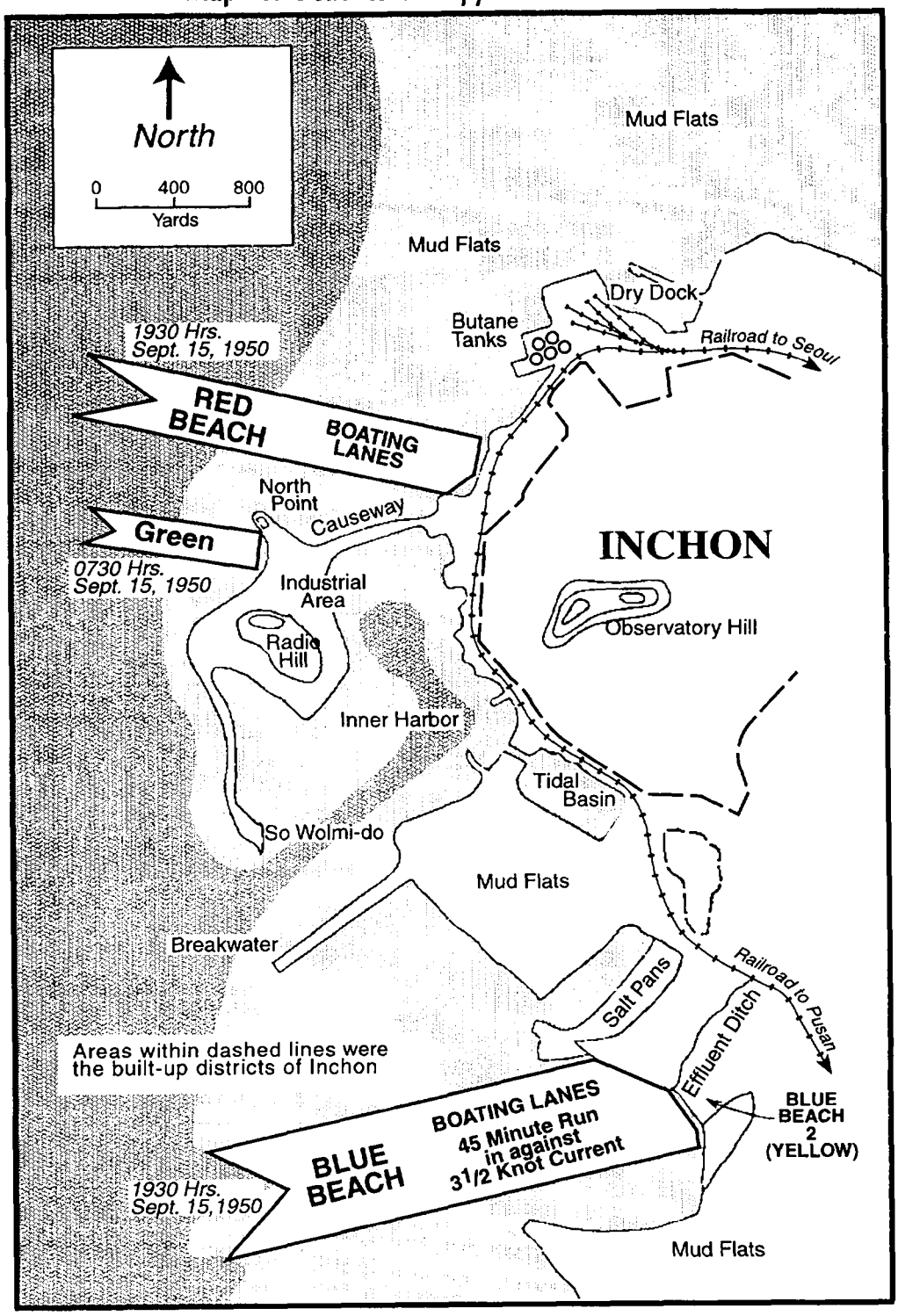
Two Contrasting Outcomes. British commandos armed with accurate descriptions of the German Navy stronghold at St. Nazaire, France conducted an amphibious raid in March 1942 and, against all odds, destroyed the only dry dock large enough to accommodate Hitler's superbattleship *Tirpitz*. The cost was high (five participants won Victoria Crosses for their valor), but ends and means were well matched. The *Tirpitz*, denied a home port, headed for Norway where British mini-submarines damaged it badly in 1943 before the Royal Air Force sank it in 1944 with a bevy of 6,000-pound bombs.[21] The bloodletting at Tarawa in November 1943 was less well planned and U.S. troops were less well equipped. More than 3,000 Marines were killed or wounded, partly because terrain intelligence was deficient. Armored amphibious tractors, the only available vehicles or landing craft able to cross that atoll's coral reef, were sufficient only for the first three waves, so follow-on forces had to wade 400-500 yards (350-450 meters) under withering fire before they reached dry land. The assault succeeded after 3 vicious days, but the value of that victory still provokes disputes.[22]

The Inchon Landings. Landings at Inchon, Korea, in September 1950 (map 10), conceived by General of the Army Douglas MacArthur and conducted mainly by U.S. Marines, capitalized on surprise to achieve success with few casualties on either side even though, as one staff officer later revealed, "We drew up a list of every natural and geographic handicap—and Inchon had 'em all":[23]

- The tidal range is tremendous.
- Low water exposes extensive mud flats.
- Only one narrow channel led to the landing areas.
- A fortified island blocked the final approach.
- No beaches were worthy of the name.
- A high sea wall separated all landing sites from the city.

The mission was to outflank North Korean invaders and relieve pressures on forces in the Pusan Perimeter, which was in danger of collapse. General MacArthur and his assistants seriously considered three alternatives in August 1950. Wonson, well north of the 38th Parallel on the east coast, seemed a bit ambitious. Kunsan, well to the south on the west coast, seemed overly conservative. MacArthur elected Inchon despite objections by the Joint Chiefs of Staff (JCS),[24] primarily because his main political aim was to free Seoul by the end of September.

Map 10. *Beaches and Approaches at Inchon*



Geographic obstacles indeed were daunting. Outdated U.S. and Japanese tide tables differed significantly, but generally agreed that water would be deep enough to float landing ships, tank (LSTs), with a draft of 29 feet (9 meters) only on September 15th, soon after sunrise and again at dusk, for periods that approximated 3 hours apiece. Schedules consequently called for the assault elements of two Marine regiments to debark 12 hours apart, with no possibility of reinforcement for first waves in the interim. Ships unable to unload troops, equipment, and supplies in that short time would be immobilized by wide, gooey mud flats that looked like solidifying chocolate but smelled like fecal matter.

LSTs and assault transports had to feel their way through tricky channels in dim light, a doubly difficult task because none at that time mounted technologically advanced navigational gear. Currents ran 6 to 8 knots (almost 10 miles per hour) when tides flowed in and out, close to the speed of available landing craft, which struggled upstream. Naval gunfire support ships had to anchor in the channel or be swept away, which made them sitting ducks for enemy artillery batteries ashore. Final approaches were so narrow there was little room to maneuver or turn around, passages were easy to mine, and one disabled ship would have blocked passage to or from final destinations. Fortunately for the amphibious task force, hostile artillery fire was desultory, no mines were found, and no ships were disabled.

Wolmi Do, a small fortified island connected to the mainland by a mile-long causeway, had to be taken on the morning tide before any ships could enter, because it dominated the harbor and waterfront in every direction. Inchon's beaches, code named Red, Green, and Blue from north to south, were small, separated from each other, bounded on the seaward side by mud flats at low tide, and backed by some combination of salt pans, piers, industrial congestion, and sea walls that had to be scaled with ladders. *Two* typhoons on a collision course with ports of embarkation in Japan as well as objective areas made matters worse.

Shrewd scheduling nevertheless enabled the invasion fleet to avoid the full brunt of both typhoons and catch North Korean foes flat-footed: late on D-Day General MacArthur told the JCS, "Our losses are light [21 killed, 174 wounded]," and U.N. Command Communique Number 9 announced that Seoul was recaptured on September 26, 1950, slightly ahead of schedule.[25] Inchon, despite geographic adversities, in short became the "jackpot spot," as Vice Admiral Arthur D. Struble, the Task Force Commander, predicted and remains a classic case study of strategic as well as tactical surprise at the U.S. Marine Corps' Amphibious Warfare School in Quantico, Virginia.

SUBMARINE AND ANTISUBMARINE WARFARE

The first recorded use of submarines as a weapon system occurred during the American Revolution when the *Turtle*, a one-man model with a hand-operated screw propeller, unsuccessfully sought to sink HMS *Eagle*, a British man-of-war, in New York harbor. The six-man *Hunley* flying a Confederate flag and armed with one torpedo attached to the bow, rammed and sank the *Housatonic*, a Federal corvette that was blockading Charleston, South Carolina, in 1864. German U-boats equipped with diesel engines, storage batteries, and self-propelled torpedoes implemented a "sink on sight" campaign in 1915 that eventually sent hundreds of Allied ships to the bottom, including the Cunard ocean liner *Lusitania* with 1,198 men, women, and children aboard. Submarines and antisubmarine warfare (ASW) forces have played increasingly sophisticated games of hide-and-seek ever since in a unique geographic medium.

Submarines. The ambition of every submarine skipper is to remain undetected on patrol and accomplish assigned missions unscathed. They can achieve those aspirations only if able to deceive enemy snoopers positioned to pick up the trail when they leave port, then disappear without a trace. Long-range missile submarines that maintain solitary vigils far from their targets are more difficult to find than those that must approach within torpedo range, but all submarines in motion emit energy signals, cause thermal disruptions, leave biological tracks of dying microorganisms in their turbulent wake, and disturb ultraviolet radiations in the sea. Nuclear-powered submarines ingest salt water to cool reactors, then discharge warm residue that rises to the surface where it leaves "thermal scars." Large submarines that maneuver at high speeds leave the most obvious "signatures."[26]

Immersion in the ocean inhibits the ability of the almost "silent service" to exchange information with and receive instructions from far distant headquarters. Transmission modes that trail antennae on the surface are dead giveaways if observers are nearby; one captain who cautiously raised his periscope discovered a flock of sea gulls riding behind him as he crisscrossed an enemy convoy. One alternative is to float expendable buoys that can send preprogrammed "burst" messages with a wide choice of frequencies before they self-destruct. All options, however, are susceptible to intercepts that are traceable back to the source. Submarines can receive Very Low Frequency (VLF) traffic on set schedules at ranges that exceed 1,000 miles (1,650 kilometers) or more, provided they interrupt activities in the deep and reposition near the surface. Repeat broadcasts that give captains more than one chance to make contact foster operational flexibility, but the narrow VLF band is congested, transmissions are no faster than telegraphy, reciprocal communications are impossible, and senders cannot verify whether addressees received their messages.[27] Extremely Low Frequency (ELF) radios, in contrast, can send strong signals to deeply submerged submarines almost anywhere around the world. The huge installations required, however, are costly and vulnerable, procedures are ponderous, and critics oppose any such project on political, social, and environmental grounds.[28]

Antisubmarine (ASW) Forces. ASW forces are by no means assured victory in their deadly game of hide and seek, despite the vast array of surveillance and weapon systems at their disposal. Not many optimists predict that science and technology will soon render oceans transparent, no matter how much money responsible officials devote to research and development (R&D). Acoustical sensors are most popular among many specialists who consider alternatives "unsound," but even those who pursue the full spectrum of possibilities encounter mind-boggling obstacles. Acoustical devices, which are particularly useful for long-range detection, must be submerged, remain stationary, or move slowly through the water lest hydrodynamic noises drown out incoming sounds that make it hard to differentiate legitimate indications from distractions. Ducted sounds travel great horizontal distances in salt water with little attenuation other than spreading and absorption, but bending and refraction distort signals if sensors are located in one layer and submarines in another where temperature, salinity, and pressure are quite different.[29]

Short-range acoustic and nonacoustic surveillance devices narrow the search after long-range lookouts locate enemy submarines within a radius of 50 square miles (130 square kilometers) or so. Many complementary systems commonly conduct the search while computers record every action and skilled analysts interpret results. Aircraft may drop dozens of sonobuoys to listen at various depths, perhaps along with submersible thermometers

(bathographs) to test the temperature of local water layers and estimate the quarry's likely depth. Magnetic anomaly detectors search for distortions that submarines make in Earth's magnetic field. Other equipment tries to spot electrical aberrations, bioluminescence, leaking lubricants, radioactive trace elements, and so-called "Kelvin wakes" that reach the surface.[30]

All ASW systems now deployed or on drawing boards nevertheless have serious limitations. No current combination can overcome all geographic obstacles. Oceans, according to most well-informed opinion, thus seem likely to remain opaque pending major technological breakthroughs that few pundits predict at any early date.

KEY POINTS

- The characteristics of salt water influence every naval activity from ship design to employment practices above, on, and beneath the surface of oceans and contiguous seas.
- Radar, visible light, infrared, and short-wave radio signals rebound from ocean and sea surfaces, whereas sound transmits well in water.
- Currents, tides, waves, swell, and sea ice strongly influence naval plans, programs, and operations.
- Beach characteristics and approaches thereto are primary concerns of amphibious forces and of logisticians whenever they must accomplish assigned missions without access to port facilities.
- Straits and other choke points adjacent to important sea lines of communication often are the objectives of military plans and operations designed to close them or keep them open.
- Naval architects constantly struggle to overcome the pernicious effects of salt water, heavy seas, and ice under conditions that civilian ships seldom experience.
- Submarine and antisubmarine warfare transpire in a unique environment that demands intimate oceanographic knowledge in addition to that required of surface sailors.

NOTES

1. Robert Debs Heinl, Jr., *Dictionary of Military and Naval Quotations* (Annapolis, MD: U.S. Naval Institute, 1966), 289.

2. Matthew F. Maury, *The Physical Geography of the Sea* (New York: Harper and Brothers, 1855). For subsequent elaboration, see Benjamin Dutton and Elbert S. Maloney, *Dutton's Navigation and Piloting*, 14th ed. (Annapolis, MD: U.S. Naval Institute Press, 1985); Rhodes W. Fairbridge, *The Encyclopedia of Oceanography* (New York: Reinhold, 1979).

3. For sea water attributes, see Harold V. Thurman, *Introductory Oceanography*, 2nd ed. (Columbus, OH: Charles E Merrill, 1978), 25-46; Richard A. Davis, Jr., *Principles of Oceanography* (Reading, MA: Addison Wesley, 1972), 69-73,134-181; P. J. Gates and N. M. Lynn, *Ships, Submarines, and the Sea* (London: Brassey's, 1990), 18-24, 85-89; William L. Donn, *Meteorology With Marine Applications* (New York: McGraw-Hill, 1946), 384-386; Leonard Engel, *The Sea* (New York: Time-Life Books, 1969), 10-12, 79-80.

4. P. J. Gates and N. M. Lynn, *Ships, Submarines, and the Sea*, 132-133; Donald C. Daniel, "Antisubmarine Warfare in the Nuclear Age," *Orbis* 28, no. 3 (Fall 1984): 530-533.

5. For sea surface behavior, see Davis, Jr., *Principles of Oceanography*, 74-133; Thurman, *Introduction to Oceanography*, 183-272; Donn, *Meteorology With Marine Applications*, 396-408; Gates and Lynn, *Ships, Submarines, and the Sea*, 85-106; Engel, *The Sea*, 77-78, 88-92.

6. J. F. C. Fuller, *A Military History of the Western World*, vol. 1 (New York: Funk and Wagnals, 1955), chapter 1.

7. The quotation is from Engel, *The Sea*, 89.

8. For marine topography, see Davis, Jr., *Principles of Oceanography*, 19-40, 289-377; Harold V. Thurman, *Introductory Oceanography*, 65-102, 139-156.

9. FM 30-10: *Terrain Analysis* (Washington, DC: Dept. of the Army, March 27, 1972, 73-80, 126, 139, 141 (superseded by FM 5-33, same title, July 1990, but the earlier edition contains more detailed information about beaches and approaches).

10. Orr Kelly, *Brave Men, Dark Water: The Untold Story of Navy SEALs* (Novato, CA: Presidio Press, 1992); parts of several chapters address beach reconnaissance missions.

11. Engel, *The Sea*, 34-35, 131-143.

12. Selected straits are described in *A/Con/13/16: Preparatory Paper for Conference on Law of the Sea* (New York: United Nations, 1957); *Sovereignty of the Sea* (Washington, DC: Dept. of State, 1965). For one regional analysis, see John H. Noer with David Gregory, *Chokepoints: Maritime Economic Concerns in Southeast Asia* (Washington, DC: National Defense University Press in cooperation with the Center for Naval Analyses,1996).

13. Alan Moorehead, *Gallipoli* (New York: Harper, 1956).

14. Kelly Couturier, "Pro-Chechen Gunmen Seize Ferry," *Washington Post*, January 17, 1996, A1, A20.

15. *Suez Canal Salvage Operations in 1974* (Washington, DC: prepared for Dept. of the Navy by Booz, Allen and Hamilton and Sea Salvage, Inc., 1975).

16. Tom Clancy, *The Hunt for Red October* (Annapolis, MD: U.S. Naval Institute Press, 1984).

17. John M. Collins, *The U.S.-Soviet Military Balance, 1980-1985* (Washington, DC: Pergamon-Brassey's, 1985), 145-151.

18. Charles H. Sinex and Robert S. Winokur, "Environmental Factors Affecting Military Operations in the Littoral Battlespace," *Johns Hopkins APL Technical Digest* 14, no. 2 (1993).

19. The section on ship design relies mainly on P. J. Gates and N. M. Lynn, *Ships, Submarines, and the Sea*, 24-46, 65-84.

20. Alfred Vagts, *Landing Operations from Antiquity to 1945* (Harrisburg, PA: Military Service Publishing Co., 1946); Joseph H. Alexander and Merrill L. Bartlett, *Sea Soldiers in the Cold War: Amphibious Warfare 1945-1991* (Annapolis, MD: U.S. Naval Institute Press, 1995); Theodore L. Garchel, *At the Water's Edge: Defending Against Modern Amphibious Assault* (Annapolis, MD: U.S. Naval Institute Press, 1996).

21. C. E. Lucas Phillips, *The Greatest Raid of All* (Boston: Little, Brown, 1960); Leonce Peillard, *Sink the Tirpitz!* (New York: G. P. Putnam's Sons, 1968).

22. Joseph H. Alexander, *Utmost Savagery: The Three Days of Tarawa* (Annapolis, MD: U.S. Naval Institute Press, 1995).

23. Walt Sheldon, *Hell or High Water* (New York: Macmillan, 1968); Robert Debs Heinl, *Victory at High Tide: The Inchon-Seoul Campaign* (New York: J. B. Lippincott, 1968), 18-121.

24. J. Lawton Collins, *War in Peacetime: The History and Lessons of Korea* (Boston: Houghton Mifflin, 1969), 114-137.

25. Ibid., 155, contains General MacArthur's quotation. See also T. R. Fehrenbach, *This Kind of War* (New York: Macmillan, 1963), chapter 15.

26. Daniel, "Antisubmarine Warfare in the Nuclear Age," 528, 535-540.

27. W. T. T. Packingham, "The Command and Control of Submarine Operations," *Naval Forces* 6, no 2 (Spring 1985): 50-53; Robert J. Carlin, "Communicating with the Silent Service," *U.S. Naval Institute Proceedings* 107, no. 12 (December 1981): 75-78.

28. "ELF Communications System Isn't Needed, Might Not Work, GAO Says," *Aerospace Daily*, March 22, 1979, 107 (cites GAO classified report, *The Navy's Strategic Communications System*, PSAD-79-48); *Seafarer ELF Communications System Final Evaluation Impact Statement for Site Selection and Test Operation* (Washington, DC: Dept. of the Navy, December 1977).

29. Robert S. Winokur and Craig E. Dorman, "Antisubmarine Warfare and Naval Oceanography," *Oceanus* 33, no. 4 (Winter 1990/91): 20-30; *Oceanography and Underwater Sound for Naval Applications* (Washington, Oceanographic Analysis Division, Marine Sciences Dept., U.S. Naval Oceanographic Office, October 1965); Daniel, "Antisubmarine Warfare in the Nuclear Age," 530-533; Jonathan B. Tucker, "Cold War in the Ocean Depths," *High Technology* (July 1985): 29-35.

30. Tom Stefanick, "The Nonacoustic Detection of Submarines," *Scientific American* 258, no. 3 (March 1988): 41-47; Paul Seully-Power and Robert F. Stevenson, "Swallowing the Transparency Pill," *U.S. Naval Institute Proceedings* 113, no. 12 (December 1987): 150-152; Thomas B. Allen and Norman Polmar, "The Silent Chase," *New York Times Magazine*, January 1, 1984, 13-17, 26-27; Daniel, "Antisubmarine Warfare in the Nuclear Age," 535-545.

5. EARTH'S ATMOSPHERE

Neither snow, nor rain, nor heat, nor gloom of night stays these couriers from the swift completion of their appointed rounds.

Motto of the U.S. Postal Service,
adapted from Herodotus

EARTH'S ATMOSPHERE, LIKE LAND AND SEA, IS A DISTINCTIVE GEOGRAPHIC MEDIUM. ARMED FORCES THAT operate therein must perform a much wider range of missions in foul weather than civil servants who deliver letters and packages. General George S. Patton, Jr., resorted to prayer during the Battle of the Bulge in December 1944, when God seemed to be giving all the breaks to his opponents. "Sir," he beseeched, "this is Patton talking. The last fourteen days have been straight hell. Rain, snow, more rain, more snow— and I'm beginning to wonder what's going on in your headquarters. Whose side are You on, anyway? . . . I am not going to ask for the impossible . . . all I request is four days of clear weather . . . so that my fighter-bombers can bomb and strafe, so that my reconnaissance may pick out targets for my magnificent artillery. Give me four days to dry out this blasted mud."[1] Whether God granted his request is debatable, but good weather broke the following day, Allied air power tipped the balance favorably, the German drive stalled, and Allied ground forces resumed the offensive.[2]

Commanders, however, cannot consistently count on prayers to manipulate atmospheric phenomena. Long-range planners find climatological surveys more reliable, while military operators, who take shorter views, lean heavily on meteorological observations that must be timely, accurate, and tailored to specific circumstances. Results, for good or ill, influence military strategies, tactics, force development, task organizations, readiness, morale, and performance.

ATMOSPHERIC PHENOMENA

Half of Earth's atmosphere lies between sea level and 15,000 feet (4,500 meters). The next 20,000 feet or so (6,000 meters) contains half of the remainder. Most militarily significant atmospheric phenomena develop within that envelope or along its periphery: barometric pressures, winds, air currents, temperatures, humidity, fog, clouds, precipitation, and storms.[3]

BAROMETRIC PRESSURE

International authorities define "normal" atmospheric pressure as 14.7 pounds per square inch at mean sea level 45 degrees north and south of the Equator (29.2 inches or 1013.2 millibars on standard barometers). Irregular heating of Earth's surface, however, causes significant deviations. Relatively high pressures permanently surround both poles, where the air always is cold and dense; relatively low pressures predominate in the tropics, where the air always is warm and light; and alternating pockets of high and low pressure that give forecasters fits travel from west to east in middle latitudes, where variable temperatures prevail. Exceptions to the rule are plentiful, but clear skies usually accompany high pressure domes, whereas depressions presage poor weather. Atmospheric pressures everywhere decrease with altitude, since the air becomes progressively thinner. Barometric pressures are one-thirtieth less at 900 feet (275 meters) than at sea level, one-thirtieth less at 1,800 feet than at 900 feet, and so on.

WINDS AND AIR CURRENTS

Surface winds blow from high toward low pressure like water flows down hill, fastest where gradients are steep because great pressure changes occur over short distances, slowest where slopes are gradual because slight changes transpire over long distances. Winds as a rule are steadier and stronger over open water than over level land, where surface friction not only limits velocities but produces distinctive effects (see table 4 on page 54 and table 5 on page 71 for comparative consequences at sea and ashore). Gusts that fluctuate 10 knots or more between minimum and maximum velocities create horizontal turbulence that changes direction erratically and becomes "bumpier" up to about 1,500 feet (450 meters), after which the influence of surface friction is noticeably less pronounced.

Surface winds are individualistic. Light air, for example, flows up slopes on warm days, whereas cool air drains downhill after dark. Sea breezes blow toward locally low pressure systems that develop during daylight hours, then face about when night falls because land heats and cools faster than water (figure 14). Monsoonal winds that visit southern Asia reverse their fields seasonally rather than daily for similar reasons. Local winds that bear such exotic names as Bora, Buran, Chinook, El Nino, Föhn, Khamsin, Mistral, Santa Ana, Shamal, and Sirocco blow hot and cold, wet and dry, in various locales and various combinations. Hurricanes, typhoons, and winds that funnel through mountain passes or roar off Greenland's ice cap commonly atttain terrifying speeds.

Winds aloft are notably different. Turbulence due to surface friction disappears, but see-saw effects from powerful up-down drafts perpendicular to the main airflow often make aircraft unmanageable. Intense shearing also can occur along boundaries between strong currents that sometimes race in opposite directions above and below one another. Two serpentine jet streams, one in the Northern Hemisphere and a twin in the south, alternately loop toward the Equator and the poles at altitudes that vary from 30,000 to 40,000 feet (9,000 to 12,000 meters). Military air crews headed from west to east in middle latitudes take advantage of tail winds therein that reach 160 knots during winter months (90-100 knots when weather is warm) and avoid bucking head winds on return trips.

Table 5. *Beaufort Scale Related to Surface Winds Ashore*

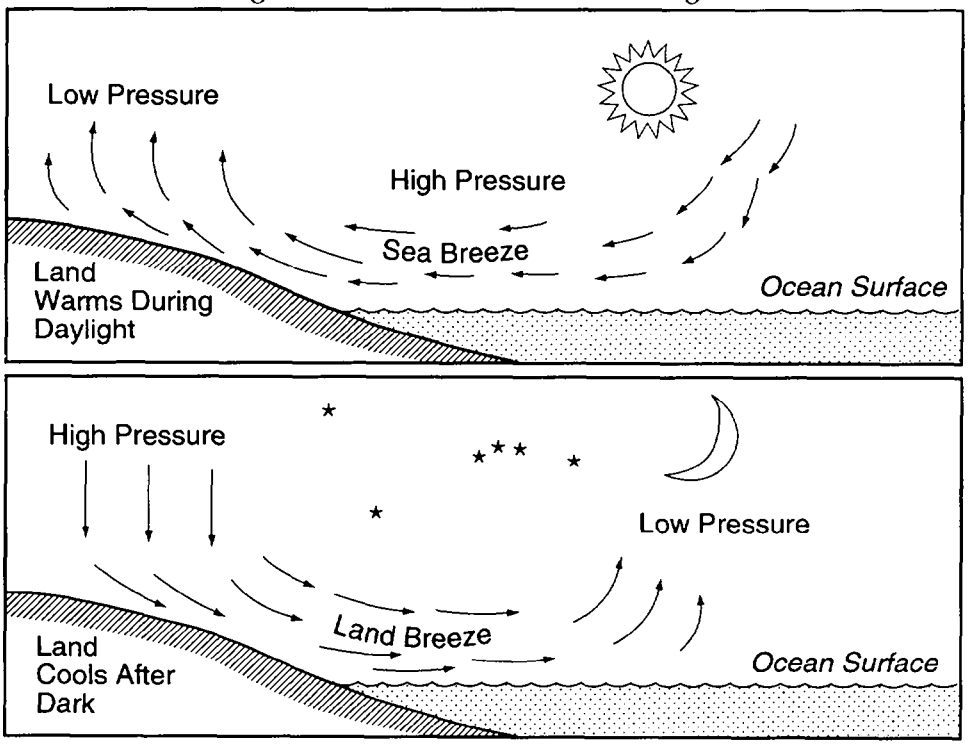
Beaufort Number	*Wind Type*	*Wind Speed (knots)*	*Situation Ashore*
0	Calm	<1	Smoke rises vertically
1	Light Airs	1-3	Smoke shows wind direction
2	Light Breeze	4-6	Wind vanes move, wind felt on face, leaves rustle
3	Gentle Breeze	7-10	Leaves and twigs sway; light flags flap
4	Moderate Breeze	11-16	Dust and loose paper blow; small branches sway
5	Fresh Breeze	17-21	Small trees in leaf sway; wavelets on inland waters
6	Strong Breeze	22-27	Branches sway; umbrellas blow
7	Moderate Gale	28-33	Whole trees sway; walking against wind takes effort
8	Fresh Gale	34-40	Twigs snap off trees; progress generally impeded
9	Strong Gale	41-47	Slight structural damage; roof slates removed
10	Whole Gale	48-55	Trees uprooted; considerable damage
11	Storm	56-64	Widespread damage
12	Hurricane	>64	Devastation

TEMPERATURE

Air temperatures near Earth's surface usually are measured in degrees Fahrenheit (^{0}F) or degrees Celsius (^{0}C), but upper atmosphere reports always cite Celsius. Military commanders and staffs express special interest in mean daily maximum and minimum temperatures as well as temperature extremes, which indicate the hottest and coldest weather that armed forces might encounter in any given month (table 6). The number of days below freezing is important in some operational areas, especially when coupled with wind chill factors

(table 7), which indicate the combined effects of low temperatures and circulating air on exposed human flesh, taking "true" wind speeds into account. Personnel riding in open vehicles at 20 miles (32 kilometers) per hour, for example, experience the equivalent of a 30 mph (48 kph) buffeting if they buck 10 mph head winds. Back blasts by propeller-driven aircraft can give ground crews a bad case of ague long before thermometer readings dip below freezing, so alert commanders take appropriate precautions. Local inversions make cold, heavy air drain down steep slopes, but air temperatures as a rule decrease 3.5 ^{0}F with every 1,000-foot (300-meter) increase in elevation above sea level. Readings drop at that rate up to 35,000 feet (10,670 meters) or so, where Fahrenheit thermometers generally register between -60 ^{0}F and -65 ^{0}F, then remain more or less constant up to an average altitude of 120,000 feet (36,575 meters), beyond the limit of most military aircraft.

Figure 14. ***Land and Sea Breeze Regimes***



Adapted from William L. Donn, *Meteorology with Marine Applications.*

Table 6. ***Militarily Important Temperature Statistics***
(A typical table in degrees Fahrenheit)

Categories	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Mean Daily Max	22	32	49	60	75	92	98	96	83	64	43	33
Extreme Max	45	48	60	78	92	98	106	104	92	70	60	48
Mean Daily Min	2	10	29	40	55	72	78	80	63	44	24	12
Extreme Min	-28	-22	-2	15	28	53	55	55	26	14	-2	-13
Days Min 32 ^{0}F or Less	31	28	23	5	2	0	0	0	4	14	24	27

Table 7. *Wind Chill Factors*

WIND SPEED MPH	What the Thermometer Reads (degrees F)											
	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
	Equivalent Effects on Exposed Flesh											
CALM	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
5	48	37	27	16	6	−5	−15	−26	−36	−47	−57	−68
10	40	28	16	4	−9	−21	−33	−46	−58	−70	−83	−95
15	36	22	9	−5	−18	−36	−45	−58	−72	−85	−99	−112
20	32	18	8	−10	−25	−39	−53	−67	−82	−96	−110	−121
25	30	16	0	−15	−29	−44	−59	−74	−88	−104	−118	−133
30	28	13	−2	−18	−33	−48	−63	−79	−94	−109	−125	−140
35	27	11	−4	−20	−35	−49	−67	−82	−98	−113	−129	−145
40	26	10	−6	−21	−37	−53	−69	−85	−100	−116	−137	−148
Little danger of freezing exposed flesh					Danger of freezing exposed flesh			Great danger of freezing exposed flesh				

RELATIVE HUMIDITY

"It's not the heat, it's the humidity," is an age-old adage, but those two atmospheric elements in fact are inseparable. *Absolute* humidity, defined as the volume of water vapor in a cubic foot or cubic meter of air, varies from nearly nil in deserts to four or five percent in some soggy climes. *Relative* humidity is the percentage of vapor present compared with the maximum amount possible, which is greatest in warm air. Saturation (100 percent relative humidity) occurs when contents and capacities become equal. Condensation from gaseous to liquid or solid states follows further cooling. Water droplets (dew) or ice crystals (frost) then form in the air or on Earth's surface, often between dusk and dawn.

Most humans find conditions acceptable when thermometers register 90 ^{0}F (32 ^{0}C), as long as relative humidity stands, say, at 20 percent, but that same temperature produces a sweat box when water vapor in the air reaches 60 percent or more, because neither precipitation nor perspiration evaporates rapidly in such environments and bodies cool slowly unless wafted by breeze. Damp cold also is debilitating. Bone-chilling winds and wet weather made life miserable for U.S. and Japanese Armed Forces who contested control of the Aleutian Islands during World War II and more recently discomfited British and Argentine troops who battled to determine sovereignty over the Falklands/Malvinas.

CLOUDS AND FOG

Clouds and fog are distinctive forms of condensation that consist of minute water particles suspended in air. Clouds remain aloft whereas fog hugs the surface, but the two are indistinguishable whenever low-lying clouds touch land or water and both obscurants limit visibility in various degrees regardless of their origin.

Fog. Ground fog, which most often develops on cool, calm, clear nights, appears first and becomes densest in depressions, then "burns off" after sunrise as soon as winds pick up and temperatures rise above the dew point (100 percent relative humidity). Poor visibility often causes nighttime traffic control problems in harbors surrounded by hills, because the atmosphere there is so close to saturation that contact with cool air above causes condensation. Industrial smoke and other manmade airborne pollutants convert fog into smog near many cities. (Table 8 displays maximum distances at which military personnel with 20-20 vision can identify prominent objects.)

Thin maritime fog, called "arctic smoke," forms in the far north and south when vapors rising from relatively warm water meet cold air, but perhaps four-fifths of all dense fogs at sea are found in middle latitudes where warm air collides with cool water. Light winds of 5 to 10 knots, which are strong enough to distribute but not disperse suspended vapors, help build huge fog banks off Newfoundland's coast where the Gulf Stream and the Labrador Current intersect. "Pea soup" fog occasionally blankets the British Isles and parts of Northwestern Europe in wintertime, when warm, wet air overrides cold land.

Table 8. *Fog Linked to Visibility*

Fog Classification	*Maximum Visibility*
Dense Fog	50 yards (45 meters)
Thick Fog	200 yards (180 meters)
Fog	500 yards (450 meters)
Moderate Fog	0.5 nautical miles (0.9 kilometers)
Thin Fog	1 nautical mile (1.8 kilometers)

Clouds. Three elemental cloud types are recognizable: cirrus and stratus, which spread horizontally; cumulus clouds, which develop vertically (table 9 and figure 15). All others are modifications. Wispy cirrus clouds composed of ice crystals habitually occupy thin, dry air above 20,000 feet (6,000 meters), whereas stratus clouds spread sheets across all or most of the sky far below. Fluffy, flat-bottomed cumulus clouds in contrast sometimes tower 30,000 feet (9,150 meters) or more from base to top. The prefix "alto" accompanies all middle level clouds, while "nimbus"—Latin for rain—designates turbulent storm clouds, including anvil-shaped cumulonimbus thunderheads that aviators try to avoid.

Cloud cover, expressed as scattered ($1/8^{th}$ to $4/8^{ths}$), broken ($5/8^{ths}$ to $7/8^{ths}$), and overcast $8/8^{th}$), determines vertical visibility. One tier may tell the whole tale, but scattered or broken clouds on two or more levels also cause overcast conditions. The lowest cloud bases determine ceilings, which range from zero to unlimited and differ significantly from place to place over hilly terrain (figure 16).

Table 9. *Cloud Classifications*

Horizontal Development			*Vertical Development*
High Clouds (> 20,000 feet) (>6,000 meters)	*Middle Clouds (7,000-20,000 feet) (2,000-6,000 meters)*	*Low Clouds (<7,000 feet) (<2,000 meters)*	
Cirrus Cirrostratus Cirrocumulus	Altostratus Altocumulus	Stratus Nimbostratus Stratocumulus	Cumulus Cumulonimbus

PRECIPITATION

Steady, intermittent, and showery precipitation from clouds strike Earth as rain, sleet, snow, hail, or glaze, sometimes in combinations, the mixture of which depends primarily on air and surface temperatures. Intensities range from drizzles to downpours, with total accumulations characterized as a trace, light, medium, and heavy. One inch of rain (2.5 centimeters) normally is equivalent to 10 inches of snow (25 centimeters). There are no comparable conversion factors for sleet or hail, which sometimes pile several inches deep, or for glaze that turns turnpikes and ship decks into impromptu ice skating rinks. Monthly and annual averages mean little unless precipitation is evenly distributed. Military commanders and staffs need to know whether three inches of rain in April spreads over most of that month or generally arrives as a "gully washer" (comedians chortle about the statistician who drowned while crossing a normally dry stream).

STORMS

Tropical cyclones (hurricanes, typhoons) and frontal systems that form along the boundary between warm and cold air masses in middle latitudes feature low pressures, high winds, overcast skies, low ceilings, poor visibility, and precipitation that varies from trickles to torrents. The most violent storms usually pass in a few hours (even minutes), while others linger for days. Tornadoes that hop, skip, and jump erratically are by far the most furious, but rarely affect military operations and exert little or no influence over plans and programs because they are short-lived, localized, and unpredictable. Tropical cyclones, typified by devastating winds that circle around a calm core (the eye), only occasionally imperil ships at sea and military installations on or near seacoasts, but thunderstorms that bring gusty, shearing, shifty winds along the front, hazardous up-down drafts, hailstones, heavy rain, and destructive electrical discharges regularly occur over land and water (figure 17). Towering cumulonimbus thunderheads, which sometimes measure more than 5 miles high, 20 miles wide, and 60 miles long (8 x 32 x 96 kilometers), pose serious impediments to military aircraft in pursuit of critical wartime missions.

Figure 15. *Cloud Types Depicted*

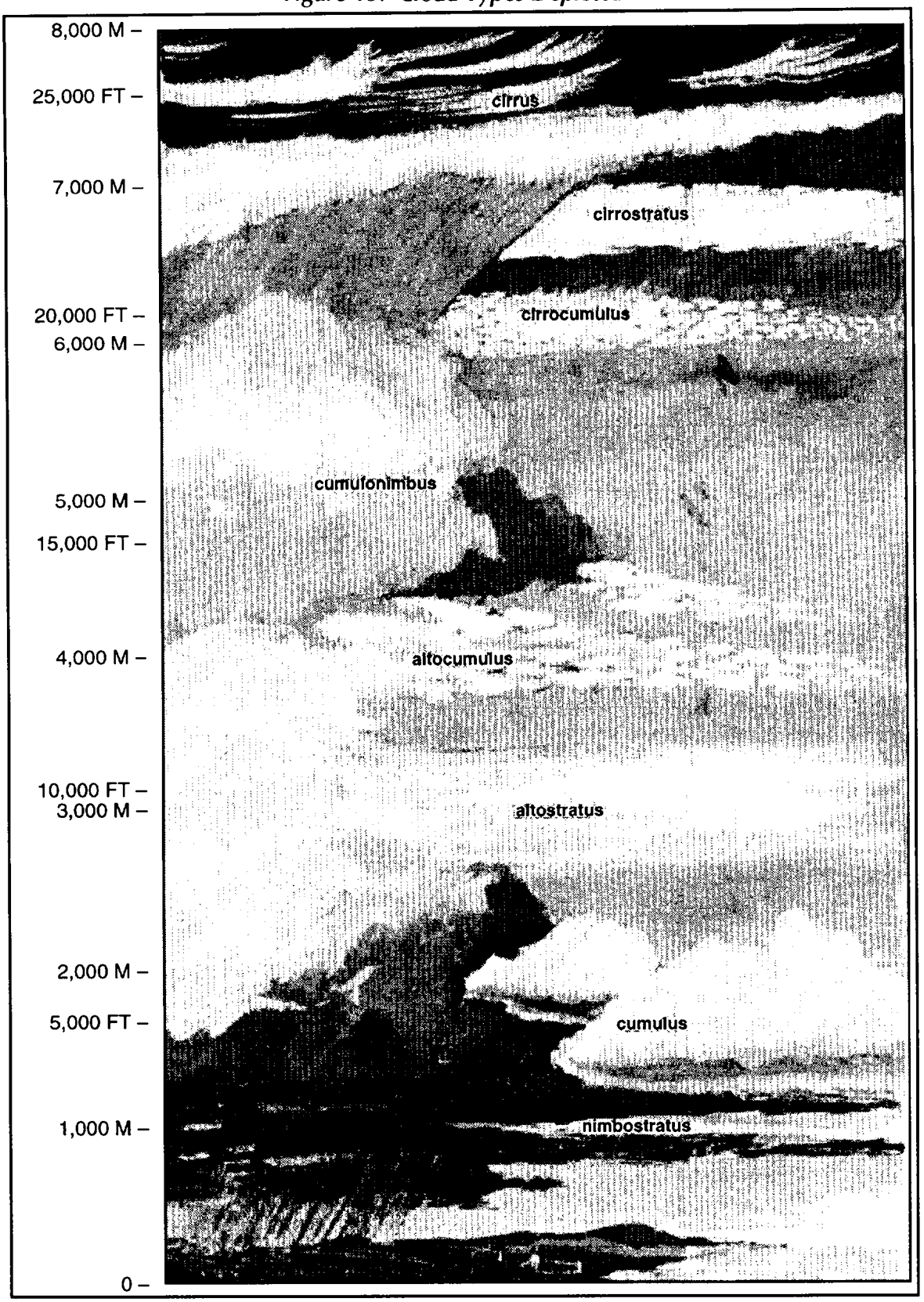
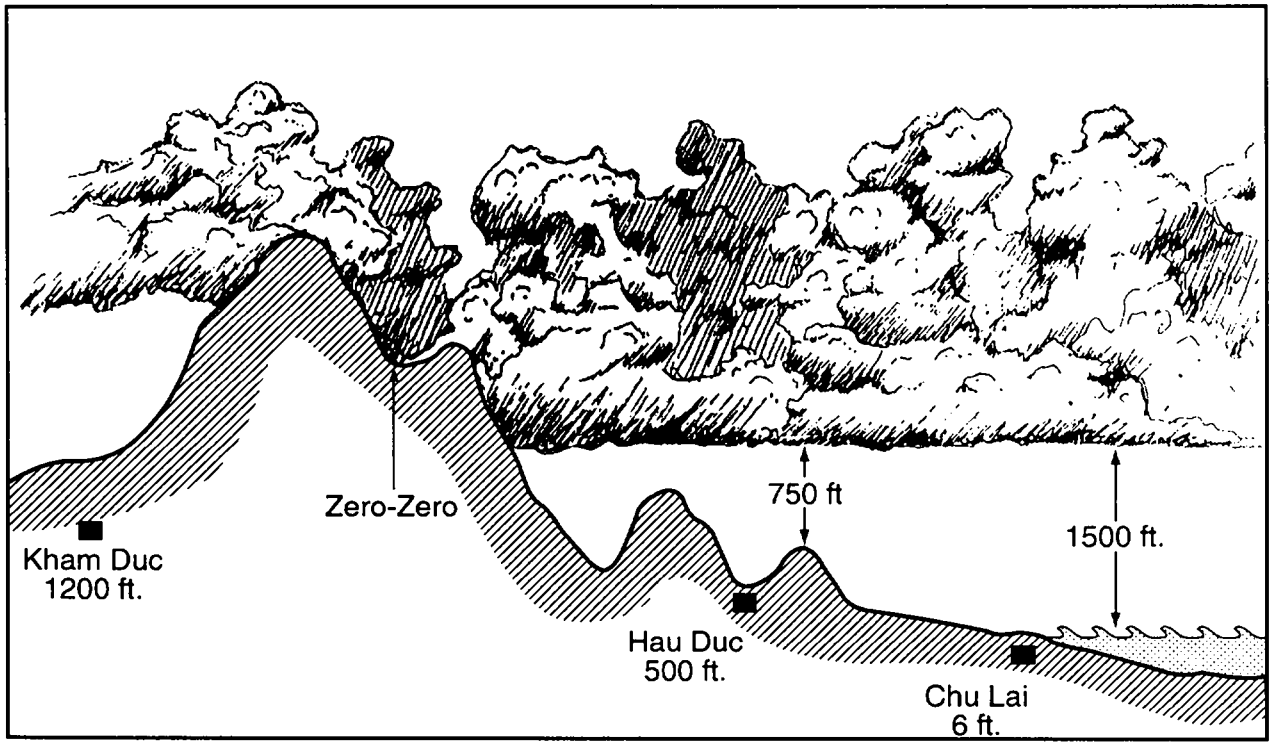


Figure 16. *Cloud Ceilings Related to Terrain*



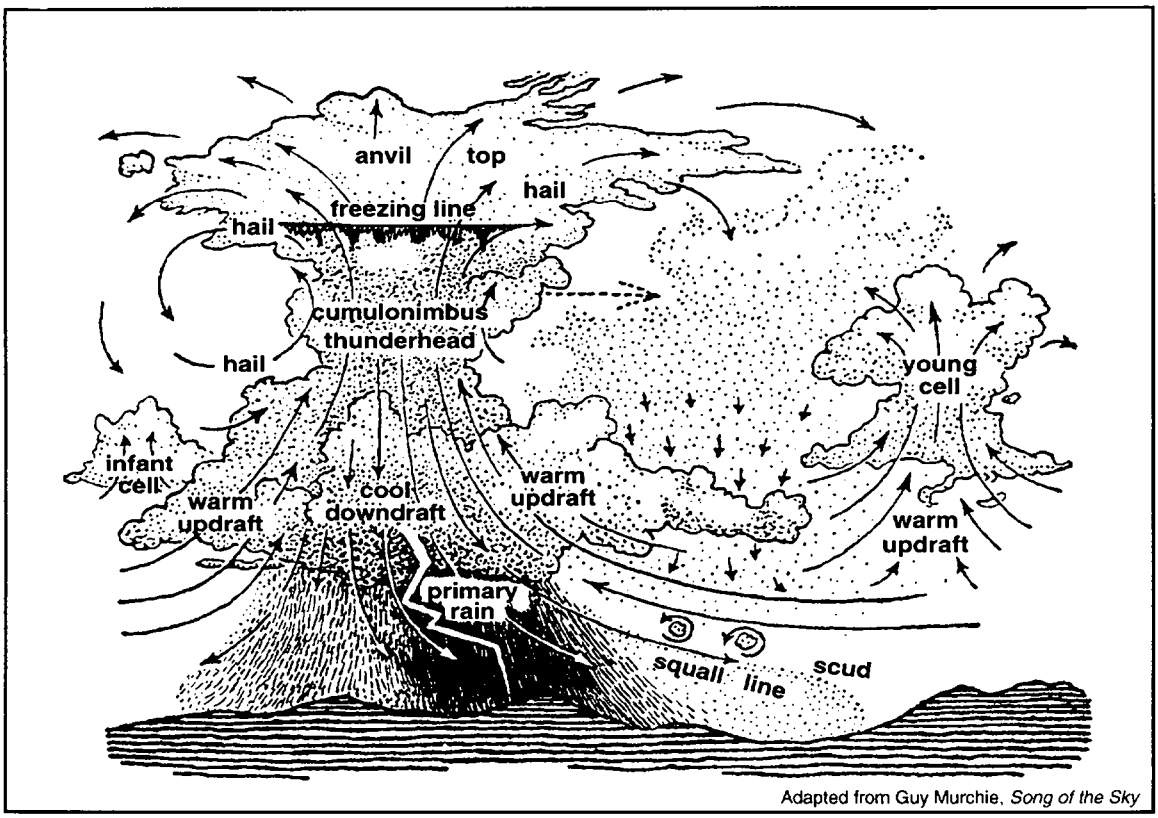
NATURAL LIGHT LEVELS

Sunshine, moonlight, and starlight are the main sources of natural illumination, which is measured in footcandles (fc). The sun at its zenith, unfiltered by clouds or fog, lights flat surfaces on Earth at about 10,000 fc compared with 0.02 fc for full moons under similar conditions (sufficient light for steady reading averages about 10 footcandles).

Daylight and darkness are not atmospheric phenomena, but staff weather officers routinely furnish military commanders with a wide range of light data for particular times and places. Relevant information includes sunrise, sunset, periods of morning and evening twilight, moon rise, moon set, lunar phases, and times that night vision devices would prove most useful. Four types of twilight, each with important military implications, are recognized universally:

- *Astronomical twilight*, which persists as long as any detectable glow remains in the sky, starts in the morning when the sun is 18^0 below the horizon, lasts until sunup, reappears after sundown, then remains until dark.

Figure 17. ***Anatomy of a Thunderstorm***



- The *beginning of morning nautical twilight* (BMNT) occurs before sunup when the sun is between the horizon and 12° below, at which times large silhouettes are distinguishable and stars that serve navigational purposes are visible in clear weather.
- The *end of evening nautical twilight* (EENT) occurs after sundown when the sun is between the horizon and 12° below.
- Normal outdoor activities are feasible without artificial light during *civil twilight*, when the sun is between the horizon and 6° below at dawn and again at dusk.[4]

Levels of natural illumination vary according to latitude and seasons of the year. Civil twilight during spring and autumn equinoxes, for example, lasts twice as long at 60° north or south as it does at the Equator. Regions near the North Pole experience 7 weeks of astronomical twilight from mid-September to mid-November, and 7 more weeks from mid-January to mid-March. Perpetual darkness prevails in the dead of winter, perpetual daylight during summertime in the "Land of the Midnight Sun" (Antarctica encounters analogous regimes in reverse order). The U.S. Naval Observatory in Washington, DC, annually updates and publishes a wide selection of light data for each day, together with conversion factors that enable users to tailor additional calculations that meet individualistic requirements.[5]

CLIMATOLOGY FOR MILITARY STRATEGISTS

Climatologists compile atmospheric statistics that disclose global and regional patterns. Displays that highlight daily-monthly-annual means and extremes become progressively more dependable, provided qualified observers compile specified information for particular places over periods that span several decades. Interpolations must supplement or supplant facts when they do not.[6]

Strategic planners and programmers, who focus their attention on next month, next year, or the indefinite future, are the principal beneficiaries of climatology, which is most important for armed forces that must prepare to implement missions in unfamiliar territory. Specialized studies not only help high-level contingency planners determine whether weapons, equipment, supplies, clothing, and other resources are well suited for operations within regions where military responsibilities might arise on short notice, but they indicate what research, development, test, evaluation, and acquisition programs would best bridge gaps between requirements and capabilities. Theater-level campaign planners, force developers, and resource allocators likewise rely on climatic assessments. General William C. Westmoreland, in his capacity as Commander, U.S. Military Assistance Command, Vietnam, for example, annually approved a series of so-called "monsoon plans" that took wet and dry seasons into account on each side of Vietnam's mountain backbone. When the Northeast Monsoon turns coastal plains to quagmires from mid-October until early March Laos and Cambodia are dry. When the Southwest Monsoon takes over from May to September that regime reverses. [7]

CLIMATOLOGICAL CLASSIFICATIONS

Every climatological classification is flawed in some respects, whether it emphasizes precipitation (arid, semi-arid, moderate, humid, wet), temperature (cold, tepid, warm, hot), or other atmospheric phenomena. Characteristically warm climes that exclude identifiable winters, cold regions that exclude identifiable summers, and intermediate climates identified by four seasons are much too broad for practical military applications. The "Torrid Zone" isn't uniformly hot (highlands in Kenya and Ecuador, which straddle the Equator, are delightfully cool). "Frigid Zones" poleward of the Arctic and Antarctic Circles aren't uniformly cold (Verkhoyansk and Omyakyon in northeastern Siberia are frozen solid in winter but swelter in summer). "Temperate Zones" are neither climatically moderate nor uniform. Classifications that focus on seasonal or annual precipitation at the expense of temperatures are equally faulty, because they fail to account for evaporation, which heat encourages—Basra, in the Iraqi desert, is notably drier than Russia's Kola coast 1,000 miles (1,600 kilometers) north of Moscow, which receives essentially the same amount of moisture but retains more of it. Most climatic maps moreover limit coverage to land and show sharp boundaries, whereas distinctive patterns appear over oceans and intersections between climatic regions generally are gradual.[8]

MILITARILY USEFUL COMPROMISES

Three basic climatic groupings with several subdivisions apiece serve most military purposes reasonably well, whether forces are aloft, ashore, or afloat: low latitude climates controlled by equatorial and tropical air masses; middle latitude climates controlled by tropical and

polar air masses; high latitude climates controlled by polar and arctic air masses. Highlands create temperature and precipitation anomalies in each case (map 11 and table 10 elaborate).[9]

METEOROLOGY FOR MILITARY OPERATORS

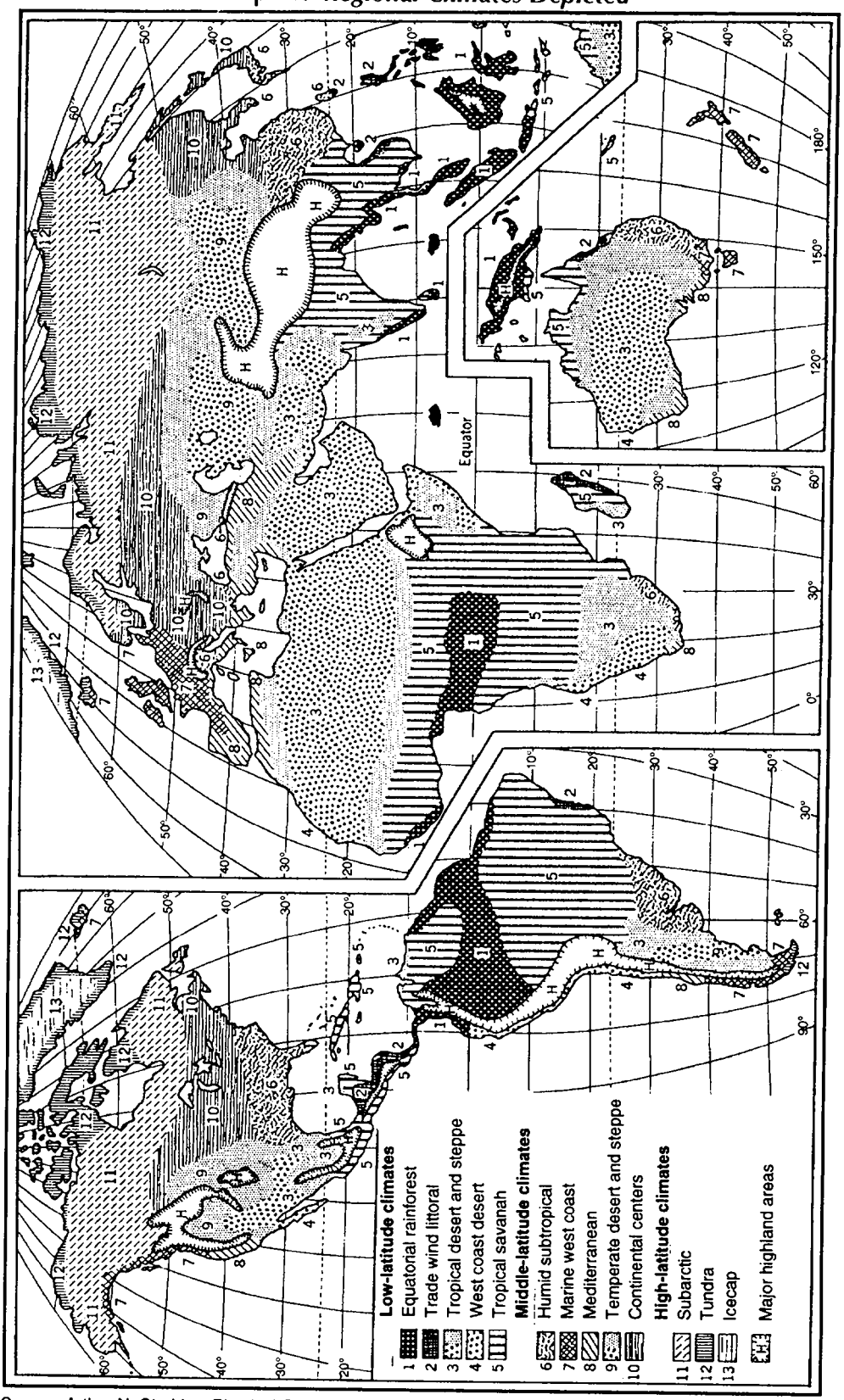
Military commanders who seek to make capricious weather work for rather than against them require timely, relevant information about current meteorological conditions and anticipated developments within respective areas of responsibility. Staff weather officers armed with the best available information peer into the immediate future, evaluate variables, identify apparent trends, apply past experience, then predict meteorological events at particular places for specified periods of time.[10] Their prognoses seldom cover more than a week (typically 1 or 2 days), because the reliability of longer outlooks remains spotty despite the proliferation of reporting stations and assistance from technologically advanced sensors on land, at sea, in the air, and in space.[11]

IMPACT ON CONVENTIONAL LAND WARFARE

General George Washington capitalized on surprise when he deliberately picked a stormy Christmas night in 1776 to cross the ice-caked Delaware River, despite roiling waters and high winds that drenched his 2,400 half-starved, threadbare troops with cold rain, wet snow, and hail. He landed early next morning near Trenton, New Jersey, caught the Hessian garrison off guard, then trounced them in little more than an hour at the expense of four American wounded.[12] Mother Nature, however, punishes imprudent commanders who arrogantly or ignorantly disregard weather. Generalissimo Joseph Stalin learned hard lessons when he ordered poorly acclimated and equipped Soviet Armed Forces to invade Finland on November 30, 1939, after one of the worst winters on record had already begun. Skillful Finnish troops, who anticipated trouble and were well prepared for frigid land warfare, inflicted 10-to-1 casualties on Soviet adversaries before they were overwhelmed by sheer weight of numbers in mid-March, 1940.[13]

Trafficability. Information about the possible impact of precipitation and temperature on trafficability deserves a high priority, because ground forces cannot maneuver effectively when the footing is unfriendly. They move fast across open terrain that is frozen solid (dashing French *cavalry* captured a complete Dutch fleet at the Texel roadstead, including its embarrassed admiral, when thick ice unexpectedly covered the Zuider Zee in 1795[14]), but mud stalls men and machines. British artillery barrages before the Third Battle of Ypres in 1917 destroyed the drainage system during incessant rains and pocked the battlefield with more than four million new water-filled craters that made rapid progress impossible.[15] German tank and truck columns stranded in muck on Soviet steppes during the next World War were cemented in place like Greek friezes when thermometers dipped below freezing after dark. Mud made a mess in mountainous territory as well as on level land during that same time frame, witness U.S. forces in Italy, where men and pack mules skidded up and down slippery trails that four-wheel drive vehicles never could negotiate.[16]

Map 11. *Regional Climates Depicted*



Source: Arthur N. Strahler, *Physical Geography*, 2d ed, 1963, p.192

Table 10. *Regional Climates Described*

Designations	*Descriptions*
1. Low Latitude Climates	
a. Rain Forests (10^0 North [20^0 in Asia] to 10^0 South)	Uniformly warm; heavy rainfall
b. Tradewind Littorals (10^0 to 25^0 North and South)	Uniformly warm; seasonally heavy rainfall on narrow east coast strips
c. Tropical Deserts and Steppes (15^0 to 35^0 North and South)	High maximum temperatures; arid or semi-arid
d. West Coast Deserts (15^0 to 30^0 North and South)	Very dry; relatively cool; limited to narrow coastal strips
e. Tropical Savannas (5^0 to 25^0 North and South)	Warm; wet season when sun is high; dry season when sun is low
2. Middle Latitude Climates	
a. Humid Sub-Tropical (20^0 to 35^0 North and South)	Cool winters and warm, humid summers on the east side of continents; frequent rain
b. Temperate West Coasts (40^0 to 60^0 North and South)	Cool; cloudy; humid; rainy, with winter maximums
c. Mediterranean (30^0 to 45^0 North and South)	Moderate temperatures; wet winters; dry summers
d. Interior Deserts and Steppes (35^0 to 50^0 North and South)	Arid; cold winters; hot summers
e. Continental Centers and Eastern Sectors (35^0 to 60^0 North)	Ample precipitation; cold winters; hot summers; variable weather; frequent fronts
3. High Latitude Climates	
a. Subarctic (55^0 to 70^0 North)	Low precipitation; fairly moist; long, cold winters; short, cool summers; huge temperature range
b. Tundra (North of 55^0 N, South of 50^0 S)	Damp cold; no warm season; moderate temperature range
c. Icecaps (Polar Regions; Greenland)	Dry; no monthly temperature above freezing
Mountains and Plateaus	Cool or cold above 5,000 feet (1,500 meters); wet or dry depending on location

Weapon Performance. Atmospheric phenomena significantly affect the performance of weapon systems and munitions. Pressure changes and relative humidity alter barometric fusing and arming calculations, dense air reduces maximum effective ranges, gusty crosswinds near Earth's surface make free rockets and guided missiles wobble erratically, while winds aloft influence ballistic trajectories. Rain-soaked soils deaden artillery rounds, but frozen ground increases fragmentation from contact-fused shells. Dense fog, which degrades visual surveillance and target acquisition capabilities, also makes life difficult for forward observers, whose mission is to adjust artillery fire. Line-of-sight weapons, such as tube-launched, optically tracked, wire-guided (TOW) antitank missiles, are worthless where visibility is very limited. Exhaust plumes that follow TOWs moreover form ice fog in cold, damp air, which conceals targets from gunners even on clear days, and reveals firing positions to enemy sharpshooters. Scorching heat makes armored vehicles too hot to touch without gloves, reduces sustained rates of fire for automatic weapons, artillery, and tank guns, and renders white phosphorus ammunition unstable.[17] Brutal cold has quite different effects, as U.S. Marines discovered in subzero combat around North Korea's Changjin Reservoir (December 1950), where mortar base plates broke on the rock hard ground and hand grenades became unpopular, because users who removed mittens to pull the pin suffered frostbitten fingers if they held the cold metal for more than a moment.[18]

IMPACT ON CONVENTIONAL SURFACE NAVAL WARFARE

Winds, towering seas, and frigid temperatures influence naval operations more than any other atmospheric factors. Results sometimes are favorable—a *kamikase* ("Divine Wind") saved Japan from invasion by a Mongol fleet in the 13th century, and Britain benefited when storms dispersed the Spanish Armada in 1588—but foul weather at sea is seldom welcome.

Aircraft Carriers. Large aircraft carriers are less affected than their escorts by heavy seas, but even so may roll nine degrees or more when their flight decks are exposed to strong winds. Small wonder, therefore, that U.S. carrier battle groups plying back and forth between Bosnia and Norfolk Naval Base, Virginia, in August 1995 took special pains to bypass *three* hurricanes that then were active in the Atlantic Ocean. Less than gale force winds demand additional tie downs for fixed-wing aircraft and helicopters, repositioning becomes a complex proposition when decks are slick, and fighters may not be able to spread folding wings until they reach catapults. Underway replenishment, always a delicate business, becomes additionally hazardous in rough weather, when waves may wash away loads suspended on transfer lines and cargo handling on deck becomes infinitely more difficult. Foul weather procedures consequently emphasize smaller than normal loads, longer than normal transfer times, and greater than normal distances between support ships and recipients to prevent collisions.[19]

Other Surface Ships. Persistent heavy weather endangers surface ship stability, buoyancy, power, and structural integrity. Experienced helmsmen have a hard time maintaining course when beset by sharp pitching, swaying, surging, yawing, and heaving, but repeated wide-angle rolls from starboard to port and back again are exceptionally dangerous, because most surface combatants and support ships may capsize if efforts to restore stability fail. Conditions are worst when ships steer a course that parallels the storm path and their roll period (9 to 10 seconds for a typical destroyer) coincides with the period between wave peaks and troughs. Paths perpendicular to the onrushing sea minimize roll but maximize pitch, which

alternately causes bows to slam and propellers to beat thin air at high speeds while the whole ship shudders. Nonnuclear ships maintain the lowest possible center of gravity primarily by replacing consumed fuel with salt water ballast, which maintains low-level weight and prevents partially filled tanks from sloshing. All savvy captains position heavy loads below deck to the greatest practicable extent, and engineers take special pains to maintain propulsive power, because wallowing ships are helpless.[20]

Thick layers of ice can quickly form on decks, sides, superstructures, hatches, masts, rigging, exposed machinery, antennas, and weapon systems when salt spray hits ship surfaces at subfreezing temperatures. Two feet or more totaling several hundred tons may accumulate within 24 hours in very cold climes, depending on wind velocities and wave heights. Seaworthiness and combat effectiveness then suffer from top heaviness and increased wind resistance.[21]

Small Craft and Boats. Amphibious landing craft and naval special operations boats are especially sensitive to wind, waves, and surf. *Cyclone* class patrol boats, the most seaworthy vessels currently available to U.S. SEALs, are fully functional through Sea State 5 (winds 22 to 27 knots, waves 10 to 12 feet, or 3 to 4 meters, high), but struggle to survive stronger storms.[22] Personnel transfers from seagoing "buses" to small boats are tricky under perfect conditions and fearful when they are not. One SEAL team aboard a slam-dunking tugboat on a training exercise in the frigid North Sea first fought to keep its six Boston whalers from washing overboard, then watched 50-knot winds flip three of them like flapjacks when they were lowered into foaming water. Forty-two heavily laden shooters had to time the swells, leap toward the boats, and pray they wouldn't be crushed or chewed by propellors.[23]

IMPACT ON CONVENTIONAL AIR WARFARE

Military aviators almost everywhere in peacetime must comply with visual and instrument flight regulations (VFR, IFR). VFR limitations for land-based, fixed-wing U.S. military aircraft generally prescribe a ceiling of at least 1,200 feet (365 meters), visibility of 3 statute miles (4.8 kilometers) at destinations as well as departure airfields, and minimum distances above, below, and around clouds en route. Lower ceilings or poorer visibility obligate pilots to file IFR flight plans.[24] VFR for land-based helicopters are more lenient.[25] U.S. aircraft carrier captains, who generally determine whether weather is agreeable for takeoffs and landings, consider prospects for successful recovery at suitable bases ashore as well as aboard the mother ship.[26] All armed forces shelve peacetime restrictions when combat or other high priority operations commence, because assigned missions then take precedence over safety.

Clouds and Fog. U.S. bomber crews during World War II fought weather along with Japanese adversaries on Umnak Island in the Aleutians, where fog was so dense that crew members poked their heads out of open windows to help pilots stay on taxi strips and steer straight courses down runways.[27] Bad weather all the way from air bases in England to drop and landing zones in Holland during Operation *Market Carden* on September 19, 1944, turned the third wave into a disaster—fewer than half of the troop transports and gliders laden with desperately needed reinforcements and supplies found their way through the "soup" to intended destinations.[28]

Technological improvements make life much easier for modern airmen, but "socked in" airports and low ceilings still ground them occasionally regardless of pressing requirements, and low ceilings sometimes obscure approaches to target areas. U.S. and allied troops at

highland outposts in Vietnam, for example, lacked close air support (CAS), assistance from gunships, and aerial resupply for all or most of many days during rainy seasons. High-performance, fixed-wing CAS aircraft at such times were limited to low-level, low-angle avenues that maximized their exposure to enemy air defense weapons and small arms (see chapter 19 for weather details in Vietnam and Laos). NATO more recently canceled or diverted nearly 360 military airlift missions in mid-December 1995, thereby delaying its initial buildup in Bosnia for more than a week.[29]

Barometric Pressures. All aviators set altimeters to reflect barometric pressure at departure airfields before they take off and update readings before they land so they always know how high they are above land or water. Accurate indications are most important for military airmen whose missions demand low-level or nap-of-the-earth flights through mountainous terrain under blacked out or murky weather conditions. Barometric pressures, together with temperatures and humidity, determine air density, which limits the ability of any given type aircraft to get off the ground with any given load and thereafter perform effectively. Heavy air that is common on cold days at sea level provides the best possible lift, but density decreases when thermometers climb. Altitude thins Earth's atmosphere so rapidly that regulations require U.S. military air crews to use supplemental oxygen when cabin altitude exceeds 10,000 feet (3,050 meters),[30] although SS *Hauptsturmführer* (Captain) Otto Skorzeny proved that fantastic feats are possible in thin air when he landed 12 gliders atop Italy's boulder-strewn Gran Sasso Mountain in 1943, snatched Benito Mussolini from his Italian custodians, and whisked him away in a light airplane.[31] Lieutenant Colonel Maden of the Nepalese Army conducted the world's highest helicopter rescue on May 13, 1996, when he plucked two half frozen survivors off Mount Everest at 19,200 feet (5,850 meters), then flew them to a hospital in Katmandu.[32]

Winds. Wind velocities and vectors strongly affect military air operations in many ways that civilian fliers seldom experience. Expeditionary airfield users cannot switch runways every time strong crosswinds develop because they possess only one runway, so prevailing winds dictate the orientation of these fields. No ocean liner or cruise ship ever deliberately heads *toward* a storm, as carrier commanding officers often do in search of sufficient "wind over deck" (20 sustained knots or more) to launch and recover fixed-wing aircraft. Psychological operations (PSYOP) leaflets are worthless when winds blow in the wrong direction.[33] Paratroopers of the 82nd Airborne Division had to accomplish their missions in July 1943 despite 35-mile-an-hour winds that scattered them across Sicily and slammed them against stone walls in the dead of night.[33] Efforts to rescue U.S. hostages that Iranian radicals held in Teheran (1980) failed when three of the eight mission-essential helicopters aborted, one because wind-blown dust storms turned it back.[34]

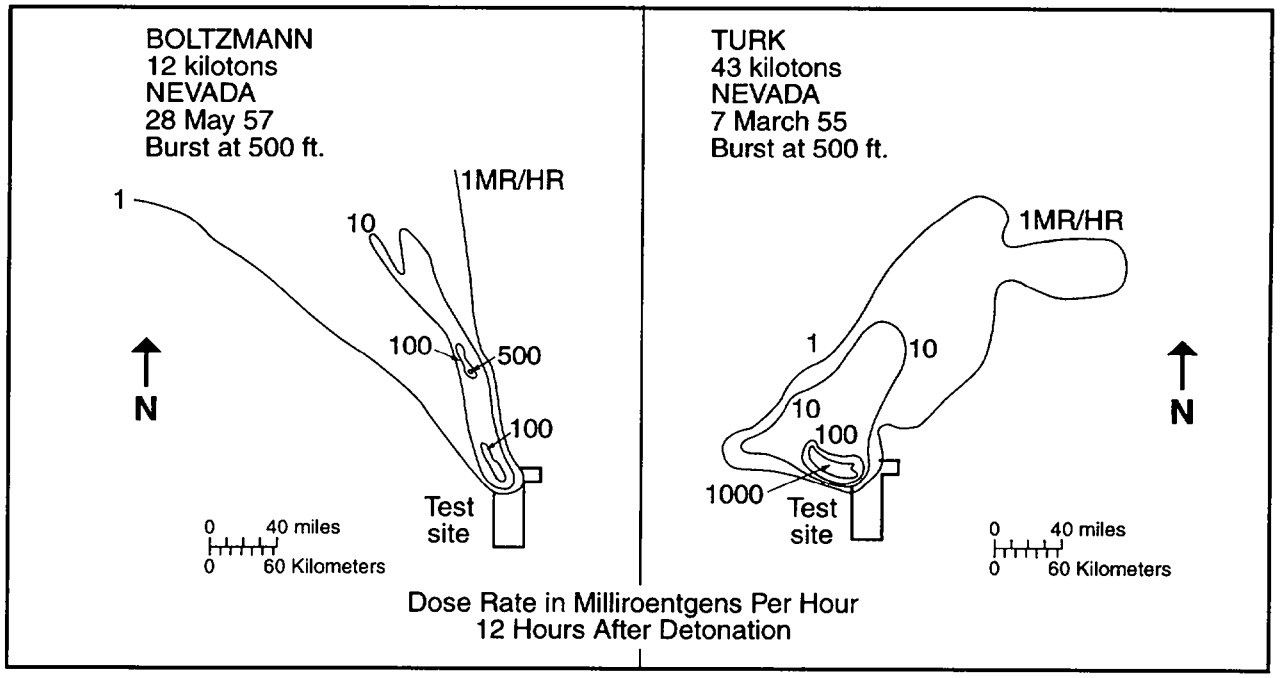
IMPACT ON NUCLEAR, BIOLOGICAL, AND CHEMICAL WARFARE

Nuclear weapons respond to weather in several ways, of which winds on the surface and aloft perhaps are most important. Chemical and biological warfare (CW, BW) agents are sensitive to several atmospheric phenomena under somewhat different conditions.

Nuclear Weapons. Low air bursts beneath clouds amplify thermal radiation by reflection, whereas heat from bursts above cloud blankets bounces back into space. Heavy precipitation raises the temperature at which thermal radiation will ignite given materials and reduces the spread of secondary fires. Detonations after dark increase the range at which

flashes from nuclear explosions blind unprotected viewers. Blasts on, beneath, or at low altitudes above Earth's surface suck enormous amounts of debris up the stems of mushroom clouds that drift downwind. The heaviest, most contaminated chaff falls back near ground zero within a few minutes, but winds aloft waft a deadly mist hundreds or thousands of miles. The size, shape, and potency of resultant radioactive fallout patterns differ with wind speeds and directions, because terrain shadows, crosswinds, and local precipitation sometimes create hot spots and skip zones within each fan. Fallout from one test conducted atop a tower in Nevada, for example, drifted northeast and retained strong radioactive concentrations around ground zero, while a second test from the same tower on a different date featured a "furnace" that was seven times hotter than its immediate surroundings 60 miles (95 kilometers) northwest of the test (figure 18). Such erratic results are hard to predict even under ideal conditions.[35]

Figure 18. ***Nuclear Fallout Related to Wind***



Biological Warfare Agents. Biological warfare agents conceivably could create international chaos on a grand scale by infecting enemy armed forces, civilian populations, livestock, and crops en masse. Small laboratories can generate BW products so quickly in militarily significant quantities that refrigerated storage facilities no longer are necessary, but microbiol pathogens and toxins as a rule last only a few hours when exposed to high temperatures and low humidity inside bombs, missile warheads, spray tanks, and artillery shells. Some biological munitions, inherently unstable, can neither tolerate sharp strains associated with projectile flights nor stand direct sunlight.[36]

Chemical Warfare Agents. Chemical warfare agents, in sharp contrast, thrive under weather conditions that biological weapons cannot tolerate. Heat and humidity help rather than hinder. Mustard and lewisite are particularly effective in hot weather, because

perspiration promotes blisters. Protective clothing, masks, and gas-proof shelters are the best insurance against CW weapons of any kind, but fatigue followed by heat prostration afflicts personnel who "button up" very long in warm climes, while air conditioned facilities that lack fool-proof filters become death traps. Persistent agents laid down as liquids last longer than aerosols and are less sensitive to vagrant winds, so chemical warfare specialists advise commanders to initiate vapor attacks when breezes blow in the right direction between three and seven knots, to avoid rainy days, and to wait for temperature inversions that trap agents in the lowest layer of air.[37]

IMPACT ON ELECTRO-OPTICAL OPERATIONS

Active and passive electro-optical (E-O) systems include image intensifiers, typified by night vision goggles; infrared devices, such as night sights; laser designators, some of which assist "smart" munitions; and low-light-level television sets able to "see" in the dark. Research and development laboratories are rapidly expanding and improving existing inventories.

Adverse Atmospheric Influences. Windblown dust, fog, haze, high humidity, clouds, and precipitation degrade or defeat all E-O systems that gather visible light. Long wave lengths are less affected than short waves, although resolution is fuzzier. Atmospheric refraction, often less obvious than a mirage, can make targets seem to move (even disappear) in shimmering surface air and otherwise reduce electro-optical effectiveness. Heat is the most common cause of that phenomenon, but similar distortions sometimes appear above snow-covered ground when temperatures are well below freezing. Infrared and millimeter wave sensors, which depend on thermal contrasts to differentiate targets from backgrounds (warm engines, for example, concealed in cool woods), cannot discriminate as well as users would like when winds, rain, snow, or insulating clouds make temperature differences indistinguishable, so experimental programs continue apace.[38]

Inadequate Light. Military operations in the past typically were timed to begin just before dawn, then continue in daylight, because few armed forces were well prepared for armed combat after dark. Light enhancement tools may some day enable soldiers, sailors, airmen, and marines to "own the night," but research and development technicians first must solve several weather-related problems. Too much light sometimes defeats night vision devices on relatively clear nights when the moon is full or nearly so, because amplifications so saturate viewing areas that light and dark almost merge. Too little light may be available on overcast nights that conceal starlight when the moon is dark or down. Most night vision implements now on the market are miniaturized compared with predecessors even a few years ago, yet remain too bulky for facile employment by foot troops. Research and development goals accordingly concentrate on sharper resolution, better depth perception, longer range, stereoscopic capabilities, smaller size, reduced weight, and greater overall versatility.[39]

IMPACT ON DIRECTED ENERGY WEAPONS

Directed energy weapons, which attack at the speed of light, occupy two basic categories. Electromagnetic beams embrace high-energy lasers (HEL) and high-powered microwaves (HPM). Particle beams include charged particle beams (CPB) and neutal partical beams (NPB).

Electromagnetic Beams. Atmosphere interferes with electromagnetic beams in at least four important ways:[40]

- *Scatter* occurs when beams strike clouds, fog, invisible vapors, dust, smoke, and other matter buoyed by air.
- *Absorption* occurs simultaneously for similar reasons.
- *Blooming* occurs when heated air makes beams expand and splay.
- *Turbulence* occurs when up-down drafts, cross currents, heat waves, and other atmospheric phenomena disrupt beams, the efficiency of which may fall by a factor of 100 to 300 within a few miles

Particle Beams. Particle beams differ from lasers in that they project a stream of highly energetic electrons, protons, neutrons, hydrogen atoms, or ions rather than radiant photons. Charged particle beams propagate well in Earth's atmosphere regardless of weather, but ranges at this writing are strictly limited. Weather is irrelevant with regard to neutral particle beams, which propagate only in the vacuum of space.[41]

IMPACT ON MILITARY PERSONNEL

Military men and women exposed daily to the elements cannot decide whether extreme heat or extreme cold is worse, but informal polls put one or both of those abominations at the bottom of almost everybody's list, regardless of individual tolerances, physical conditioning, and degrees of acclimatization. Cold coupled with bitter winds and heat coupled with high humidity are the worst weather combinations by consensus.

Cruel Cold. Dry cold below freezing encourages frostbite among poorly clothed and trained personnel. German Armed Forces in Russia suffered 100,000 casualties from that cause during the winter of 1941-1942, of which 15,000 required amputations. Human breath turned to icicles in that brutal cold, eyelids froze together, flesh that touched metal cold-welded, gasoline accidentally sprayed on bare skin raised blisters the size of golf balls, butchers' axes rebounded like boomerangs from horse meat as solid as stone, and cooks sliced butter with saws. Dehydration, contrary to popular misconceptions, can be prevalent in frigid weather when personnel exhale bodily moisture with every breath. Low temperatures, which inhibit clotting, cause wounds to bleed more freely, and severe shock due to slow circulation sets in early unless treated expeditiously. U.S. medics armed with morphine for that purpose once kept syringes in their armpits so they would be warm enough to work when needed. High-Altitude High-Opening (HAHO) parachutists who exit aircraft in subzero temperatures experience extreme chill when they free-fall for 30 minutes or more at a terminal velocity of 120 miles per hour (193 kph). Survival often becomes the only practicable objective of forces on the ground when wind chill factors plummet far below freezing. [42]

Wet cold is even more debilitating in some respects. Crippling trench foot, a classic casualty producer, is caused by prolonged immersion of lower legs and feet at temperatures a bit above freezing. Prominent symptoms begin with numbness, followed by swelling, terrible pain and, in untreated cases, gangrene. During World War II, in the European Theater of Operations, trench foot assumed epidemic proportions among U.S. combat infantrymen who for days on end waded rather than marched through chilly muck, lived in water-filled foxholes, and lacked access to shelter or dry shoes and socks. More than 45,000 of them filled field hospitals to overflowing between November 1944 and February 1945, a loss equivalent to the front-line rifle strength of 10 divisions.[43]

Oppressive Heat. Armed forces in enervating heat face a different set of difficulties. Water consumption soars to prevent dehydration, since exertions over an 8-hour period in 100 °F (38 °C) heat demand about 15 quarts a day (14 liters). Logisticians in the desert are hard pressed to supply huge loads, which amount to 30 pounds per person, or 270 tons for an 18,000-man U.S. armored division. Heat coupled with high humidity saps strength more quickly, especially when military personnel wear flak jackets or don protective clothing in anticipation of enemy chemical warfare attacks.[44] Myriad other matters attract concerted attention. Food handlers, for example, fight a ceaseless war against bacteria that contaminate unrefrigerated perishables in mobile kitchens lacking modern amenities. The rate of gum accumulations in stored gasoline quadruples with each 20 °F increase in temperature, which clogs filters and lowers octane ratings when forces deplete stockpiles slowly.

Hypothermia occurs when human body temperature drops below normal (98.6 °F), whether surroundings be cold, cool, or warm—individuals can become hypothermic in 80 °F (26.7 °C) water if immersed too long. The first visible signs may be uncontrollable shivering and impaired abilities to accomplish simple tasks. Sluggishness and amnesia appear next if body temperature continues to drop, then shivering ceases, stupor sets in, and respiration slows. Heart failure, internal bleeding, and death occur below about 78 °F (25.6 °C) unless warmth, dry clothing, and perhaps stimulants reverse that process in time.[45] Combat swimmers in seas between 60 and 40 °F wear wet suits that trap a thin layer of warm water next to their skin (synthetics that "breathe" better than rubber are preferred materials). Watertight dry suits over thermal underwear are essential in colder water.[46]

KEY POINTS

- Weather and climate influence almost every military activity on land, at sea, and in the air during peacetime as well as war.
- Military strategists and long-range planners rely on climatological statistics that observers in many locations around the world have collected over periods that usually span many years.
- Military tacticians and short-range planners rely primarily on current weather forecasts that seldom peer more than a few days into the future.
- All atmospheric phenomena and ambient light levels influence operations by all military services in various ways and differing degrees
- Extremely hot and cold temperatures, high humidity, water-logged soils, and snow-covered terrain impose critical constraints upon ground forces.
- High winds, stormy seas, extremely cold temperatures, and sea ice impose critical constraints upon surface navies.
- Low cloud ceilings, low visibility, winds, air currents, and barometric pressures impose critical constraints upon land-based and naval air operations.

NOTES

1. Carlo d'Este, *Patton: A Genius for War* (New York: Harper Collins, 1995), 685-688.
2. John S. D. Eisenhower, *The Bitter Woods* (New York: G. P. Putnam's Sons, 1969), 375-430.
3. William L. Donn, *Meteorology With Marine Applications*, 1st ed. (New York: McGraw-Hill, 1946); Arthur N. Strahler, *Physical Geography*, 2d ed. (New York: John Wiley and Sons, 1963), chapters 7, 8, 10, 11; Guy Murchie, *Song of the Sky* (Boston: Houghton Mifflin, 1954).
4. *Physical Geography*, 76-78; Field Manual 34-81-1: *Battlefield Weather Effects* (Washington, DC: Dept. of the Army, December 23, 1992), 2-4, 3-6, 3-7, G10, G12, G16.
5. *The Air Almanac* (Washington, DC: Government Printing Office, issued annually).
6. FM 5-33: *Terrain Analysis* (Washington: Dept. of the Army, July 1990), B-1, B-2; FM 34-81-1: *Battlefield Weather Effects*, 2-7; *Air Force Doctrine Document 45: Aerospace Weather Operations* (Washington, DC: Dept. of the Air Force, August 31, 1994), 2-4.
7. Author's recollections as Chief, Campaign Planning Group, U.S. Army, Vietnam, 1967-1968; Harlan G. Koch, "Monsoons and Military Operations," *Military Review* 45, no. 6 (June 1965): 25-34.
8. *Physical Geography*, 182-188.
9. Ibid., 188-193; 194-255 elaborate region by region.
10. For representative guidelines, see Joint Pub 3-59: *Joint Doctrine for Meteorological and Oceanographic Support* (Washington, DC: Office of the Chairman, Joint Chiefs of Staff, December 22, 1993) and Air Force Doctrine Document 45: *Aerospace Weather*. Historical background is available in John F. Fuller, *Thor's Legions: Weather Support to the U.S. Air Force and Army, 1937-1987* (Boston, MA: American Meteorological Society, 1990).
11. William J. Cook, "Ahead of the Weather," *U.S. News and World Report*, April 29, 1996, 55-57; Kevin McManus, "Data from Weather-Observing System Sometimes All Wet," *Washington Post*, January 22, 1996, A3.
12. Christopher Ward, *The War of the Revolution*, vol. 1 (New York: Macmillan, 1952), 91-304.
13. Allen F. Chew, "Beating the Russians in the Snow: The Finns and the Russians, 1940," *Military Review* 60, no. 6 (June 1980): 38-47, and *Fighting the Russians in Winter: Three Case Studies*, Leavenworth Papers No. 5 (Fort Leavenworth, KS: U.S. Army Command and General Staff College, Combat Studies Institute, December 1981), 17-30.
14. Samuel van Valkenburg, ed., *America at War: A Geographical Analysis* (New York: Prentice-Hall, 1942), 103.
15. Leon Wolff, *In Flanders Fields: The 1917 Campaign* (New York: Viking Press, 1958), especially xii, 81-87, chapters 9 and 13.
16. *The Winter Line*, American Forces in Action Series (Washington, DC: Historical Division, U.S. War Dept., June 14, 1945), 5, 15, 88, 90.
17. FM 34-81-1: *Battlefield Weather Effects*, appendices B-D, H, J.
18. S. L. A. Marshall, *Infantry Operations and Weapons Usage in Korea, Winter 1950-51* (Chevy Chase, MD: Operations Research Office, Johns Hopkins University, 1951), 21, 94, 101.
19. *U.S. Navy Cold Weather Handbook for Surface Ships* (Washington, DC: Chief of Naval Operations, Surface Ship Survivability Office, OP 03C2, May 1988), 2-9 to 2-11, 6-5-6-7, 6-10, 7-1, 8-1 to 8-4.
20. Ibid., 8-1 to 8-4
21. Ibid., 2-1 and 2-2, 2-4, 7-1.
22. "Special Boat Section," *Naval Special Warfare Command Fact File* (Coronado, CA: January 1993); *What Is Naval Special Warfare?*, undated (1993), 8, 11, 25-28, 30-37.
23. Richard Marcinko, *Rogue Warrior* (New York: Pocket Books, 1992), 250-254.
24. Air Force Instruction 11-206: *General Flight Rules* (Washington, DC: Dept. of the Air Force, July 25, 1994), chapters 7-8; OPNAV Instruction 3710.7Q: *NATOPS General Flight and Operating Instructions* (Washington, DC: Office of the Chief of Naval Operations, May 1, 1995), 5.10-5.15;

Army Regulation 95-1: *Flight Regulations* (Washington, DC: Dept. of the Army, May 30, 1990), 9-10, 21-23.

25. For weather effects on helicopter operations, see *Aviation Weather,* 16 student handouts 2/5/9/9E-0525-23 (Fort Rucker, AL: U.S. Army Aviation Center, 1995).

26. *NAVAIR 00-80T-105:CV NATOPS Manual* (Washington, DC: Naval Air Systems Command, December , 1985), 5-18 and 5-19; Steve York, *Meteorological and Sea Surface Effect Upon Naval Aviation,* memorandum to the author, June 1996.

27. Brian Garfield, *The Thousand Mile War: World War II in Alaska and the Aleutians* (Garden City, New York: Doubleday, 1969), 114.

28. Cornelius Ryan, *A Bridge Too Far* (New York: Simon and Schuster, 1974), 416-418.

29. *Warfighting and Weather: Bosnia—1995,* a briefing slide (Washington, DC: Office of the Director, Air Force Weather Service, undated,1996); "Fog Again Prevents U.S. Forces From Reaching Tulza," *Washington Post,* December 18, 1995, 16.

30. Air Force Instruction 11-206, 16; OPNAV Instruction 3710.7Q, 8-4.

31. Glenn B. Infield, *Skorzeny: Hitler's Commando* (New York: St. Martin's Press, 1981), 29-45.

32. Jerry Adler and Rod Nordland, "High Risk," *Newsweek,* May 27, 1996, 55, 57.

33. John R. Galvin, *Air Assault* (New York: Hawthorne Books, 1969), 97-110.

34. *Rescue Mission Report* (The Holloway Report) (Washington, DC: Joint Chiefs of Staff Special Review Group, 1980), 9-10, 38-45; James H. Kyle, *The Guts to Try* (New York: Orion, 1990), 246-255; Paul B. Ryan, *The Iranian Rescue Mission* (Annapolis, MD: U.S. Naval Institute Press, 1985), 67-75.

35. DA Pamphlet 39-3: *The Effects of Nuclear Weapons,* rev. ed. (Washington, DC: Government Printing Office, February 1964), 436-488.

36. *Technologies Underlying Weapons of Mass Destruction* (Washington, DC: Office of Technology Assessment, December 1993), 103, 105; *The Problem of Chemical and Biological Warfare,* vol. 2, CB Weapons Today (New York: Stockholm International Peace Research Institute, 1973), 37-48, 61-72; Terrance and Kathleen White, "Biological Weapons: How Big Is the Threat?" *International Defense Review,* August 1990, 843, 845.

37. FM 21-40: *Chemical, Biological, and Nuclear Defense* (Washington, DC: Dept. of the Army, October 15, 1977), chapters 1 and 5; *ABC Warfare Defense Ashore,* Technical Publication PL-2 (Washington, DC: Bureau of Yards and Docks, Dept. of the Navy, April 1960), chapters 2-4.

38. FM 34-81-1: *Battlefield Weather Effects,* appendix F.

39. Glenn W. Goodman, Jr., "Owning the Night," and John G. Roos, "Generation Gap," *Armed Forces Journal International* (May 1996): 40, 43-45; Robert G. McClintic, "Rolling Back the Night," *Army* 19, no. 8 (August 1969): 28-35.

40. Kosta Tsipis, "Laser Weapons," *Scientific American* (December 1981): 54-57.

41. "Report to the APS of the Study Group on Science and Technology of Directed Energy Weapons: Executive Summary and Major Conclusions," *Physics Today* (May 1987): S-8, S-10.

42. FM 34-81-1: *Battlefield Weather Effects,* L-1 through L-3; U.S. *Navy Cold Weather Handbook for Surface Ships,* 9-2, 10-1, 10-6, 10-7.

43. Graham A. Cosmas and Albert E. Cowdrey, *Medical Service in the European Theater of Operations,* U.S. Army in World War II (Washington, DC: U.S. Army Center of Military History, 1992), 488-496; *U.S. Navy Cold Weather Handbook for Surface Ships,* 9-2, 10-6.

44. FM 34-81-1: *Battlefield Weather Effects,* L-3 through L-6.

45. *U.S. Navy Cold Weather Handbook for Surface Ships,* 9-1, 10-4 and 10-5.

46. Peter B. Bennett and David H. Elliott, eds., *The Physiology and Medicine of Diving,* 4th ed. (Philadelphia, PA: W. B. Saunders), 302-341.

6. REGIONAL PECULIARITIES

Den Brer Rabbit talk mighty 'umble."I don't keer w'at you do wid me, Brer Fox," sezee, "so you don't fling me in dat briar-patch. Roas' me, Brer Fox," sezee, "but don't fling me in dat briar patch," sezee.

Joel Chandler Harris,
"The Briar Patch," *Uncle Remus: His Songs and His Sayings*

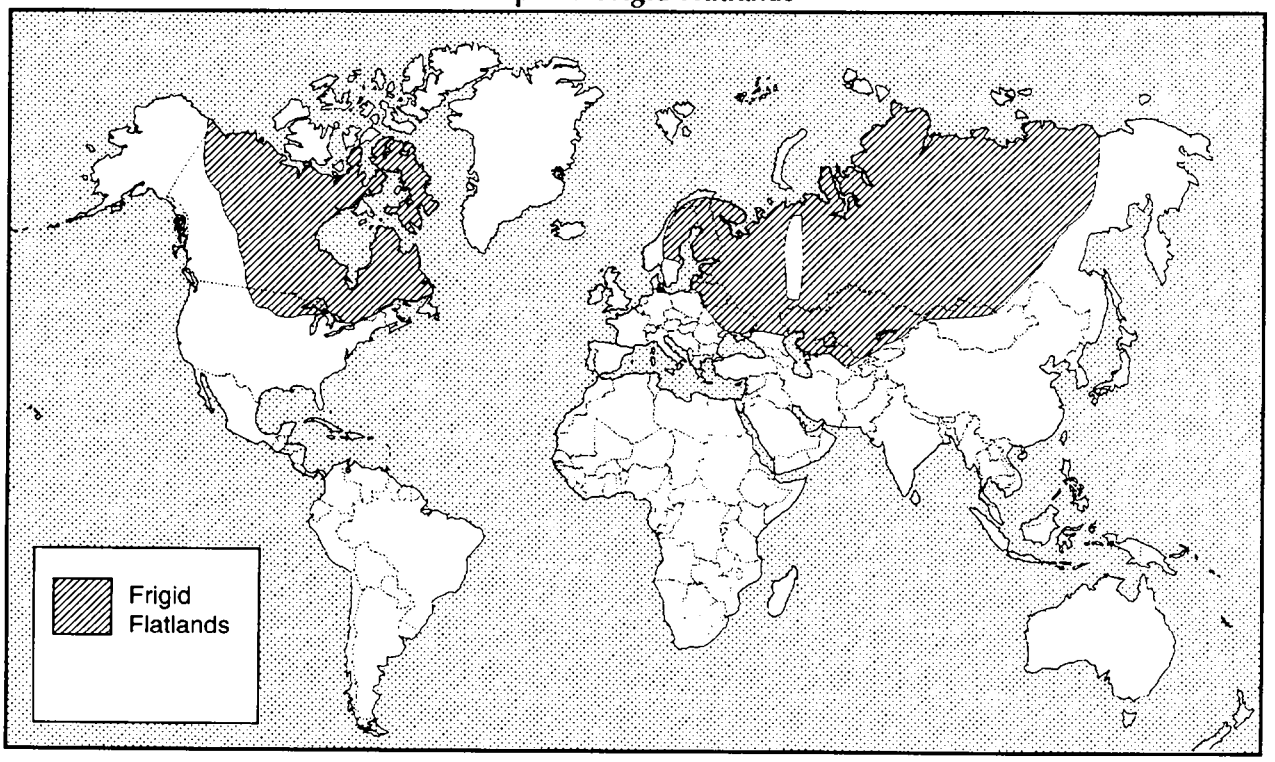
READINESS TO ACCOMPLISH ASSIGNED MISSIONS WHEREVER AND WHENEVER REQUIRED HAS BEEN AN imperative military objective since time immemorial. Preparations, however, must suit situations, because neither man nor beast can be equally well prepared for every eventuality. Brer Rabbit, "bred and bawn in a briar-patch," knew he could out-fox Brer Fox in the brambles, but was bound to lose on bare ground. Military machines tailored to suit any given situation on land, at sea, in the air, or in space similarly function most effectively in disparate environments only after they satisfactorily modify strategies, tactics, techniques, weaponry, equipment, clothing, and supplies.

Wise commanders, well aware that every geographical area of responsibility (AOR) possesses unique spatial relationships, topography, oceanographic characteristics, weather, and climate, honor the Principle of Regional Peculiarity, which posits, "Armed forces perform best when organized, equipped, and trained to accomplish particular missions in particular geographic locales."[1] The following discourse, which incorporates considerations covered in chapters 1 through 5, addresses seven distinctive regions that affect military operations in markedly different ways: frigid flatlands; frigid seas; mountains; deserts; forests; wetlands; and coastal waters.

FRIGID FLATLANDS

Most military activities on polar ice caps thus far have been confined to scientific investigations such as those at Camp Century, near Thule, Greenland, and Little America in Antarctica.[2] There is no evidence that competition for potentially valuable resources beneath those wastelands will soon culminate in armed combat, but perennially and seasonably frigid flatlands that extend as far south as the northern United States, much of European Russia, and central Siberia have seen vicious wars in the past and likely will again (map 12).[3]

Map 12. *Frigid Flatlands*



PERSONAL SURVIVAL

Military manuals and commanders invariably emphasize mission accomplishment, but subordinates exposed to killing cold often put personal survival first. Robert W. Service noted one offbeat technique in his poem about Sam McGee, a poorly acclimated prospector who begged to be cremated just before he succumbed on a frigid night in Alaska:

> And there sat Sam, looking cool and calm, in the
> heart of the furnace roar.
> And he wore a smile you could see a mile, and
> he said, "Please close that door.
> It's fine in here, but I greatly fear you'll let in
> the cold and storm—
> Since I left Plumtree down in Tennessee, it's
> the first time I've been warm."[4]

Real world warriors unfortunately find Sam McGee's solution an unsatisfactory way to prevent disabling frostbite, hypothermia, dehydration, and cold-related diseases such as influenza in regions so frigid that spit crackles before it hits the ground and human flesh freezes in less than a minute after exposure to cruel winds. Practical measures then become crucially important to combat forces and logistical troops alike.[5]

Arbitrary cold weather uniform regulations are inadvisable, because metabolisms differ and cold-wet/cold-dry requirements are dissimilar in some respects, but six or seven layers of clothing that are relatively light, loose, wind resistant, waterproof, and warm are preferable

to one or two heavy garments in any case. Typical articles include long underwear, a woolen shirt and trousers, quilted coat and trouser liners, wind-breaker jacket and trousers, a pile cap with earflaps, a fluffy face mask, a parka liner, and parka. Cushion-sole socks, vapor boots (best for use with skis, snow shoes, and by troops in static positions), mukluks, gloves (preferably mittens), and a white camouflage suit round out each individual's wardrobe. Body armor adds bulk and weight, but goggles or other protection against snow blindness do not.

Combat and support troops engaged in strenuous activities must guard against overdressing, which can be just as injurious as overexposure if excessive perspiration leads to exhaustion or evaporation causes bodies to cool too rapidly. Experienced personnel consequently unbutton, unzip, or shed clothing to ensure proper ventilation whenever necessary. Chemical warfare in cold climes poses two special risks: impervious protective shells, which must be baggy enough to slip over all other layers, are virtually impossible to vent; rubber masks cannot be worn over beards, remain pliable enough to ensure an air-tight fit only when warm, and encourage frostbitten faces in any cases.[6]

Shelter. Shelters frequently spell the difference between life and death in frigid regions. Not many troops are as fortunate as U.S. peacekeepers in Bosnia, who soon after arrival were able to rotate between the field and elaborate modules where they warmed themselves during the winter of 1995-96, enjoyed hot meals, laundered dirty uniforms, slept on cots, and relaxed for 3 days at a time until the next batch of 550 arrived at one of six such "cities."[7] Most military personnel in wintry areas of operation instead occupy small-to-medium-sized tents. Unlike Ringling Brothers, Barnum, and Bailey Circus, which formerly used elephants to help roustabouts erect and strike Big Tops, they must unfurl heavy canvas stiff with cold (usually in the dark), try to drive tent pegs into tundra frozen harder than bricks (perhaps aided by explosives), build snow walls to ward off howling winds, then chop out before they displace. Base camps generally boast wooden floors, while warm sleeping bags atop air mattresses or other insulating materials are obligatory on bare ground. Troops in the open occasionally construct expedient shelters such as igloos and snow caves, which insulate as well as rock wool or fiber glass, but truck cabs and armored vehicles make poor bedrooms, because carbon monoxide is an ever present danger, and cold, hard surfaces rob sleepers of warmth.[8]

Food and Water. Generous, lightweight, well-balanced, nutritious, and preferably warm rations are essential in very cold weather, especially for troops engaged in strenuous activities. The U.S. Army sets 4,500 calories per day as a goal, although Finnish counterparts with greater practical experience recommend 6,000. Sweets make excellent instant-energy snacks between regular meals. Commanders and cooks must constantly bear in mind that food not in well-insulated containers will freeze in transit between kitchens and consumers. Each individual moreover requires 4 to 6 quarts (liters) of drinking water per day to prevent dehydration in cold weather, although adequate sources are difficult to tap when streams turn to ice. Five-gallon (18-liter) cans as well as canteens freeze fast in subzero temperatures, even when first filled with hot water. Problems compound when logisticians factor in water for hygienic purposes, not to mention huge amounts needed to decontaminate units hit by persistent chemical warfare agents.[9]

Leadership. Physical fitness, acclimatization, and training may prepare military men and women for cold weather warfare, but ample food, proper clothing, and adequate shelter

cannot sustain them if a sizable percentage, bundled from head to foot against the cold, nearly deaf and blinded by parka hoods, begin to hibernate. Strong junior officers and noncommissioned officers then become truly indispensable, for units can disintegrate and missions fail under such conditions.

MATERIEL MAINTENANCE

Big maintenance problems begin to develop at about -10 ^{0}F (-23 ^{0}C) and intensify with every degree that thermometers drop thereafter:

- Lubricants stiffen.
- Metals lose tensile strength.
- Rubber loses plasticity.
- Plastics and ceramics become less ductile.
- Battery efficiencies decrease dramatically.
- Fuels vaporize incompletely.
- Glass cracks when suddenly heated.
- Seals are subject to failure.
- Static electricity increases.
- Gauges and dials stick.

Combustion engines are hard to start, partly because battery output at best is far below normal (practically zero at -40 ^{0}F and -40 ^{0}C). Tires inflated in garages at moderate temperatures slip on rims and rip off valve stems when trucks drive out the door into extreme cold. The value of collapsible fuel bladders is dubious below about -20 ^{0}F (-29 ^{0}C), cold-soaked connectors, control knobs, and electrical contacts are hard to assemble and repair, and fiberglass water trailers freeze because they cannot tolerate immersion heaters. Flammable fuels are apt to erupt unless motor vehicles and tent stoves are properly grounded. Maintenance man-hours required to cope with such problems balloon in the absence of heated facilities. More of almost everything is needed: more mechanics, more battery chargers, more replacement parts, more fuel. Different oils and greases also are required.[10]

Cold weather increases aircraft maintenance difficulties by at least one order of magnitude, greater in the absence of overhaul hangars. De-icing is crucially important, because even a thin coating on air foils can be fatal. *Eight* F-84 fighters, for example, crashed shortly after take-off in the early 1950s, because ice that blocked jet intakes caused their engines to explode.[11]

MISSION ACCOMPLISHMENT

Whether frigid flatlands favor offense or defense is subject to conjecture. Forces on the attack benefit from blowing snow, which facilitates surprise but makes land navigation difficult for troops that lack Global Positioning System (GPS) assistance. Defenders in static observation posts benefit from blizzards that cover tracks and camouflage positions, but generally suffer more cold casualties than offensive forces on patrol. Brilliant thermal contrasts caused by hot objects against cold backgrounds—such as moving vehicles and heated tents—may benefit one side, both, or neither. Blankets of snow that reflect moonlight, starlight, and the Aurora

Borealis on long winter nights illuminate friend and foe alike. Cold weather limitations on mobility and logistics, which elementally influence mission accomplishment, are amplified below.

Overland Mobility. Infantrymen, who regularly log about 3 miles an hour on level to rolling terrain, struggle through knee-deep snow and come to a standstill when drifts are sticky or much deeper, whereas heavily laden military skiers, tutored by skilled instructors during long periods of intensive training, glide over such surfaces. Snowshoeing is less glamorous, slower, and requires greater exertion, but most troops can learn all they need to know in an hour or so. Trailbreakers normally leave early to blaze the way and, when necessary, navigate for the main body through trackless territory where few topographic features make prominent landmarks (hi-tech global positioning devices tell troops where they are but not how to set true courses).[12]

Any tendency for armed forces to be roadbound degrades military capabilities at every level, because frigid flatlands combine wretched cross-country trafficability with exceedingly sparse transportation networks. All-wheel drive trucks as a rule bog down when snows on roads measure more than one-third of wheel diameters, stall in line waiting for plows to clear the way through deep drifts, and cannot easily traverse tundra or muskeg even when the land is bare. Track-laying vehicles, which are better able to negotiate rough ground, lose traction when snows are much deeper than their ground clearance. Tank drivers who repeatedly rock back and forth trying to break through put power plants, drive trains, and sprockets under great stress and make it difficult for recovery crews to set them free if they finally go belly up. The utility of tractor-drawn cargo sleds, snowmobiles, air-cushion vehicles, and other special purpose transports skyrockets under such conditions,[13] but frozen lakes and streams make safe routes if load-bearing capacities are sufficient for vehicles of particular weights and drivers proceed single file at specified intervals. Soviet forces during the winter of 1941-42, for example, delivered substantial supplies to starving Leningrad via the "Road of Life" across Lake Ladoga, despite intense German artillery fire and aerial bombardment.[14]

Air Power. Frigid flatlands are sparsely settled except along the southern fringe. That geographic fact magnifies needs to gain and retain air superiority as soon as possible, so that air combat forces can conduct reconnaissance, deep-strike, and close-support missions while air mobility forces deploy, redeploy, supply, evacuate, and otherwise support troops on the ground. Frozen lakes and streams make extemporaneous airfields for lightly laden ski planes after engineers smooth out rough spots and helicopters enjoy large latitude in their choice of landing zones, but fighter, attack, bomber, and airlift squadrons that lack very short or vertical takeoff and landing (VSTOL, VTOL) capabilities require hard-surfaced runways.

Military air operations always are iffy in wintry weather, which often poses worse hazards than armed enemies. Improperly insulated buildings, black-topped runways, taxi strips, and parking areas collapse if they absorb enough sunshine to melt underlying permafrost. Low ceilings, ice fog, and snow storms may prevent takeoffs or landings for several consecutive days, while wind-driven drifts close airports unless cleared repeatedly. Sensible commanders suspend close air support missions when "whiteouts" drastically reduce horizontal visibility and "grayouts" distort depth perception during prolonged periods of morning and evening twilight.[15] Heliborne and parachute assaults are numbing propositions in subzero weather, as members of the U.S. 504th Parachute Infantry Regiment discovered in February 1954 during Operation *Arctic Night* near Thule, Greenland, when thermometers read -35 °F (-37

^{0}C), the airspeed was 130 knots, and the prop blast that hit them as they leaped through wide open doors was far colder than conventional wind-chill charts ever register (table 7, page 73). Only strict discipline and thoughtful preparations prevented jump injuries and cold casulaties[16]

Supply. Cold clime logistical loads expand prodigiously in response to requirements for more of almost everything from rations, clothing, tents, water heaters, and stoves to whitewash, snow plows, antifreeze, batteries, repair parts, construction materials, and specialized accouterments such as snow shoes and skis. Armed forces in wintry weather burn fuel at outrageous rates. Motor vehicles churning through snow, for example, consume perhaps 25 percent more than on solid ground. It takes 10 gallons (38 liters) of diesel per day to keep a 10-man squad tent habitable when thermometers register -20 ^{0}F (-29 ^{0}C). Additional petroleum, oil, and lubricant (POL) supplies are needed to keep distributors in business. Small wonder, therefore, that centralized logistic facilities, including field kitchens (the main source of warm meals for ground combat forces), often become tempting targets in frigid flatlands.[17]

FRIGID SEAS

Fierce seafarers dressed in wild animal skins were familiar with frigid seas long before Viking raiders invaded Ireland in the 6th century A.D. Naval interests in the North Atlantic, North Pacific, and Arctic Oceans, which intensified sharply during World War II, remained strong throughout the Cold War between the United States and the Soviet Union (1946-1989) and likely will continue to do so, because all three are strategically located.

SURFACE OPERATIONS

The subfreezing weather that creates frigid seas confines surface combatants, support ships, and merchantmen inside ice-clogged harbors much of the year unless icebreakers clear the way to open water. All crews, ships, and embarked aircraft experience many of the problems that afflict armed forces ashore and endure additional hardships that are uniquely naval.

Icebreakers. No nation has greater need for icebreakers than Russia, where only the Black Sea Fleet enjoys ice-free ports (map 1 on page 12 and map 8 on page 51). The Gulf of Finland often freezes 3-feet (1-meter) thick at Saint Petersburg and Kronstadt, which is home port for the Baltic Fleet. The Northern Fleet, ensconced near the Norwegian frontier where the Gulf Stream slightly warms the Barents Sea, is situated more favorably but still relies on icebreakers, as do ships of Russia's Pacific Fleet as far south as Vladivostok, where assistance is essential from November through March as a minimum. No naval base save Petropavlovsk-Kamchatskiy, washed by the relatively tepid Kurishio Current, has easy access to the ocean.

Russians since the late 19th century consequently have specialized in icebreakers, which not only unclog their ports during brutal winters but drive wedges between floes on high seas, locate leads in polar ice, widen such channels for ships that follow in trail, and otherwise facilitate naval operations. Icebreakers of all countries characteristically are stubby enough to maneuver in close quarters and feature broad beams designed to cut wide swaths, enough horsepower to slice paths where required without repeated ramming, cutaway bows that ride over ice instead of hitting it head on, and reinforced hulls flared to lift the ship under pressure rather than let it be crushed. Huge fuel expenditures in regions where underway

replenishment may be impossible led the Soviet Union in 1957 to develop and deploy the *Lenin*, the world's first nuclear-powered icebreaker expressly designed to bull its way through ice fields more than 6 feet (2 meters) thick and remain self-sufficient for more than a year.[18]

Housekeeping Problems and Responses. Surface ships and crews that cannot cope well with freezing temperatures, wild winds, and towering waves can anticipate cruel treatment. Routine preparations in many respects parallel those of armed forces in dank arctic regions ashore: protective clothing to shield wearers against cold weather; rations with high caloric contents; warm quarters; winterized weapons and equipment; specialized supplies; and preventive maintenance precautions.[19] Housekeeping problems peculiar to life aboard naval ships nevertheless are evident.

Cramped compartments put storage space for cold weather gear at a premium, especially on board small surface combatants such as destroyers, frigates, and corvettes. It takes about 1 cubic foot, for example, to stow the layered winter clothing of each individual, twice that much for one-piece exposure suits. Galleys generally must find room for 10 percent more food than they stock in warmer climes. Bulky drums of antifreeze, ice preventives, de-icing chemicals, and heavy bags of sand soak up precious space. So do additional repair parts needed to compensate for abnormally rapid expenditures as a direct result of severe weather. Commanders also must accommodate many awkwardly dimensioned implements, lash down impedimenta that does not fit in lockers, and assure easy access to stocks in greatest demand. What to take and what to leave behind involves painful tradeoffs.[20]

Frozen salt water spray, unknown inland, can cover decks, bulkheads, superstructures, air intakes, hatches, masts, rigging, exposed machinery, antennas, and weapon systems with thick layers of ice that increase displacement, decrease freeboard, degrade combat capabilities and, if not countered in time, endanger ship stability. Rock salt, calcium chloride, ethylene glycol, ethanol, urea, and other materials that depress the freezing point of sea water cause ice to melt at temperatures well below 28.5 ^{0}F (2 ^{0}C), but caution is advisable, because all mingle good and bad attributes. Urea emits ammonia gas and is not as efficient as salts pound per pound, but is less corrosive. Ethylene glycol, which works better than most substitutes at temperatures as low as 5 ^{0}F (-15 ^{0}C), is expensive and creates slippery surfaces. The Law of Diminishing Returns consequently determines which applications would be most cost effective and simultaneously least detrimental.[21]

Hazards Underway. Surface ships underway in arctic and antarctic waters even during summer months face hazards that no other regions duplicate. Tremendous waves on July 18, 1942, not only dumped water down the air intakes of rolling destroyers between Kodiak, Alaska, and Kiska in the Aleutian Islands but induced seasickness to such an extent that "vomit clung to every surface." Shipmates on the heavy cruiser *Indianapolis,* who almost immediately rescued a man overboard, discovered that hypothermia already had killed him. Sister ships curtsied past each other in dense fog until two blinded destroyers finally collided, then a third rammed a fourth, whereupon the task force returned to port without firing a shot.[22]

Perpetual ice packs cover the Arctic Ocean between 90^{0} and 80^{0} or so north latitude, but the irregularly shaped Marginal Ice Zone (MIZ) that forms farther south each winter sometimes extends fingers as far as Newfoundland and the Sea of Japan. Surface ships that venture into the mushy forward edge of the MIZ without icebreaker assistance may damage screws and rudders, while those that proceed too far risk major hull damage or could be

immobilized until rescuers arrive. Floes that vary from a few feet to several miles in width habitually break off from the MIZ and float south, accompanied in the North Atlantic by icebergs that primarily originate in Greenland, Baffin Island, and Svalbard.[23]

Allied convoys that carried U.S. Lend-Lease supplies from Iceland to arctic ports in the Soviet Union dodged those floating obstacles as well as enemy armed forces during World War II (maps 13 and 14). Crews on the so-called "Murmansk Run" were tethered by life lines to hawsers that stretched from bow to stern on each pitching ship. Tanks, locomotives, trucks, and crated aircraft had to be winched back into place repeatedly after wrenching motions broke their bonds. Convoy PQ-13, which left Reykjavik in March 1942, first met 100-mile-per-hour winds that scattered 19 of its cargo ships and 9 escorts over 150 miles of the Barents Sea, then came under relentless German bomber and submarine attacks. Many crewmen perished in the frigid waters or suffered from severe frostbite before 11 of 35 transports finally completed that traumatic voyage in July (three ships survived because whitewash and bedding sheets helped them blend with ice floes). [24]

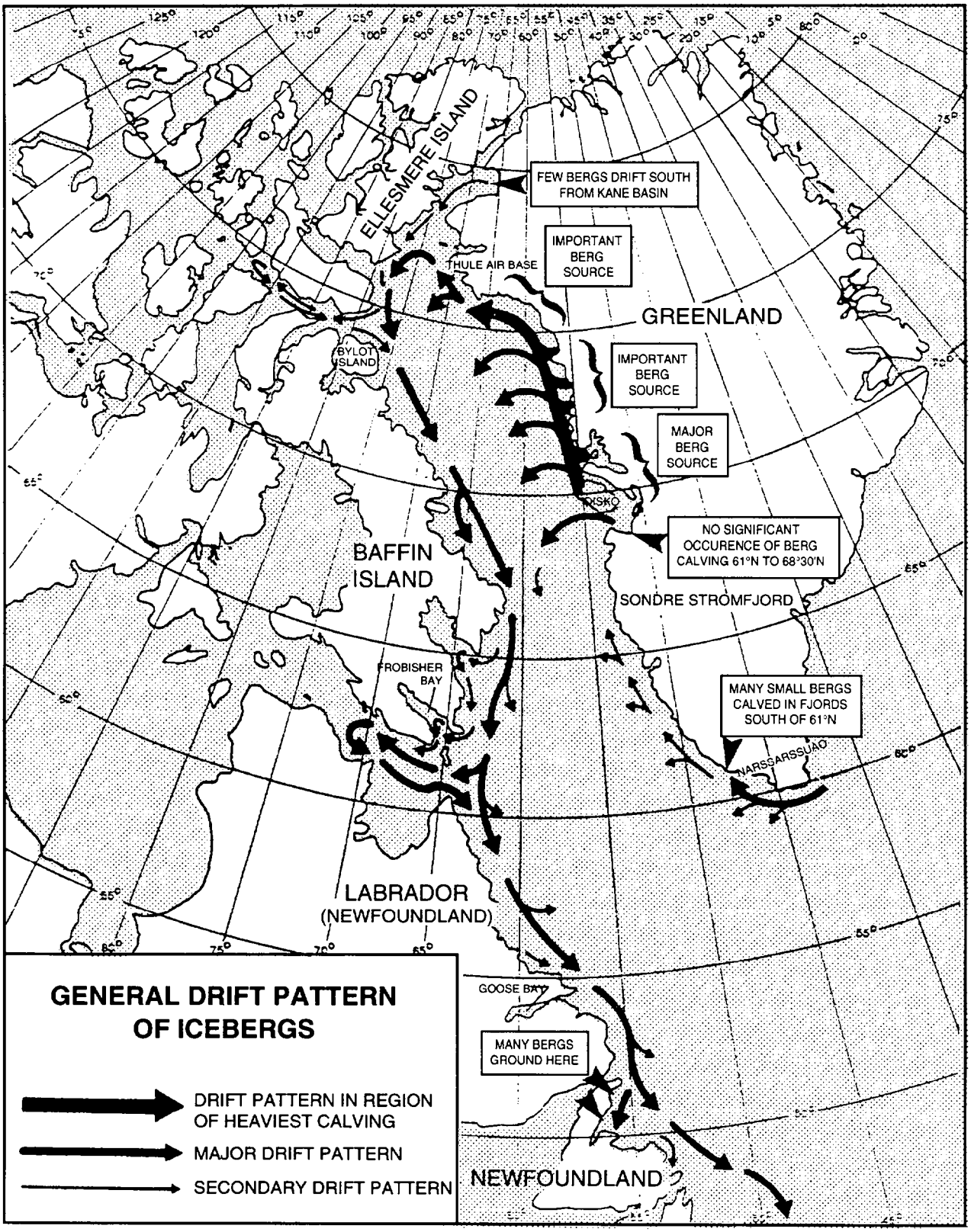
SUBMARINE OPERATIONS

The search for a Northeast Passage that skirted Siberia from the Atlantic to the Pacific Ocean started in the 16th century with four fearless navigators: Hugh Willoughby, Richard Chancellor, Stephen Burrough, and Willem Barents. Four more failed to find a Northwest Passage along what currently is Canada's arctic frontier (Giovanni da Verrazano, Sir Martin Frobisher, John Davis, and Henry Hudson). Baron Nils Nordenskiöld finally made the trip from west to east in 1878-1879 and Roald Amundson took a 3-year trek from east to west between 1904 and 1906,[25] but we now know that no militarily reliable arctic route for surface ships exists in either direction, even in summer with the aid of icebreakers.

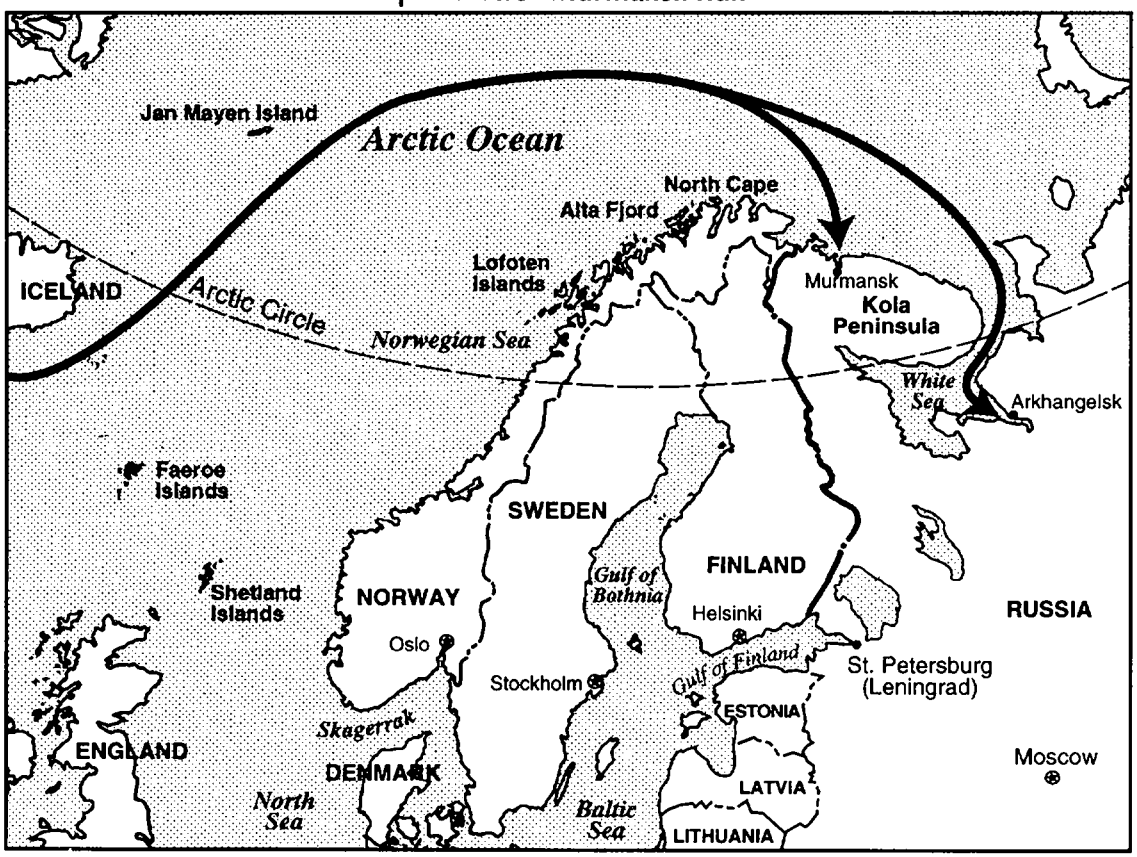
Naval operations *beneath* ice-filled seas nevertheless have been feasible since the U.S. nuclear-powered attack submarine *Nautilus* (SSN-571), equipped with special sonar and navigational gear, crossed under the polar ice pack en route from Seattle, Washington, to the Atlantic Ocean in August 1958.[26] The *Skate* (SSN-578), with a hardened sail and other novel features, surfaced though heavy ice the following year (map 15).

Soviet ballistic missile submarines occupied bastions beneath the Barents Sea and the Sea of Okhotsk late in the Cold War, but naval strategists and tacticians believe that cat-and-mouse competition could spread to other peripheral seas in Marginal Ice Zones south of the Arctic Ocean. Oceanographers, who are amassing detailed intelligence concerning bathymetry, topographic characteristics, water densities, bio-acoustics, sound transition, and ambient noise, conclude that the floating canopy of sea ice, which measures from 1 to more than 100 feet (30 meters) thick, is rock hard on top, has the consistency of cheap concrete below, is a dynamic mass under constant thermal stress, and moves sluggishly in predictable directions under the influence of currents and prevailing winds. Underneath, it constitutes an upside down world of bad lands, buttes, blocks, ridges, spires, hills, dales, planes, open cracks, lakes, and massive imprisoned icebergs, all superimposed above a similar landscape that shapes the floor.[27] Submarines able to operate most effectively in that complex environment could safely ignore high speed and deep submergence abilities but need an array of sophisticated navigation and target acquisition/tracking sensors that scan 360 degrees front and rear, left and right, above and below. Reliable ways to surface through solid ice also seem obligatory, because crews otherwise would perish if air supplies failed for any

Map 13. *Iceberg Routes to the North Atlantic*



Map 14. *The "Murmansk Run"*

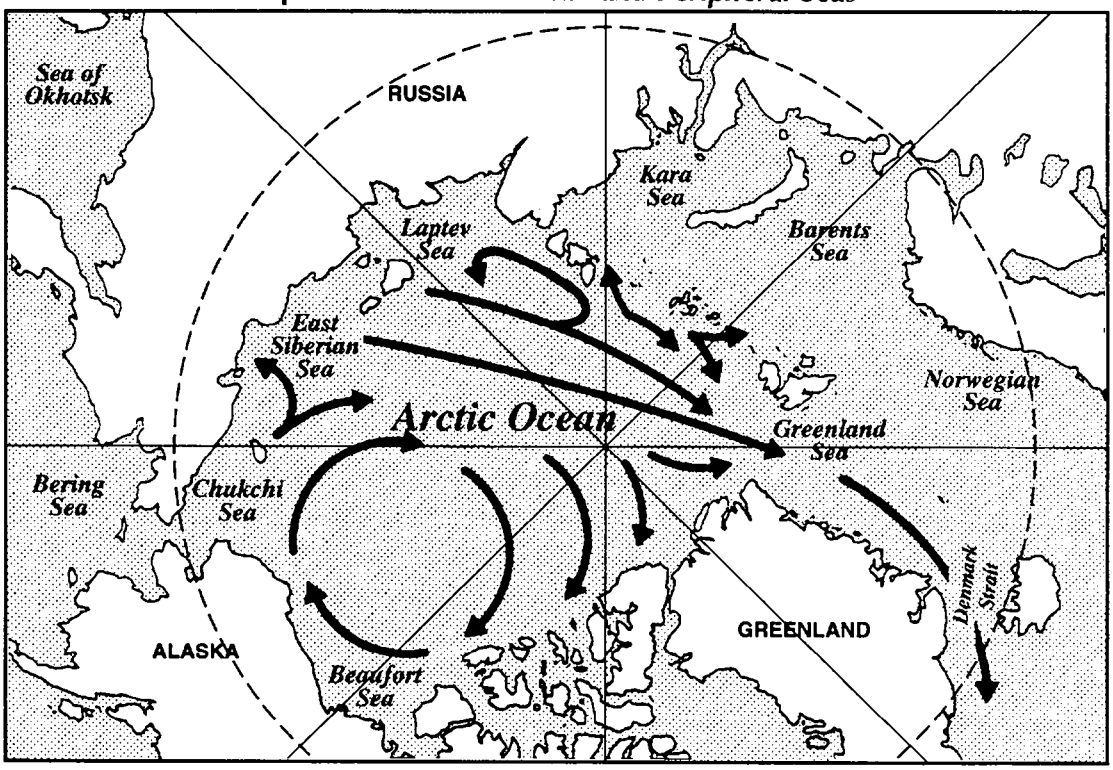


reason. Combat could be likened to jungle warfare in at least one respect: heavily armed defenders could silently wait until adversaries creeping through the clutter come within reach, then trigger ambushes. The quest for offensive countermeasures consequently emphasizes stealthiness and abilities to differentiate friends from foes quickly at close quarters. Some authorities also believe that stubby, ellipsoidal submarines should replace long, cigar-shaped models that cannot maneuver well in tight spaces.[28]

MOUNTAINOUS REGIONS

Imposing mountains that girdle the Pacific Basin and cut across Eurasia, together with high hills on every continent save Australia, constitute almost half of Earth's surface above sea level (map 16). All ranges, chains, and cordilleras large and small feature compartmented topography, steep gradients, and few high speed avenues, but latitudes, elevations, shapes, soils, hydrology, vegetation, and climate nevertheless produce distinctive variations.[29] Snow-covered European Alps are quite unlike the relatively low but rugged Sierra Maestras that harbored Fidel Castro and his revolutionary band before they overthrew Cuban dictator Fulgencio Batista in 1959.[30] Sere spires in the Sahara and neighboring Sinai only faintly resemble forested slopes in rain-drenched Vietnam. The military implications of mountainous regions moreover are controversial, because tactical advantages sometimes become strategic liabilities, and vice versa.

Map 15. *The Arctic Ocean and Peripheral Seas*



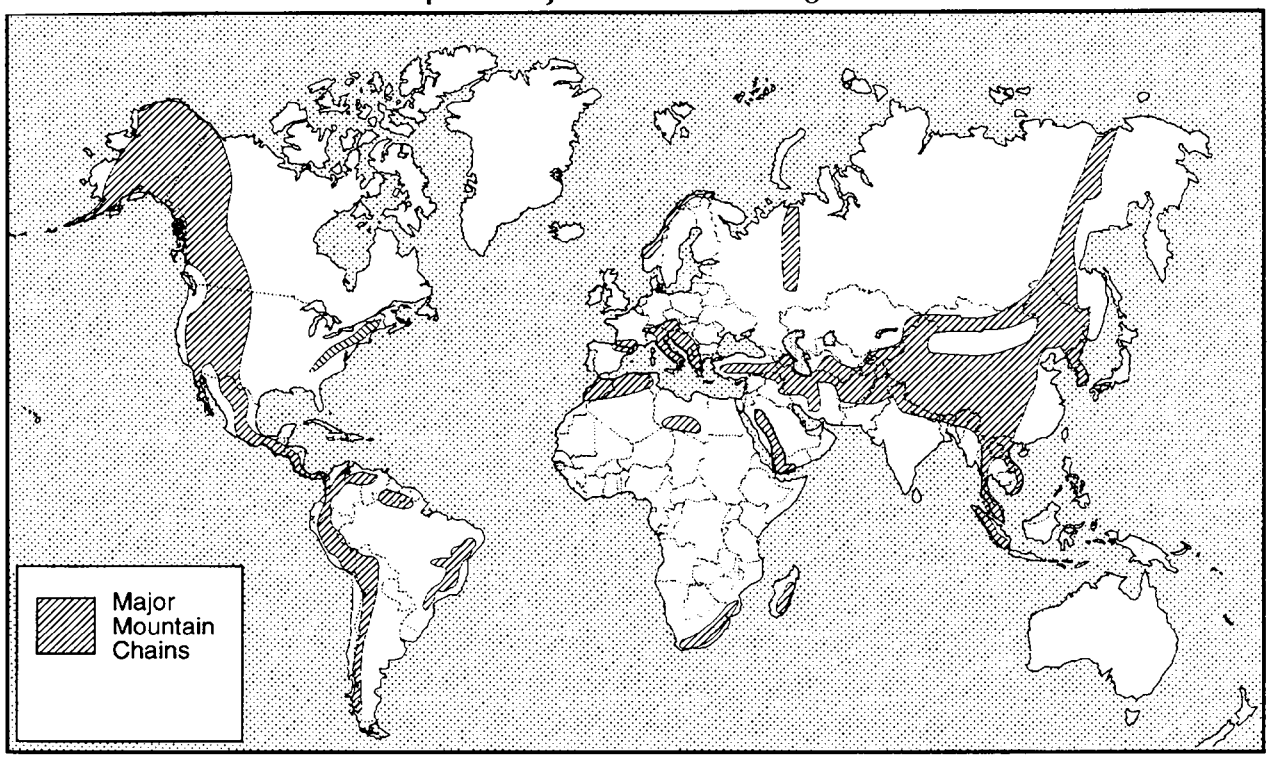
COMMON DENOMINATORS

Environmental adversity overcome only by special skills characterizes all mountains, regardless of their configuration or locale. Armed forces that are superlatively prepared for operations on flatlands often do poorly until they adjust.

Environmental Adversity. British Field Marshal the Viscount Slim once ruefully observed that senior military planners who plot distances and calculate movement times on small-scale maps cannot appreciate what impediments mountains impose. "To do that," he opined, "you must scramble up the precipitous slopes and slide down the other side, endlessly, as if you were walking along the teeth of a saw."[31]

Movement indeed is difficult in mountainous terrain where obstacles abound, defiles limit maneuver room, and armed forces perched above are well positioned to dominate opponents below. Motorized conveyances as a rule are confined to roads that, with few exceptions, are rudimentary, narrow, and poorly constructed, with steep shoulders, switchback curves, numerous bridges (many of them flimsy), tunnels, trestles, and culverts, all of which restrict traffic flow and invite enemy interdiction. One disabled tank or truck, even a jackknifed trailer, could immobilize an entire column under such conditions. Steep slopes stymie wheeled vehicles and discourage tanks which may stall, slide, throw a track on loose gravel, or topple sideways if driven on too sharp a slant. Cross-country trafficability consequently is confined to foot troops and pack animals in the worst areas. Air mobility is a welcome supplement when weather permits, but is unreliable because thick fog or strong winds accompanied by severe turbulence often intervene unexpectedly and disrupt flight operations for prolonged periods.[32]

Map 16. ***Major Mountainous Regions***



Mountain weather, typified by meteorological anomalies such as temperature inversions, capricious winds, and sudden squalls, adversely affects foot sloggers as well as aircraft. Intense solar radiation causes valley thermometers to rise swiftly after sunup wherever the atmosphere is pollution free and drop after dark as soon as heavy, chilled air drains downslope. Daytime temperatures may vary as much as 40 or 50 °F (20 or 25 °C) between sun and shade at high altitudes. Leeward locations are sheltered from winds, which elsewhere sweep across exposed mountainsides and accelerate through constricted passes that act as amplifiers. Appropriate uniforms thus depend in large part on particular places and times of day—troops clad for early morning climbs in cold climates frequently become too warm well before noon.[33]

Usable space for airstrips, heavy weapons, and logistic installations usually is scarce, cramped, and vulnerable. The airport that serves Sarajevo in former Yugoslavia remained open for U.N. humanitarian relief flights in the early 1990s only at the pleasure of Bosnian Serbs, who held commanding high ground until all belligerents accepted the Dayton Accords in November 1995 and NATO deployed powerful peacekeeping forces.[34] Helicopters can deposit and provision light artillery batteries in advantageous locations that otherwise would be inaccessible, but self-propelled and heavy, towed howitzers seldom stray far from main roads along valley floors, which makes it hard for them to hit reverse slopes whenever angles of fire are excessively high. Forward observers moreover find that artillery directed against

ridgelines and narrow valleys is difficult to adjust, because slight increases or decreases in tube elevation result in wasted rounds that overshoot or land short, perhaps among friendly troops.[35]

Special Skills. Requirements for rock climbers who can lug 100-pound rucksacks up 90-degree angles are limited, because military operations infrequently take place on mountainous terrain that demands esoteric techniques. Urgent needs, however, sometimes arise, which was the case in December 1943, when 600 U.S. and Canadian riflemen of the 1st Special Service Force (the "Devil's Brigade") scaled a 1,000-foot (305-meter) cliff that was almost perpendicular, then surprised and defeated German defenders atop Monte la Difensa near Cassino, Italy. A battalion of the U.S. 10th Mountain Division equipped with pitons and ropes topped that feat 4 months later when they worked their way up the 3,000-foot, very nearly vertical, ice-glazed face of Riva Ridge in the northern Apennines with similar results.[36]

The value of large, technologically superior ground forces is less than on level land, where they can maneuver fluidly and bring tremendous firepower to bear. Most combat missions instead emphasize decentralized small unit actions by subordinate elements of standard infantry battalions. Success depends primarily on skilled junior leaders and self-reliant foot soldiers who are superbly conditioned and well schooled in the fundamentals of mountain warfare (untutored gunners shooting down hill, for example, tend to aim high, while firing up hill has the opposite effect until training corrects those faults). Land navigation, scouting, patrolling, cover, concealment, survival, escape and evasion are topics that deserve close attention. So does local security, given the fact that mountains have been the natural habitat of guerrillas since human beings began to keep records. Dispersed command posts, airstrips, and logistic facilities necessarily located at wide spots along well-traveled roads make lucrative targets.[37]

Standard infantry divisions tailored for mountain warfare generally replace a good deal of heavy equipment with lighter loads that are easily transportable. They also add engineers to construct, improve, and maintain roads, trails, airfields, helicopter landing zones, and logistical tramways, install obstacles, and prepare field fortifications. Space satellites or multichannel relay stations airlifted to perches from which they have long-range views as a rule must retransmit FM radio messages that otherwise could not reach intended recipients because topographical features block line-of-sight paths. Strenuous activities moreover increase requirements for food and water; heavy reliance on helicopters expends aviation fuel at abnormally rapid rates; and rough usage calls for unusually large reserves of clothing and repair parts, of which tires, tie rods, transmissions, brake shoes, armored vehicle tracks, fuel pumps, and winch parts are typical.[38]

Bridges, tunnels, other transportation bottlenecks, and enemy traffic on narrow mountain roads are ideal interdiction targets for tactical aircraft armed with precision-guided munitions, providing weather permits. Close-air-support (CAS) sorties in tight terrain conversely are difficult to control, and crews may run fatal risks if hostile forces seed the most favorable approaches with a profusion of air defense weapons that are cleverly concealed and perhaps protected by bedrock. Low-level flights by high-performance fixed-wing aircraft and unmanned aerial vehicles almost always must follow constricted corridors that expose them to enemy weapons on both flanks.[39]

Massive mountains in many respects are very different than high hills, despite the common characteristics and interchangeable skills just discussed. Geographical phenomena associated with ever thinner air and colder temperatures at high altitudes are militarily more important than topographical distinctions.

Rarefied Atmosphere. The Rockies, Andes, and the awesome Karakorum-Himalayan wall that separates China from the Indo-Pakistani subcontinent typify massive mountain chains. Nearly 150 peaks top 10,000 feet (3,000 meters): 45 in Asia, 33 in the United States, 25 in Latin America, 16 in Europe, and 12 in Africa. Antarctica, Greenland, and Oceana contain the remainder. Mount Everest, Godwin Austin (K2), and 14 other giants that exceed 25,000 feet (7,600 meters) all dwarf imposing Mont Blanc, the loftiest spot in the Alps at a mere 15,781 feet (4,810 meters). Those figures are significant, because rarefied atmosphere poses potentially life threatening problems for land forces transferred on short notice from near sea level to elevations much above 10,000 feet. Difficulties increase almost logarithmically between 10,000 and 20,000 feet, as 16th-century Spanish conquistadors discovered during their search for El Dorado on the Peruvian *altiplano* and as Indian troops reconfirmed in 1962, when they rushed from low-lying garrisons to block Chinese intruders knocking at their Himalayan door.[40]

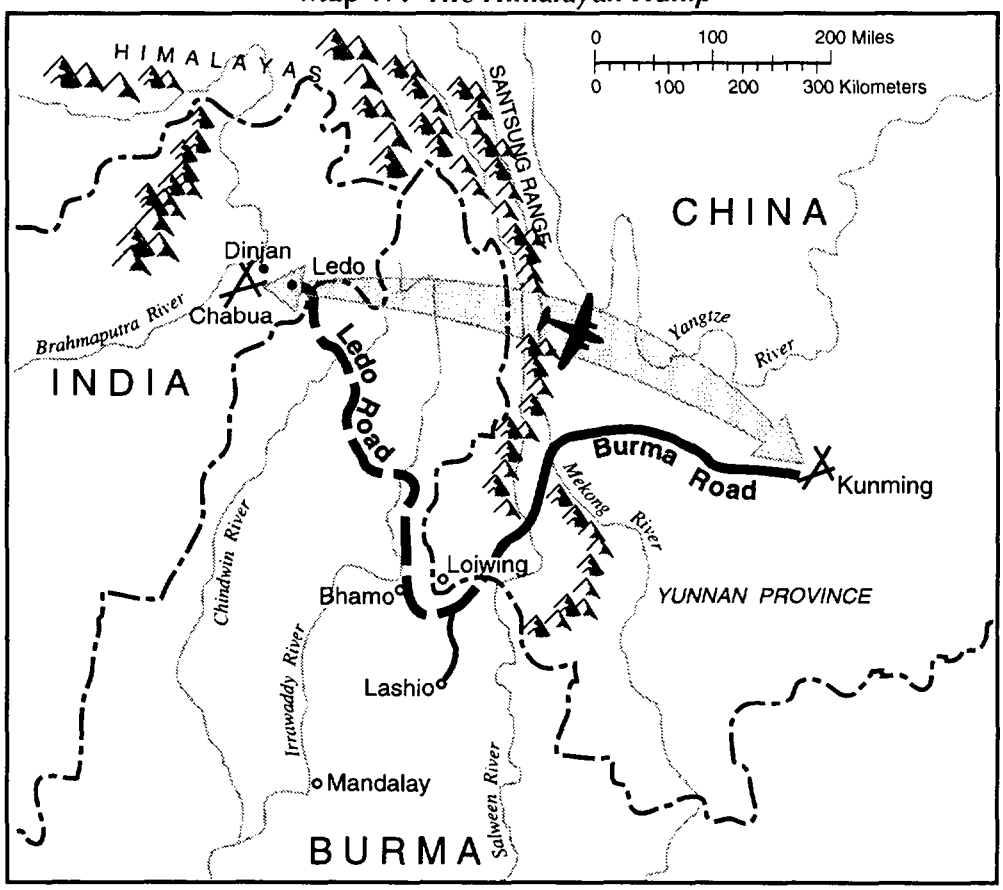
Oxygen deprivation, clinically called hypoxia, causes almost all persons in such situations to suffer for several days from headaches, shortness of breath, pounding heartbeats, dizziness, nausea, fatigue, loss of appetite, and depression. Severe cases may lead to pulmonary congestion or cerebral edema, both of which culminate in early death if medics fail to evacuate stricken soldiers immediately to lower elevations (2,000 feet/600 meters or less) where they can rest, recuperate, and receive supplemental oxygen. Labored breathing in thin, dry air not only hastens dehydration but dangerously reduces the water content of human blood (from 15 to 50 percent in extreme cases) unless troops regularly replenish exhaled fluids. The rapid buildup of red cells at high altitudes encourages frostbite and hypothermia, because thickened blood becomes sluggish, especially in hands and feet.

Even moderate "mountain sickness" inhibits sudden bursts of energy, such as lobbing hand grenades and heaving heavy gear onto truck beds. Such symptoms usually fade within a few days, but night vision disorders persist for weeks and it normally takes months before troops can fully perform duties that demand prolonged exertion or concerted attention to detail. Staged ascents that permit 2 to 4 weeks training at intermediate levels en route to higher elevations can alleviate if not eliminate most disabilities, but fast-breaking contingencies seldom allow such luxuries. The side that acclimatizes first thus enjoys great advantage.[41]

Rarefied atmosphere also impairs the performance of air-breathing engines, which, like human beings, gasp for oxygen. Trucks overheat and lose 10 to 25 percent of rated horsepower at elevations above 7,000 feet (1,800 meters). Poorer than usual acceleration and grade-climbing capacities are among the most noticeable consequences. Fixed-wing aircraft need longer runways to take off and land with given loads, while helicopters struggle to get off the ground with gross weights they could easily lift at sea level. Smart crew chiefs, loadmasters, and others who calculate density altitudes therefore allow healthy margins for error at destinations as well as points of departure and, if necessary, plan two trips instead of one to prevent avoidable accidents. Pilots flying through thin air moreover must constantly

be alert for vicious air currents and winds that variously blow down slopes after dark, reverse course after daybreak, curl over crests, bounce off valley walls, drop aircraft a thousand feet or more (300+ meters) in unpredictable down drafts, and whiplash them without warning.[42] Nap-of-the-earth missions designed to avoid enemy air defense guns and missiles are extremely dangerous in mountainous terrain, especially at night under blackout conditions, but high-level flights can be equally hazardous. U.S. crews who repeatedly flew heavily laden transports 500 treacherous miles over the Himalayan "Hump" from India to China with supplies for Chiang Kai-shek, then back again through stormy skies, accomplished logistical miracles during World War II (map 17).[43]

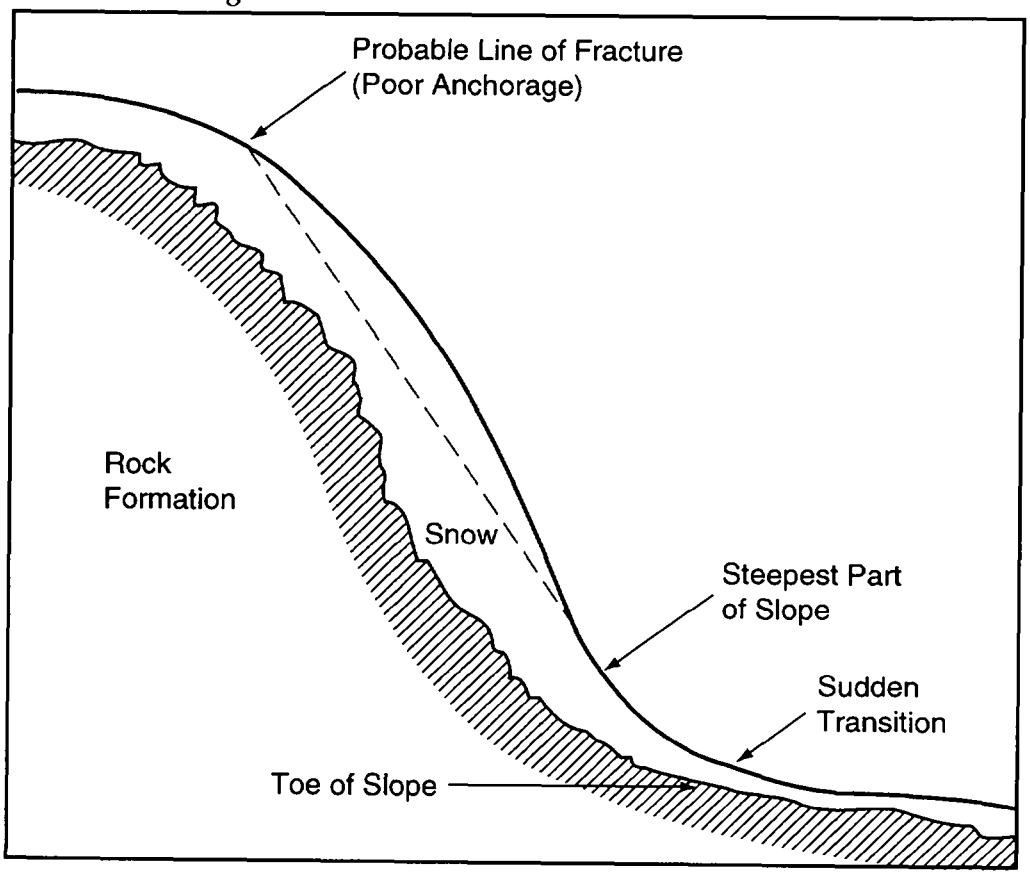
Map 17. *The Himalayan Hump*



Avalanches. Massive avalanches pose additional dangers wherever deep snows cover steep mountains at high elevations (at least 40,000 Austrian and Italian alpine troops were buried alive in Tyrolian territory during World War I, one-fourth of them on 2 terrible days in 1916). The worst avalanches occur on convex slopes, where successive layers of snow come under increasing tension until they fracture at the sharpest point on the curve (figure 19).[44] Slides start spontaneously when snow banks collapse under their own weight, when rising temperatures weaken bonds, and when falling temperatures increase brittleness. Shearing

actions by skis, even snow dropping out of trees, can start the process. Long-range vibrations from thunder, sonic booms, explosions, moving vehicles, even the sound of human voices can loosen tons of snow that accelerate almost instantaneously from 0 to 60 miles an hour or more (100 kph) and pulverize everything in their path as they roar down gullies devoid of vegetation. Accurate forecasts are not yet possible, so wise commanders avoid suspicious spots to the extent possible consistent with their missions, preferably with assistance from residents whose first-hand knowledge of local avalanches dates back many years.

Figure 19. ***Conditions Conducive to Avalanches***



THE RELATIVE VALUE OF VERY HIGH GROUND

Alexander the Great crossed and re-crossed Central Asia's Hindu Kush circa 329 B.C. through wind-swept, snow-covered mountain passes at altitudes between 10,000 and 11,000 feet (3,050 and 3,350 meters). Hannibal led armed forces over Europe's high Alps from west to east five centuries later, followed by Julius Caesar going in the opposite direction on his way to Gaul, but those famous warriors, like predecessors and successors ever since, won their most decisive victories at moderate elevations.[44] There is no evidence that innovative tactics or technologies will substantially increase the relative value of *very* high ground any time soon.

DEFENSIVE CREDITS

Mountainous terrain opens opportunities for numerically inferior but disciplined troops to establish defensive positions-in-depth with interlocking fields of fire, take advantage of abundant natural obstacles that are difficult to breach, blast field fortifications into bedrock, destroy bridges on high-speed enemy approaches, litter other routes with land mines, locate tanks and artillery in defilade, implement deception plans, and stockpile supplies conveniently. Offensive formations, less familiar with local terrain features, often attack across ground devoid of cover and so steep that foxhole digging is impossible. Multiple columns that proceed along parallel corridors seldom are mutually supporting, since they can neither see nor communicate effectively with each other and, if defenders have chosen positions wisely, must assault up hill.

Celtic, Roman, Burgundian, barbarian, Austrian, Swedish, French, and Prussian warriors all failed to defeat defenders in the Vosges Mountains, which seldom exceed 4,000 feet (1,220 meters). The U.S. Seventh Army, assisted by strong air power, slugged it out on that ancient battleground with German Army Group G from mid-October 1944 until mid-January 1945 before it became the first armed force in history to break through the Vosges against determined opposition.[46] Dogged Axis defenders who manned the Winter Line that ran across Italy from the Tyrrhenian Sea to the Adriatic blocked Allied routes to Rome for 7 months, between November 1943 and May 1944. Monte Cassino, the most publicized cork in that bottle, is barely 1,700 feet high (520 meters), but tough German paratroopers ensconced on top resisted long after February 15th, when U.S. bombers pulverized the abbey on its summit with 600 tons of bombs.[47] Stalemated front lines see-sawed back and forth along Korea's mountainous spine for 2½ years to gain dubious tactical advantage from early 1951 until July 27, 1953, when both sides signed a cease-fire agreement.[48]

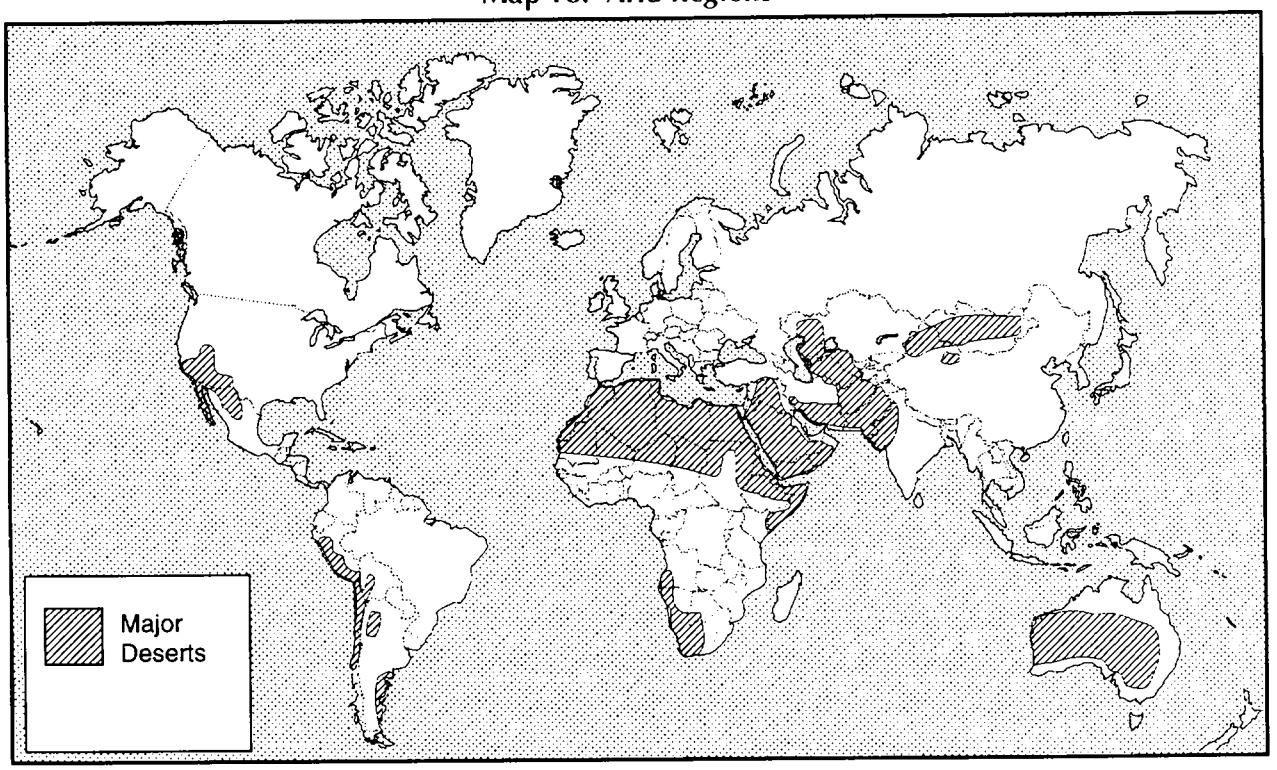
DEFENSIVE DEBITS

Carl von Clausewitz, in his great tome *On War*, justifiably called defensive combat in mountainous terrain "a true refuge for the weak—for those no longer able to seek an absolute decision."[49] Belligerents who deliberately elect that form of conflict may buy time with which to reinforce and refurbish, then resume the offensive, but can "win" in place only if rivals quit first because costs have become too high. The best they can do otherwise is defer eventual defeat.

ARID REGIONS

The Cradle of Western Civilization, which always has been largely arid aside from the Fertile Crescent that links the Nile and Tigris-Euphrates Valleys via the Levant, saw the earliest recorded warfare. Sumerian, Akkadian, Assyrian, Babylonian, and Egyptian armies came first, followed by Persians, Macedonians, Parthians, Romans, Arabs, Crusaders, Turks, French, British, Americans, and Israelis, among others. Joshua, Ramases, Sargon, Ashurbanipal, Darius, Alexander, Khalid, Tamerlane, Allenby, and Lawrence of Arabia were a few among many who won military fame as desert warriors in that cockpit.[50] Deserts around the world remain hotbeds of armed combat (map 18).

Map 18. *Arid Regions*



All deserts are sun seared, wind scoured, and dry (average annual rainfall as a rule is less than 10 inches/25 centimeters), but great diversity nevertheless is evident. Some arid lands are immense, others are small by comparison; linear dimensions, elevations, relative humidity, and distance from sea water vary considerably; topographical features run the full range from monotonous plains to spectacular peaks. Three and a half million square miles of Sahara Desert stretch from east to west across all or part of 10 North African countries, while the lanky Atacama, which runs from north to south in Chile, measures more than half as long but covers only 4 percent as much area. Death Valley, California, the lowest point in North America at -86 feet (-30 meters) is blistering hot in summer, whereas Mongolia's Gobi Desert on an interior plateau far above sea level is bitterly cold when winter winds blow in from Siberia. Most desert air is uncommonly dry, but high humidity turns Persian Gulf and Red Sea coasts into sweat boxes. Stony ground, contrary to popular misconceptions, is more common than humongous sand dunes, such as those in Saudi Arabia's Rub al Khali and southern Chad.[51]

CLIMATIC ECCENTRICITIES

Climatic eccentricities such as irregular rainfall, intemperate heat, and gale force winds even so characterize deserts the world over. Military personnel consequently require special equipment, training, and acclimatization

Irregular Rainfall. Unpredictable c loudbursts habitually replace prolonged, gentle, widespread rains that bless most well-watered regions. Downpours dump double or triple the average annual amount of precipitation in an hour or two, sink into sand or run off hard surfaces, provide brief respites from drought, then leave the land as barren as before. Dakla Oasis, located due west of Luxor, Egypt, is not atypical: it once went more than a decade without a drop of rain, although its yearly quota is about five inches (13 centimeters). Raging torrents without warning fill desiccated stream beds to overflowing, then sweep away bridges, buildings, military bivouacs, and other impedimenta that rashly block their paths. Roiling waters in southeast Tunisia turned Wadi Zigzaou into an impromptu moat that Field Marshal Bernard Montgomery's armored columns failed to breach on March 20, 1943. Four Valentine tanks crossed after British sappers paved the bottom with bundles of brush, but the next tank in line sank up to its turret in muck.[52]

Intemperate Heat. Oven-like summers generally prevail, even in parts of the Gobi Desert and China's Taklimakan where *mean* winter temperatures remain below freezing for several months each year. Thermometers that commonly hover around 120 °F (48 °C) in mid-afternoon are "mild" compared with sand temperatures, which may exceed 165 °F (73 °C). The crew compartments of heavily armored vehicles that lack air conditioning can become unbearable, while thin-skinned truck cabs heat up faster and reach even higher temperatures—185 °F (84 °C) is not exceptional. Those figures are significant, because 120 °F is the threshold of human pain and readings as low as 140 °F (60 °C) may cause first-degree burns.

Most British and German troops in the North African desert during World War II wore short-sleeved shirts and short pants or stripped to the waist, although clothing that provides better coverage not only prevents sunburn and sand blasting by violent winds but serves as a coolant when sweat-soaked. Savvy aircraft and vehicle mechanics also wear gloves. Aircraft payloads plummet in excessive heat, which reduces lift capacities, while sensitive computers, sensors, communications equipment, and other electronics malfunction. Batteries hold their charge less efficiently (one U.S. armored division requires 3,660 batteries to keep 327 Abrams tanks and 283 Bradley fighting vehicles rolling, not to mention many additional tracked vehicles and trucks that swell the total severalfold). Bombs and missile warheads as well as artillery and tank ammunition are best stored in open pits protected by double sun screens, perishable food spoils quickly, and unrefrigerated water left unattended in the sun becomes unpalatable before it vaporizes. Hot nights and high humidity on the order of 90 to 100 percent make duty eternally hard to endure along some sea coasts, even for well-acclimated troops, but temperatures inland may drop 70 °F (21 °C) or more after dark. Armed forces skilled at night fighting thus enjoy a sharp edge.[53]

Gale Force Winds. Destructive gales that blow for days at a time also are desert trademarks. Windblown sand, powerful enough to amputate unprotected telephone poles over time, impartially abrades everything in its path for a few feet above ground level while towering clouds of silt as fine as talcum powder blacken the sky, inflame eyes, and make troops wish for respirators. Sand and dust storms together reduce visibility to near zero, infiltrate tents, jam weapons, clog machines, pit optical devices, contaminate food and drink,

and generate enough electricity to drive magnetic compasses crazy (explosives apparently detonated at an ammunition dump near Tobruk, Libya, in 1942). Grit additionally blankets stockpiles, shortens the life span of equipment despite preventive measures, increases logistic loads commensurately, and otherwise makes life miserable for man and beast. Military operations slow, sometimes stop, during the worst wind storms.[54]

Acclimatization Problems. Most military personnel in fit condition take about 2 weeks to acclimate, but may never reach peak performance in oppressive heat. Commanders consequently schedule strenuous activities during the coolest parts of each day and allow longer than usual rest periods, consistent with mission accomplishment. Personal hygiene and sanitation problems moreover can become unmanageable unless troops practice prophylactic medicine, which is easier said than done. (Members of Field Marshal Rommel's Afrika Korps sometimes scrubbed sweaty uniforms with sand to keep them from rotting.) Prickly heat, which upsets sweating mechanisms, encourages heat prostration, while dirt and insect bites turn minor scratches into running sores unless treated promptly. Flies feed on garbage, human feces, and dead bodies that burst under the hot sun, batten in food and open wounds, then spread diseases such as dysentery, diarrhea, and other intestinal disorders. Latrines are crucially important, but shifting sands fill slit trenches almost as fast as they can be dug in some regions, whereas rocky ground elsewhere makes excavations impossible without explosives.[55]

WATER REQUIREMENTS

Water for drinking, cooking, bathing, laundry, use in military hospitals, and assorted other purposes is a priceless commodity in arid regions, more precious than any other natural resource, including petroleum. Sources, repositories, purification facilities, desalinization plants, tank trucks, water pipelines, and associated assets accordingly constitute prime military targets.

Supplies. Large, reliable sources are limited to a few bodies of fresh water and perennial rivers, such as the Colorado, Tigris, Euphrates, Indus, and Nile, which survive high evaporation rates only because far distant watersheds feed them copiously and consistently. Smaller streams run dry several months each year. Once famous oases such as Kashgar, Yarkand, and Khotan, which Marco Polo visited along Central Asia's Silk Route on his way to Cathay in the year 1272, are barely able to supply current civilian populations. Neither they nor ribbon-like counterparts that stretch for miles across the otherwise waterless Sahara could long support large-scale military operations. (Lieutenant General Gus Pagonis, the chief logistician during U.S. and allied operations against Iraq in 1990-1991, was appalled to find that XVIII Airborne Corps alone would need billions of gallons over the first few months.[56]) Easily accessible reservoirs that lie beneath dry stream beds and some alluvial fans cannot supply such quantities.

Drilling for water in open wastelands is at least as chancy as sinking wildcat oil wells, because precise locations are problematic, the most promising sumps often lie 500 to 800 feet (150-250 meters) below the surface, some are brackish, and extraction in many cases would require high capacity pumps. Prudent users purify water regardless of its source to remove disease-bearing bacteria and minerals that might calcify inside military machines.

Major armed forces in arid regions as a direct result often must import or desalinate most water supplies.[57]

Demands. Water rationing, once a popular but ill-conceived part of the acclimatization process, has been discredited because performance suffers and dehydration poses ever present dangers. Sweat evaporates so rapidly in dry desert heat that humans commonly lose about 1 pint of water per hour even at rest, yet never notice adverse effects or feel thirsty until the deficit reaches four times that amount (2 quarts, or 2 liters), by which time heat prostration may be imminent. Heavy exertion requires much greater intake, but Rommel's Afrika Korps in the summer of 1942 carried only 15 *quarts* per day for trucks and tanks as well as personnel. His parched troops made every drop count, yet still ran dry during one offensive and survived only because they captured British water supplies.[58] U.S. military personnel in Saudi Arabia and Kuwait, who were much better endowed logistically, consumed approximately 11 *gallons* per day (42 liters), plus 10 to 12 gallons more per vehicle. Refrigerated vans kept a good deal of it palatable despite intense desert heat.[59]

FIREPOWER AND MANEUVER

Alan Moorehead, an Australian journalist during World War II, once compared combat on flat desert floors to warfare at sea, because both environments lack distinctive landmarks. Massive land forces, like opposing flotillas, can maneuver at will for favorable positions, remain over the horizon until they make contact, and concentrate on enemy forces rather than key terrain, except for occasional struggles to control transportation bottlenecks such as Kasserine Pass in Tunisia.[60]

Conventional Operations. Mounted operations that marked desert warfare before the advent of saddles and stirrups have done so ever since.[61] Motorized British forces, for example, took just 3 days to destroy three Italian divisions and capture 39,000 foot soldiers outside Sidi Barrani, Egypt in December 1940.[62] Iraqi troops who dug in after they invaded Kuwait 50 years later took a worse walloping, first from coalition aircraft that severed all links with their homeland and pulverized static positions, then from airmobile, armored, and mechanized divisions that used vertical and horizontal envelopments to great advantage during the 100-hour ground phase of a 6-week war.[63] The victors in both cases suffered few casualties compared with the vanquished.

Land transportation of all types must detour around steep slopes and deep gullies as well as huge dunes, such as those that sprawl across southern Iran, the Sahara Desert's Great Western Erg, and Saudi Arabia's Empty Quarter. Soft sand, sharp rocks, and thorns as thick as thumbs inhibit cross-country movement by trucks, especially those that tow trailers (the 1st Brigade of the Saudi Arabian National Guard unhappily suffered 161 flat tires when it moved from Riyadh to blocking positions in August 1990). Tracked vehicles, however, can more easily traverse the gravelly plains, stony pavements, and stretches of shallow sand that characterize most deserts.

Level to rolling desert landscapes, virtually devoid of vegetation, afford fine fields of fire for flat trajectory weapons, which usually are employable at maximum ranges. Skilled weather officers in possession of technologically advanced techniques can help air crews and ground-based gunners employ infrared sensors and lasers despite heat, haze, and dust by predicting which side of particular targets will be hottest at particular times each day. They also can calculate "thermal crossover" times that tell when the contrast between targets and

surrounding territory will be greatest and least, given the thermal properties of various materials. Metals, for example, heat and cool quickly, whereas asphalt heats slowly and stays hot a long time. Aerial observers, who claim clear views as far as naked eyes and sensors can see, find it easy to identify many stationary targets and can track low-flying helicopters as well as vehicular columns, both of which reflect light from wind screens and raise telltale clouds of dust. Great visibility also facilitates the use of air-to-ground missiles from positions beyond the reach of enemy air defense weapons. The side able to establish air superiority early consequently gains a decided edge.[65]

The monotonously beige color of most desert soil nevertheless makes it difficult to distinguish different elevations, except during early morning and evening hours when terrain features cast long shadows. Ground-level observation in fact often is better on clear nights than at mid-day, when glare is intense, bright sunlight blinds all who face in its direction, and shimmering mirages not only distort depth perception but make images seem to float. Radar altimeters help pilots and navigators when the sun is high and on bright moonlit nights.[66]

Special Operations. Special operations forces can function independently or complement conventional formations in arid regions despite the presence of enemy air power and the paucity of vegetation. British Colonel David Stirling's nascent Special Air Service (SAS), assisted at times by the Long Range Desert Group, which excelled at reconnaissance, ran rampant in the northern Sahara between November 1941 and January 1943, often 100 miles or so behind hostile lines, where they destroyed aircraft on the ground, blew up motor pools, detonated ammunition stocks, set fire to petrol dumps, hijacked vehicles, mined roads, and derailed trains.[67] Nineteenth century guerrillas in Afghanistan gave British troops headaches, and their descendants so plagued technologically superior Soviet invaders in the 20th century that the Kremlin finally quit to preclude unacceptable losses in money, military manpower, and materiel after 10 frustrating years, from 1980 to 1989.[68]

Nuclear, Biological, and Chemical Operations. Peacetime tests in lieu of practical experience suggest that nuclear, biological, and chemical (NBC) weapons employed against troops widely dispersed in the desert would be less potent than usual in some respects and more dangerous in other regards. Overall usefulness would depend mainly on climatic patterns, local weather conditions, and topographic configurations.

The radius of heavy damage from nuclear detonations on level to rolling terrain likely would be shorter than in cool climes, because heat reduces static overpressures that give shock waves their punch. Troops in gullies or foxholes and weapon systems protected by revetments consequently would be somewhat safer than on frigid flatlands. Less powerful blast effects rocketing through light desert air, however, could disable distant thin-skinned targets such as aircraft parked in the open, while thermal radiation and dazzle concurrently burned and blinded exposed personnel. The direction and duration of radioactive fallout from gigantic dust clouds would depend on the erratic behavior of desert winds and turbulent currents.[69]

High concentrations of toxic chemical warfare munitions designed to inflict mass casualties would be required whenever desert heat is intense, because sizzling temperatures, strong winds, and unstable air masses dissipate vapors and evaporate liquids rapidly. Perspiring personnel who shed protective clothing prematurely nevertheless would be extremely vulnerable to lethal and incapacitating agents that attain maximum effectiveness on sweaty skin. Even bogus threats and false alarms can undercut enemy capabilities if they

make troops don impermeable gear repeatedly, perhaps for lengthy periods. Masks impair breathing and muffle oral communications, protective gloves degrade tactile dexterity, poreless suits act as portable saunas, time to accomplish routine tasks expands, and fatigue sets in fast. Bright sunlight, dry air, and heat would limit biological warfare aerosols to very small areas, provided they survived storage, but commanders and key subordinates at every level should take positive steps to prevent enemies from polluting water supplies, because deprivation could be disastrous.[70]

LOGISTICAL STRAINS

Arid regions that facilitate maneuver warfare on a grand scale may be a tactician's dream, but vast deserts that are hot, dusty, hard scrabble, and devoid of militarily useful resources give logisticians nightmares. Most supplies must be imported, consumption rates soar, maintenance requirements multiply, and extended mobile operations strain distribution systems. Troubles burgeon as distances from support bases increase. Painful consequences ensue whenever combat forces stall because rates of advance and other maneuvers outstrip logistical capabilities.

Fleets of fuel tankers must make repeated round trips between supply points and customers, because long-distance, cross-country motoring over sand, loose gravel, and other surfaces that afford poor traction greatly decreases the gas mileage obtainable from wheeled and tracked vehicles. High mileage accrued in hot weather on rough terrain mainly in low gears moreover is hard on engines, radiators, springs, shock absorbers, transmissions, batteries, tank tracks, tires, and drivers. Constant vibrations crack and break metal. Gaskets and fan belts wear out quickly. Grit grinds assorted parts subject to friction, such as ignitions, brake shoes, bushings, bearings, water pumps, and carburetors, as well as microphones, switches, and circuit breakers. Air, fuel, and oil filters demand daily servicing and frequent replacement. Similar supply and maintenance problems afflict all other types of military materiel, as U.S. Lieutenant General Gus Pagonis graphically described after Operation *Desert Storm* in his unofficial report entitled *Moving Mountains*.[71]

TROPICAL RAIN FORESTS

Tropical rain forests, which never are neutral, favor well-prepared forces and penalize military leaders who fail to understand that:

- Small unit actions predominate.
- Overland movement invariably is slow and laborious.
- Troops mounted on horseback and motor vehicles are less mobile than foot soldiers.
- Natural drop zones, landing zones, and potential airstrips are small and scarce.
- Visibility and fields of fire for flat trajectory weapons are severely limited.
- Land navigation requires specialized techniques.
- Tanks, artillery, other heavy weapons, and close air support aircraft are inhibited.
- Command, control, communications, and logistics are especially difficult.
- Special operations forces and defenders enjoy distinctive advantages.
- Quantitative and technological superiority count less than adaptability.

A 1941 pamphlet, *Read This Alone—and The War Can Be Won,* indoctrinated Japanese divisions drawn from frigid Manchuria for duty in steamy Malaya and Singapore, where they quickly defeated untutored British defenders and their Indian allies. Analogous U.S. documents at that time conversely slighted jungle warfare or received scant attention from America's senior military officials. The U.S. Marine Corps *Small Wars Manual (1940),* predicated on long service in Haiti (1915-1934), the Dominican Republic (1916-1924), and Nicaragua (1926-1933), was only marginally related to combat in tropical rain forests, and in any event, most Marines on the eve of World War II found amphibious operations a far more entertaining topic. The U.S. Army largely ignored *Field Manual 31-20: Jungle Warfare,* which reached a very restricted audience after distribution in December 1941. Commanders as well as rank and file in both services accordingly received on-the-job training under trying conditions.[72]

JUNGLE WARFARE SETTINGS

Copious, year-round precipitation, torrid temperatures, and high humidity combine to create rain forests, which are dense, dripping, dank, and dark (map 19). Rain gauges often record as much as 7 inches a day (17.8 centimeters) in Bougainville in the Solomon Islands, but this may seem moderate compared with nearby New Britain, where monsoonal deluges sometimes dump more than double that amount. Lieutenant General "Vinegar Joe" Stilwell, the senior American commander in Burma during World War II, noted in 1944, "The 'dry season' in this country is a joke . . . We have had rain in December, 12 days in January, 18 in February, 10 in March, 10 in April, and now it's *really* going to rain." He was right; the summer monsoon started on May 1st. Wall-to-wall foliage, always in full leaf, blocks any breeze, while rain forest floors turn into noxious mush.[73]

Virgin rain forests, such as most of those in the Amazon Basin and equatorial Africa, consist mainly of mature trees (the largest tower 200 feet/60 meters or more), the spreading branches of which interlock to form three or four overarching canopies high above huge boles. Undergrowth is sparse, because little or no sunlight reaches the forest floor, although a latticework of giant lianas, some at least a foot thick, festoons from great heights to the bottom. Secondary jungles that sprout wherever nature or humans have cleared the land feature luxuriant undergrowth in the form of saplings, thickets, thorny vines, and ferns. Some species of bamboo that must be akin to Jack's beanstalk grow 3 feet (1 meter) a day and ultimately tower more than 100 feet. Dense stands of razor-sharp kunai grass taller than most men frequently cover open spaces not occupied by rice paddies, small farms, or park-like plantations where well-spaced rubber and coconut trees are planted in neatly kept rows.[74]

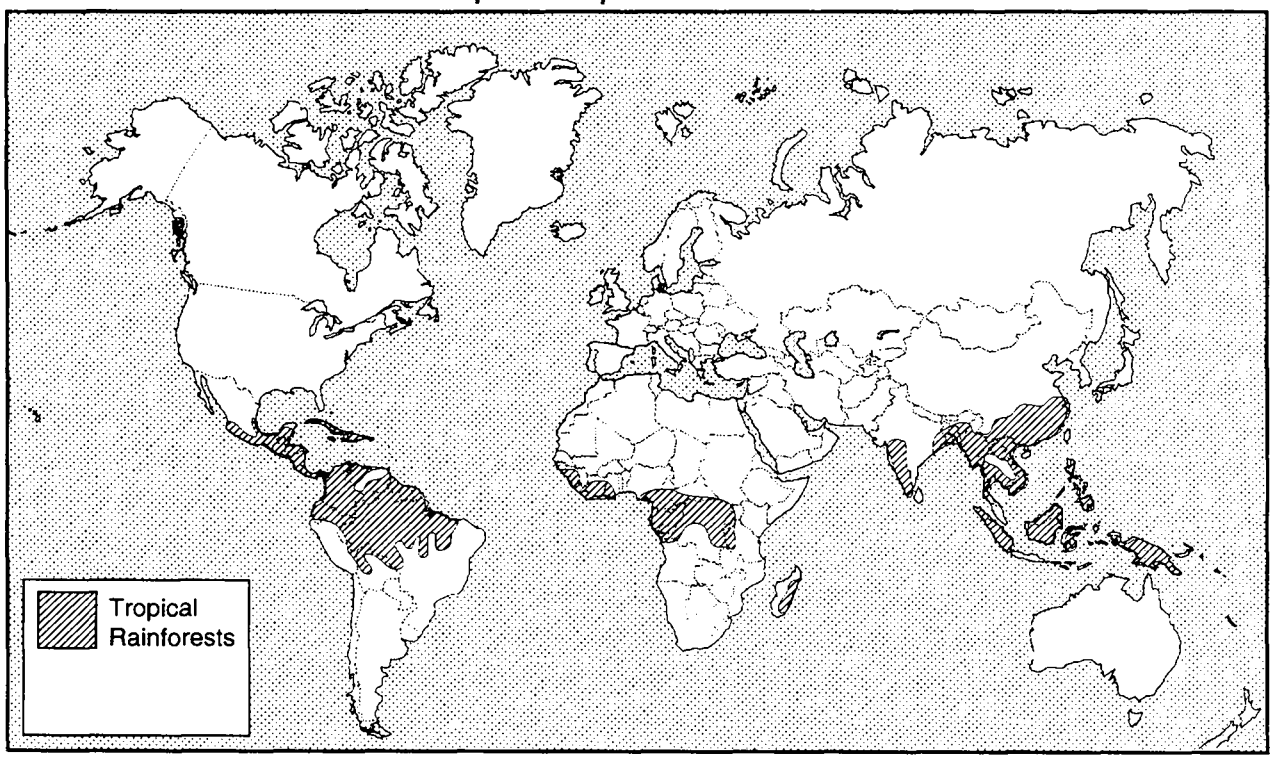
The world's largest rain forest lies on level to rolling terrain astride the Equator in South America from the foothills of the Andes to the Atlantic Ocean. Most African jungles also rise above lowlands, but jungle shrouded mountains cover Central America, some Caribbean islands, India's west coast, most of southeast Asia, and archipelagos that stretch from Sumatra to Tahiti. Great environmental diversity is evident. Guadalcanal, for example, mingles plains, foothills, and mountains with varied vegetation that includes grassy patches, coconut groves, and forbidding jungles, whereas the tiny island of Tulagi, just 17 miles away across Sealark Channel, is a homogeneously wooded hill mass. New Guinea, which after Greenland is the second largest island on this globe, grows tropical rain forests on awesome slopes.

Oppressive heat and humidity prevail there during daylight hours, but penetrating cold sets in after dark at high altitudes.[75]

CLOSE COMBAT

Infantry squads, platoons, and companies grope slowly through jungles at reduced distances between elements with little or no direct assistance from adjacent units, because visual contact and natural fields of fire for flat-trajectory weapons seldom exceed a few yards (meters). Vehicles are road-bound with rare exceptions. Tense searches that culminate in fleeting fire-fights at point-blank range characterize up close and personal combat. Thomas Hobbes, in his 1651 treatise, *Leviathan*, inadvertently described the "solitary, poor, nasty, brutish, and short" life of many jungle warriors who experience "continual fear and danger of violent death." Armed conflict under such circumstances emphasizes needs for simple, centralized plans, standing operating procedures (SOPs) that anticipate unexpected contingencies, decentralized execution, and, above all, astute junior leaders.

Map 19. *Tropical Rain Forests*



Emphasis on Sixth Sense. Wrap-around rain forests intensify latent tendencies toward claustrophobia and paranoia, since belligerents can neither see nor hear well under best case conditions. Visibility is so limited, even by aerial observers and surveillance satellites, that cleverly concealed enemy fortifications are hard to spot. Thermal imagers work reasonably well despite thick foliage, but light amplification devices, infrared sensors, and radar are less effective. Wet vegetation also muffles sound, as Merrill's Marauders discovered when they hacked their way through rock-hard bamboo thickets in Burma—they made a racket like

spike-driving gandy dancers building a railroad, but men in the rear heard nothing. Dangers from "fratricide" are ever present, especially during pitch black nights filled with weird noises that prompt trigger-happy neophytes to shoot at every moving shadow until they become accustomed. The sound of jingling dog tags, rifle safeties snapping open, and bolts slamming shut nevertheless sends audible warnings at short-range. Frightened birds and wild animals that suddenly screech or fall silent may also indicate enemy activity. Senses of smell and touch can occasionally supplement or supplant sight and sound: shaving lotion, scented soap, insect repellent, cigarette smoke, and other non-indigenous aromas literally are dead giveaways; point men on patrol use fingers and twigs to feel cautiously for trip wires. Foot sloggers gifted with intuitive powers of perception called Sixth Sense enhance survival prospects for comrades as well as themselves.[76]

Land Navigation. Knotty land navigation problems persist, even when assisted by Global Positioning Systems (GPS). Military maps are much better than in 1942, when U.S. Marines at Guadalcanal found that Mount Austen, one of their immediate objectives, was situated several miles rather than a few hundred yards behind the beach, but important shortcomings persist, partly because cameras aloft infrequently see the forest floor. Jungles moreover rapidly reclaim little used roads, rail lines, and other landmarks that appear prominently on outdated maps. Newcomers thus do well to emulate Merrill's Marauders who, whenever possible, employed Kachin guides to lead them through Burmese jungles, because they knew every wrinkle in their home territories. Australian-recruited "coastwatchers" performed admirably as scouts, porters, and spies throughout the Solomon Islands with such success that U.S. Admiral William F. (Bull) Halsey claimed that they "saved Guadalcanal and Guadalcanal saved the Pacific." The United States and Australia both decorated one such hero, Jacob Vouza by name, who later was knighted.[77]

Overland Movement. Overland travel in jungles averages about ½ mile an hour where the going is good and ½ mile a day where it is not, unless troops follow well-trodden trails that invite adversaries to install mines, booby traps, road blocks, and ambushes. Command, control, and communication (C^3) problems are particularly difficult in thick secondary growth, which weakens HF/VHF radio transmissions, makes wire circuits hard to install (not to mention maintain), invalidates most visual signals, and makes surface messenger service both risky and slow. Air mobility is unreliable, because local weather is uncooperative, adversaries often cover the best helicopter landing zones (LZs), which are scarce and small, and LZ construction from scratch in double, triple, or quadruple canopy rain forests is a costly, time-consuming process without assistance from explosives.

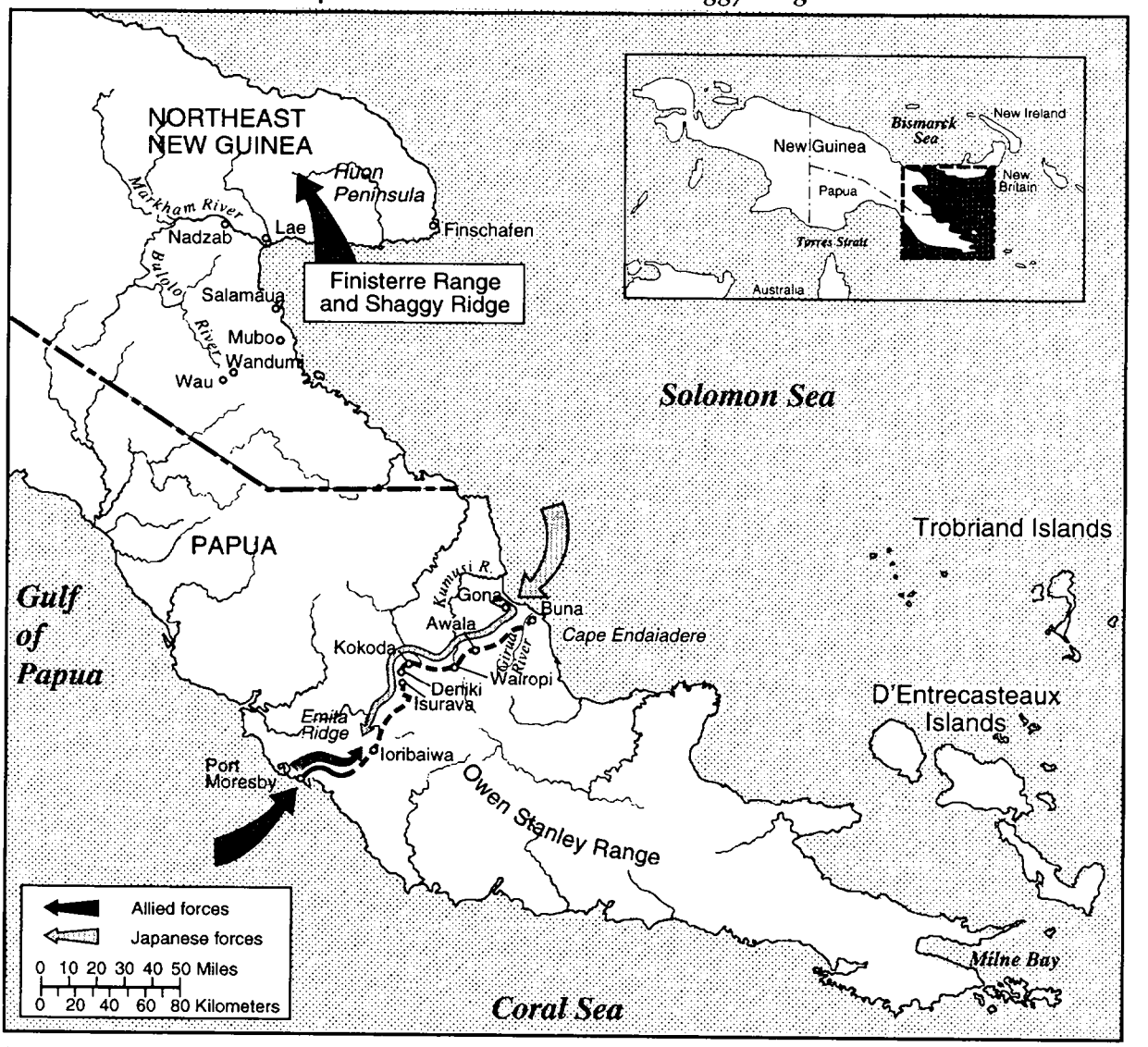
The infamous Kokoda Track, still the only passable land route over the Owen Stanley Mountains between Port Moresby and Buna in Papua, New Guinea, saw extensive jungle warfare under aggrieved conditions during World War II (map 20). Australian, Japanese, then U.S. troops, drenched daily by rainfall that measured as much as an inch (2.5 centimeters) in 5 minutes, engaged in savage struggles over vertical terrain where maneuver room was virtually zero. The Forward Edge of the Battle Area (FEBA) atop razor-backed Shaggy Ridge sometimes consisted of one Australian rifleman sniping at one Japanese counterpart while everyone else waited in line. Haggard heroes who clawed their way single file from one precarious perch to another through a tunnel of trees say the jagged Finisterre Range farther east was worse.[78]

Guerrillas and Undergrounds. Dian Fossey, author of the celebrated book, *Gorillas in the Mist,* might have written a sequel entitled *Guerrillas in the Mist* if poachers hadn't cut her life short, because jungle fringes offer ideal bases of operations for irregular forces, provided undergrounds in nearby communities help recruit, indoctrinate, and train personnel, raise funds, furnish information, provide supplies, and otherwise support rebel causes. Guerrillas who sally forth from and return to rain forests have repeatedly given pursuers fits with raids, ambushes, and acts of sabotage in tropical parts of Latin America, Asia, and Africa.[79]

HEAVY FIREPOWER

Heavy, accurately aimed firepower delivered by aircraft, artillery, and tanks is almost an oxymoron wherever tropical rain forests rise from flatlands. Fire support in jungle covered mountains is even less effective.

Map 20. ***The Kokoda Trail and Shaggy Ridge***



Adapted from Rafael Steinberg, *Island Fighting.*

Carpet bombing directed against sprawling targets concealed in rain forests inflicts psychological as well as physical casualties when bombardiers hit the right spot, but military benefits often are poor compared with ecological devastation and wasteful expenditures of ordnance. Aerial interdiction strikes against enemy supply lines that lead through jungles also demand huge efforts in return for modest results (see chapter 19, which discusses attempts to stop traffic on the Ho Chi Minh Trail). Fixed-wing aircraft and helicopter gunships equipped with sophisticated target acquisition devices such as laser designators frquently fly close support missions for friendly troops in contact with enemy forces under dense foliage, but the danger of "fratricide" is great.

Artillery units often are vulnerable to hit-and-run raids as well as counterbattery attacks, because suitable firing positions along scarce roads and trails rule out "shoot and scoot" tactics. Time-delay fuses that let munitions penetrate canopies before they detonate are preferable to proximity, mechanical, and electronic fuses that trigger harmless explosions among lofty branches. The range and direction of artillery fire moreover are difficult to adjust—aerial spotters can tell where rounds strike treetops, but seldom see targets on the ground, while land-based forward observers, who depend on sound instead of sight to calculate corrections, are disadvantaged given the short distance that noises are audible in jungles. U.S. Military Assistance Command, Vietnam (MACV) maintained only one armored cavalry regiment and no armored or mechanized divisions on its trooplist, essentially because opportunities to employ tanks in jungles and swamps generally are confined to clearings, plantations, and improved trails.[80]

Astute commanders, however, occasionally can make good use of artillery and tanks despite restrictions just delineated. Lieutenant General Slim, the senior British commander in Burma during World War II, concluded that "tanks can be used in almost any country except swamp." He used them to engage enemy strong points with infantrymen "riding shotgun," as did U.S. Army and Marine counterparts who conducted island-hopping campaigns in the South Pacific.[81] Vietnamese divisions under General Vo Nguyen Giap manhandled artillery, other heavy weapons, and perhaps 8,000 tons of supplies many miles over mountains and through presumably impenetrable jungles, established firing positions on high ground that dominated Dien Bien Phu, then dealt defenders a decisive defeat that drove France from Indochina.[82]

STAYING POWER

Staying power, a key requirement during protracted conflicts, is elusive in rain forests where ammunition, uniforms, maps, rations, medical supplies, and all other military materiel not safeguarded or immediately consumed are subject to rotting and rust. Maintenance problems coupled with the paucity of supply routes makes replenishment a laborious process. Debilitating diseases, medical evacuation (medevac) difficulties, and rapid rates of decay make life miserable for all concerned, including casualties, litter bearers, burial details, and graves registration personnel.

Maintenance and Replenishment. Jungle logisticians work under demanding conditions, because roads, trails, inland waterways, drop zones, landing zones, and fixed-wing airstrips suitable for large-scale supply and evacuation purposes not only are scarce but are hard to secure and maintain. Check points, roving patrols, convoy escorts, mine clearance crews,

and engineering gangs soak up personnel like sponges. Pack mules and porters often are the best (sometimes the only) reliable means of transportation. Allied forces on the Kokoda Track in New Guinea in fact employed more than *10,000* barefoot Papuans, who lugged backbreaking loads over the Owen Stanley Mountains. Costs and times required to construct new land lines increase dramatically with distance—it took 28,000 combat service support troops, 35,000 indigenous laborers, $150 million in World War II dollars, and 2 years to build the 1,100-mile (1,770-kilometer) road that led across Burma from Ledo in Assam to Kunming in China. That primitive avenue, which traversed jungles, gorges, rapids, and 21 closely spaced hairpin turns along one short stretch, was hardly an arterial highway but qualified as an engineering masterpiece nonetheless (see chapter 11 for details).[83]

Medical Miseries. Jungles are filled with animate and inanimate objects that bite, sting, and stick, a host of microorganisms that are harmful to humans, fungus infections that troops affectionately call "jungle rot," and steamy atmosphere that encourages profuse perspiration, body rashes, and heat exhaustion. Many tropical maladies traceable to insects include dengue fever, scrub typhus, and allergic reactions to bee stings. More casualties could be traced to malaria than to hostile fire during World War II campaigns in the South Pacific. Blood-sucking leeches, whose saliva contains an anticoagulant, leave sores that turn into ulcers unless properly treated. Typhoid fever, cholera, hepatitis, diarrhea, and amoebic dysentery thrive in contaminated food and water. Immunizations and scrupulous field sanitation practices can dramatically reduce most resultant nonbattle casualties which, like nonwalking wounded, must be evacuated to aid stations or hospitals. Patients and medical personnel both prefer air medevac whenever feasible, because stretcher bearers struggle through jungles, even for a few hundred yards.[84]

Cadavers don't last long in the heat and high humidity of tropical rain forests, whether they lie in the open or occupy shallow graves. The pervasive stench of putrefying flesh, as one veteran put it, "sticks to your . . . eyebrows, your gum line and the balls of you feet" before flies, ants, maggots, beetles, birds, and animals pick all bones clean. Personnel whose primary job is to retrieve remains face a revolting task. Positive identification of corpses that lack dog tags frequently awaits confirmation from dental records, skeletal scars, or DNA samples. [85]

WETLANDS

Wetlands, which strongly compete for the title "Least Trafficable Terrain," are saturated with and partially, completely, perennially or intermittently inundated by salty, brackish, or fresh water. Some are collocated with dense forests, others lie on open lands at high and low elevations in almost every clime including deserts, where they occasionally parallel streams and permeate river deltas. The generic term "swamp" subsumes wet woodlands; marshes feature tall grass, rushes, reeds, and cattails; bogs comprise spongy, poorly-drained soils variously covered with sedges, heath, mosses, lichens, and other stunted plants.

SEASONAL SWAMPS

The Russo-Finnish Winter War of 1939-40 is the only large-scale armed conflict ever fought on the tundra or in the taiga (Russian for "swamp forests"), which overlie most of the frigid flatlands in Canada, European Russia, and Siberia (map 12, page 94). Wetland warfare in

those sparsely settled, geographically forbidding regions could never last long in any case, because summers are short and moisture-soaked soil is frozen solid most of each year.

Seasonal swamps are militarily more significant in poorly drained regions a bit farther south, where summers are longer and warm weather is wetter. Brigadier General Francis Marion made a name for himself as the "Swamp Fox" when his guerrilla bands ran British redcoats ragged in the Carolinas during the American Revolution, then disappeared into sodden sanctuaries.[86] The Pripet Swamp, currently located in parts of Belarus, Ukraine, and European Russia, has channelized mass migrations and military operations for centuries. That formidable morass, which intersperses dense woods with countless ponds, moors, treacherous meadows, and shifting streams, extends 300 miles (480 kilometers) west to east and 140 miles (225 kilometers) north to south astride the Pripet Rivier, not counting two discontinuous offshoots that lead to Lakes Peipus and Lagoda near the Gulf of Finland (map 21). The entire complex expands twice a year, once in springtime when melting snows raise water levels and rivers overflow, again in the fall for about 4 weeks from the onset of autumn rains until the first hard frost. Permanent inhabitants are scarce, except along the fringe and in a few local centers such as Pinsk.

Cross-country movement is slow for foot soldiers and impossible for motor vehicles in most places. Roads in the region are widely spaced, mainly unimproved, largely of local importance, and, like all rivers save the Pripet, run north-south at right angles to topographical corridors between Russia and Poland. Many lanes are so narrow that military vehicle columns can neither detour nor turn around. German engineer troops during World War II used readily available logs to build mile after mile of "corduroy" roads in the absence of gravel and stone—trucks, tanks, and kidneys suffered incessant concussions as convoys bumped along at 5 miles per hour, but there was no better way to breach swampy obstacles.[87]

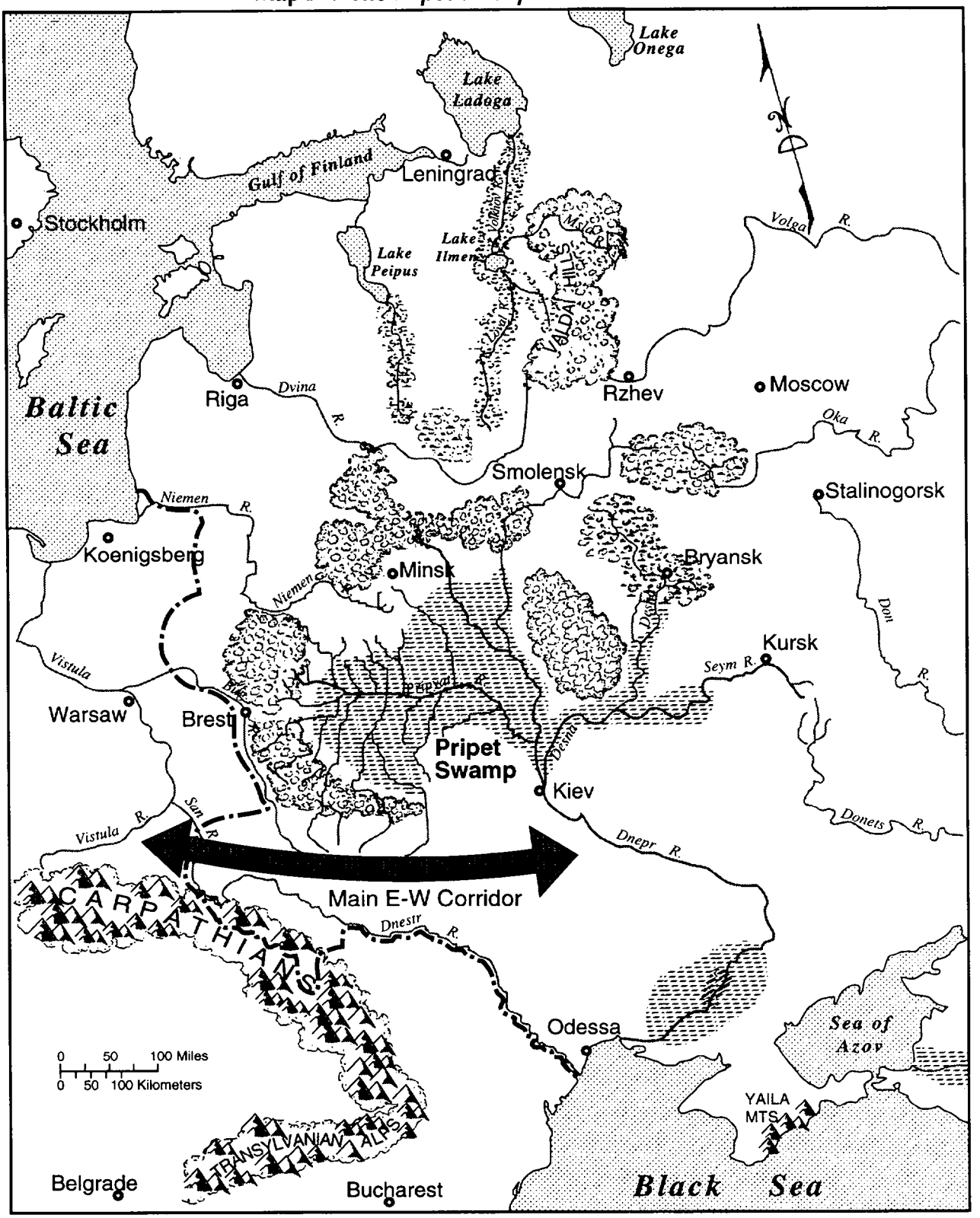
The Pripet Swamp, which created a great gap between German Army Group Center and Army Group North soon after Hitler invaded the Soviet Union in June 1941, made it impossible for large military formations to conduct mutually supporting operations. Attempts to bypass such extensive wetlands proved perilous, because outflanked Soviet stay-behind forces and partisans pounced on logistical troops as soon as German spearheads disappeared.[88] Commanders and staffs committed to combat in other high-latitude swamps should anticipate similar problems.

PERENNIAL SWAMPS

Perennial swamps, all in the tropics or subtropical lands, share many characteristics with seasonal wetlands but never freeze, are refilled constantly, and tend to be deep. Three distinctive categories with significantly different military implications are discernible: Category One emphasizes grassy wilderness; Category Two mingles rice paddies and plantations with primeval swamps; Category Three features tidewater forests.

Category One: Grassy Wilderness. The Everglades have seen more warfare than any other wetlands in Category One. That immense marsh, between Lake Okeechobee and the tip of Florida, is 40 miles wide (65 kilometers) and more than 100 miles long (160 kilometers). Head-high saw grass and other aquatic plants emerge from an alligator-infested solution of water and muck that seems almost bottomless in some places. Moss-draped

Map 21. *The Pripet Swamp and Its Offshoots*

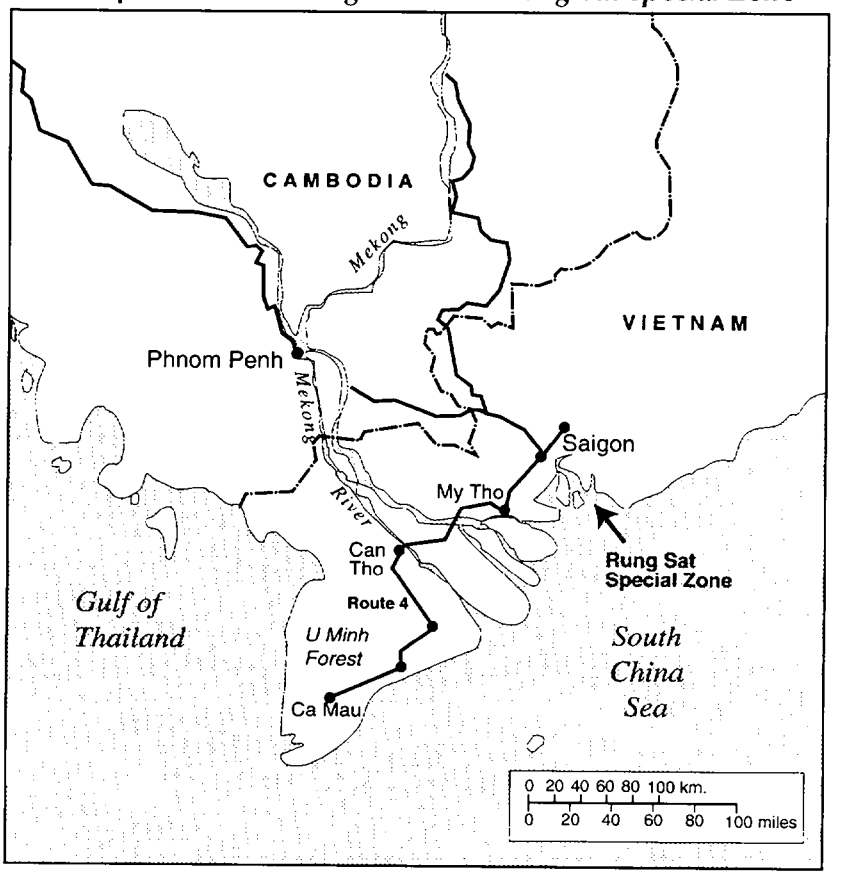


gumbo limbo, strangler fig, bald cypress, mahogany, and eight species of palm trees in assorted combinations adorn dry ground, which is at a premium.

General Andrew Jackson defeated, but did not demoralize, Seminole Indians under Billy Bowlegs in 1817-18. Superb guerrilla warriors simply melted into marshlands that then covered more than 3 million acres. Chief Osceola, who resisted subsequent U.S. efforts to resettle his tribe west of the Mississippi River, played tag in the Everglades with U.S. Army troops for 8 exasperating years (1835-42) during the Second Seminole War. Inconclusive operations not only cost the United States more lives and money than any other counter-Indian campaign but left several hundred recalcitrant tribesmen in control of ancestral lands. The U.S. Government paid them to move after the Third Seminole War (1855-58) failed to root them out, but a few resisted until 1934, 117 years after General Jackson entered the Everglades.[89]

"Scorched earth" programs took precedence over search and destroy missions in the early 1990s, when Iraqi dictator Saddam Hussein sought to exterminate, control, or chase Muslim Shiite "Marsh Arabs" from their homeland at the head of the Persian Gulf, along with army deserters and additional dissidents. Actions to drain the swamps and divert the Tigris-Euphrates Rivers drastically reduced water levels, increased pollution-related diseases, and disrupted age-old life styles. Iraqi troops then set widespread grass fires. Those compassionless steps coupled with aerial bombardments and artillery barrages quickly depleted the despised populations.[90]

Map 22. ***The Mekong Delta and Rung Sat Special Zone***



Category Two: Paddies, Plantations, and Primeval Swamps. No region represents Category Two more ably than the Mekong Delta, where regular and irregular armed forces battled from 1945 until 1975 to control its overflowing rice bowl and huge population. That strategically crucial property, bounded by the Gulf of Thailand and the South China Sea, spreads 16,000 square miles or so (40,000 square kilometers) southwest of Saigon, which later became Ho Chi Minh City (map 22).

About one-third of those flatlands are unreclaimed jungles or marshes, such as the Plain of Reeds, a sprawling prairie west of Ho Chi Minh City that is waterlogged during the wet season but dry enough to burn when rain-bearing winter monsoons stop blowing. Many vulnerable bridges and ferry sites mark Route 4, the only hard surface road to Ca Mau via Can Tho and other agricultural centers. The best of the rest are mainly paths of convenience rather than militarily useful lines of communication. Cross-country movement is laborious for foot troops and, in many places, impossible for vehicles even during the dry season. Wall-to-wall settlements and farmlands on scanty high land leave little room for airfields and permanent helicopter pads.[91] The scarcity of suitable materials moreover makes construction an expensive and time-consuming process. It took U.S. Army Engineers 6 months and approximately $20 million to dredge and deposit 5,295 cubic yards (4,045 cubic meters) of sand per acre over a 600-acre artificial island, erect buildings on site, and provide essential amenities in 1967 for a brigade-sized Mobile Afloat Force near My Tho.[92]

Swamp-style riverine warfare, a specialized form of amphibious operations, became a fine art in that watery environment dominated by more than 4,000 miles (6,400 kilometers) of navigable rivers and streams. "Brown water" sailors emulated Commodore Daniel T. Patterson, who established a U.S. precedent during the War of 1812 when his gunboats in Mississippi River bayous briefly delayed British redcoats on their way to New Orleans. The U.S. Army, Navy, and Marine Corps employed more advanced techniques and a "mosquito fleet" of schooners, flat-bottom boats, bateaux, and canoes in the Everglades a few years later; 20th-century successors in Nicaraguan and Philippine wetlands produced additional refinements.[93]

U.S. riverine forces in the Mekong delta, who had superior technologies at their disposal, devised innovative concepts, doctrines, tactics, organizations, weapons, equipment, and modes of transportation. Their flotillas contained a motley assortment of "pocket battleships," amphibious landing craft, armored troop carriers, mine sweepers, air-cushion vehicles, patrol boats, and rubber rafts, all well-adapted for warfare in shallow waters where tight turns, islands, sand bars, swamp grass, fish traps, low bridges, mines, and enemy-installed obstacles restricted maneuvers. Support forces afloat provided command, control, and integrating communications, air-conditioned barrack ships replete with sick bays, surgery wards, and water purification plants, plus supply, maintenance, repair, and salvage facilities. Web-footed infantrymen fervently wished for man-portable bridges, individual water wings, and similar amenities that were nonexistent or in short supply, but they benefited from flexible tactics that creative thinkers concocted explicitly for close combat where stream banks were slick as well as steep and adversaries concealed in dense vegetation could see and hear assault troops well before they arrived.[94]

Category Three: Tidewater Forests. Veterans of combat in tidal forests near Buna on Papua New Guinea's Coral Sea coast recall towering trees that made it impossible to see the sun during daylight hours or the stars at night. Creeks constituted tunnels through mangrove

swamps where gnarled buttress roots rose from black, sucking mud, and Japanese machine gun nests concealed in those natural abatis seemingly blocked every route.[95]

Vietnam veterans believe the Rung Sat Special Zone, a tidewater forest in the northeast corner of the Mekong Delta (map 22), made Buna and other wetlands look like picnic grounds. High tides there, which run as fast as 8 knots, raise and lower water levels as much as 16 feet (5 meters), drastically change channel directions and depths, and inundate most "dry" land twice daily. Mangrove and banyan trees protrude from brackish, polluted waters that, give or take a couple of percentage points, cover eight-tenths of the Zone. Nipa palms, brambles, brush, and serrated grass adorn hundreds of small islands, few of which were cultivated or inhabited. Boat crews along with U.S. and South Vietnamese troops ashore were constantly subject to ambush, because chemical defoliants, liberally applied, failed to dislodge insurgents or significantly disrupt their activities. Leeches couldn't tolerate such salty water, but that was about the only good news—insects swarmed; tight-tolerance weapons, ammunition powder trains, and primer cords often malfunctioned; mortar base plates sank in soggy soil unless they rested on sandbags; foxholes and bunkers turned into outdoor bath tubs. American soldiers and SEALs sloshing around in that dank region led such debilitating lives that medics recommended, and policymakers approved, repeated returns to dry ground after no more than 48 to 72 hours, lest foot infections, jungle rot, strain, and fatigue dangerously reduce proficiency. Rung Sat missions continued nonetheless, because the main commercial shipping channel and military supply line between Saigon and the sea ran through that region, along with other major waterways of local importance. Severe consequences would have ensued if U.S. Armed Forces and their allies had allowed Viet Cong insurgents to stop traffic.[96]

COASTLANDS AND SMALL SEAS

Naval conflicts began in coastal waters and small seas when organized warfare was in its infancy. Combatant ships subsequently ranged far and wide but, for technological and tactical reasons, conflicts occurred fairly close to shore until World War I. Carrier battle groups, attack submarines, and antisubmarine warfare forces during World War II conducted "blue water" campaigns on a grand scale never seen before or since. The United States Navy thereafter reigned supreme on the high seas until Soviet adversaries under the guidance of Fleet Admiral Sergei G. Gorshkov began to challenge U.S. preeminence in the mid-1960s. The Cold War, however, wound down a quarter of a century later without a shot fired in anger at sea and most observers at this writing generally agree that naval conflicts far from land seem a remote possibility for the foreseeable future. Naval strategists in countries large and small accordingly concentrate once again on littorals and small seas, where problems not only are different from those they must solve in mid-ocean but are infinitely more complex than those that predecessors faced a few years ago.

LITTORALS AND SMALL SEAS DELINEATED

Webster's Dictionary defines littorals as "the shore zone between high and low water marks," whereas the United States Navy and Marine Corps, perhaps playing interservice politics, see a much broader region that reaches from the "open ocean" (undefined) to the shore, thence overland 650 nautical miles (1,200 kilometers).[97] This document, in search of a realistic compromise, addresses littorals that extend seaward from the shoreline no more than 100

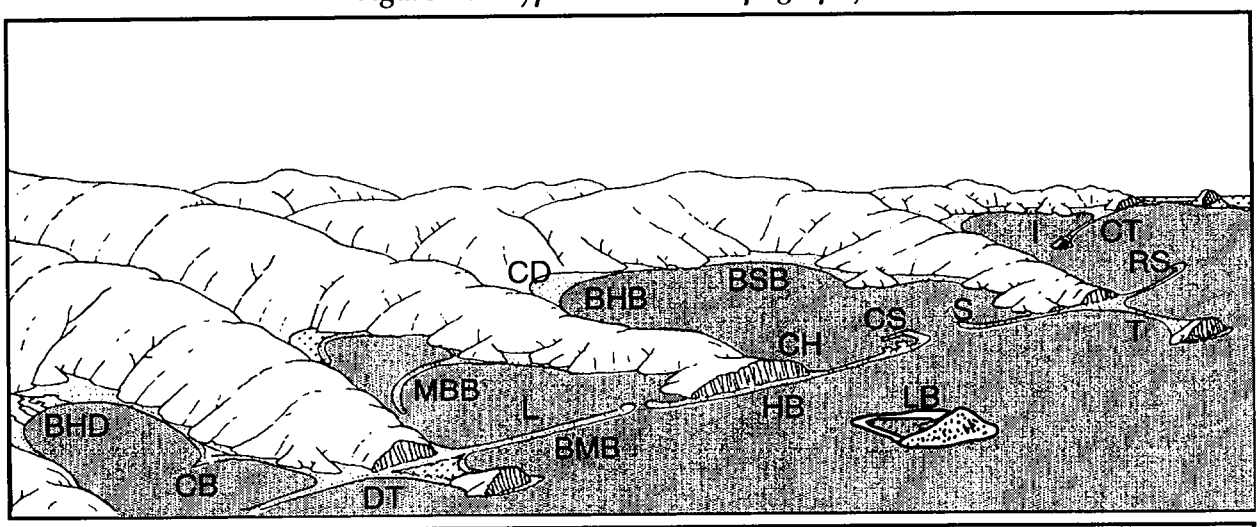
nautical miles (185 kilometers) and an equal distance inland, which affords enough depth in each direction to stage, conduct, and support coastal operations, including amphibious assaults.

The Adriatic, Aegean, Black, and Red Seas, Bo Hai and Korea Bay (northwest and northeast arms of the Yellow Sea), and the Persian Gulf typify small seas, the centers of which lie less than or little more than 100 miles from land. The Baltic, Bismarck, Caribbean, Coral, North, Mediterranean, and South China Seas, the Gulf of Mexico, the Seas of Japan and Okhotsk, and comparable oceanic offshoots are too large to qualify.

TYPICAL COASTAL TOPOGRAPHY

Littorals and small seas invariably include seashores, offshore approaches, and exits inland. The geographic features in each environment are strikingly different and infinitely more numerous than those associated with "blue water" (figure 20).[98]

Figure 20. ***Typical Coastal Topography***



BHB = bayhead beach	CH = cliffed headland	L = lagoon
BHD = bayhead delta	CS = complex spit	LB = looped bar
BMB = bay-mouth bar	CT = complex tombolo	MBB = mid-bay bar
BSB = bayside beach	DT = double tombolo	RS = recurved spit
CB = cuspate bar	HB = headland beach	S = spit
CD = cuspate delta	I = inlet	T = tombolo

Adapted from Arthur N. Strahlen, *Physical Geography,* 2d ed. (New York: John Wiley and Sons, 1963), 419

Offshore Approaches.

- Hydrodynamic conditions: tidal range great or slight; cross-currents and surf weak or strong; distance between low and high water marks measured in 10s or 100s of yards (meters)
- Water temperatures and salinity: stable or unstable
- Inshore sea bottoms: level or incised, gentle or steep, soft or solid

- Channels: few or many, deep or shallow, wide or narrow, well or poorly marked
- Assorted obstacles: sand bars, spits, hooks, mud flats, shoals, reefs, tombolos (natural causeways), lagoons, seasonal ice, sea weeds, ship wrecks, and trash
- Ambient noise: loud or muted; localized or universal; sounds caused by ships, recreational boats, fish, and fowl.

Seashores.
- Beaches: wide or narrow, short or long, sand, shingle, or mud
- Trafficability: good or poor
- Human habitation: dense, sparse, or absent
- Harbor and port facilities: many or few; antiquated or modern.

Exits Inland.
- Natural obstacles: cliffs, terraces, promontories, pinnacles, grottoes, caves, and caverns; sand dunes, marshes, swamps, and forests
- Cities, towns, villages, and isolated dwellings: large or small, many or few, flimsy or solid construction
- Roads and railways: many or few; high or low capacity; unobstructed or bottlenecked
- Airfields and landing zones: large or small, conveniently or inconveniently located, few or many modern facilities.

SELF-PRESERVATION PROBLEMS

Self-preservation takes precedence over other naval missions whenever hostile armed forces convert littorals into combat zones, because enemy guns and guided missiles aloft, afloat, and concealed ashore expose slow-moving surface ships to high-density, high-intensity, short-range surprise attacks (grottos and caves make grand hiding places). Assorted surface combatants, amphibious ships, cargo/troop transports, oil tankers, and auxiliaries in cramped quarters all make tempting targets. Egyptian Styx surface-to-surface antiship missiles that were primitive by modern standards set a precedent during the 1967 Arab-Israeli War when they sank the Israeli destroyer *Eilath* in shallow water. Moored and floating mines, the "weapons that wait," are cost effective as well as devastating. Italian frogmen, for example, surreptitiously planted limpet mines that put two British battleships on the harbor bed outside Alexandria, Egypt, in 1941. Fifty years later the U.S. Navy spent $17 million and 2 months to repair the billion-dollar Aegis guided missile cruiser *Princeton* after it rammed one Iraqi mine worth about $3,500.[99]

Littoral warriors who lack split-second reflexes and state-of-the-art computers are out of luck, because reaction times often are measured in a minute or two at most. Subsonic, sea-skimming cruise missiles flying 600 miles per hour (965 kph) hit targets 25 miles (40 kilometers) away 150 seconds after launch. Half that time likely elapses before missile defense crews can detect hostile projectiles with head-on radar cross-sections roughly equivalent in size to cormorants, leaving 75 seconds in which to confirm threats, track them, compute altitudes, ranges, and velocities, then fire. Saturation attacks, supersonic missiles, enemy evasive actions, false images caused by coastal clutter, and restrictive rules of engagement designed to safeguard friendly forces and neutrals are further complications.[100]

Effective countermeasures are hard to conceive. Stealthy ship designs could reduce visual, acoustic, electronic, infrared, and radar "signatures," but skeptics contend that such advantages would be far from foolproof, because laws of physics make it impossible for large surface combatants to "disappear" within small search areas. Budgetary constraints probably limit applications to a few high-value surface combatants other than huge aircraft carriers, which would be very costly to convert.[101] Some students of littoral warfare consequently are convinced that submarines able to sit quietly on muddy sea bottoms and maneuver well in shallow water may be the most effective countermeasures, because adversaries that lack an astonishing array of ASW sensors and weapon systems would be hard pressed to find them and finish them off (figure 21). Others advocate an influx of fast boats.[102]

POWER PROJECTION PROBLEMS

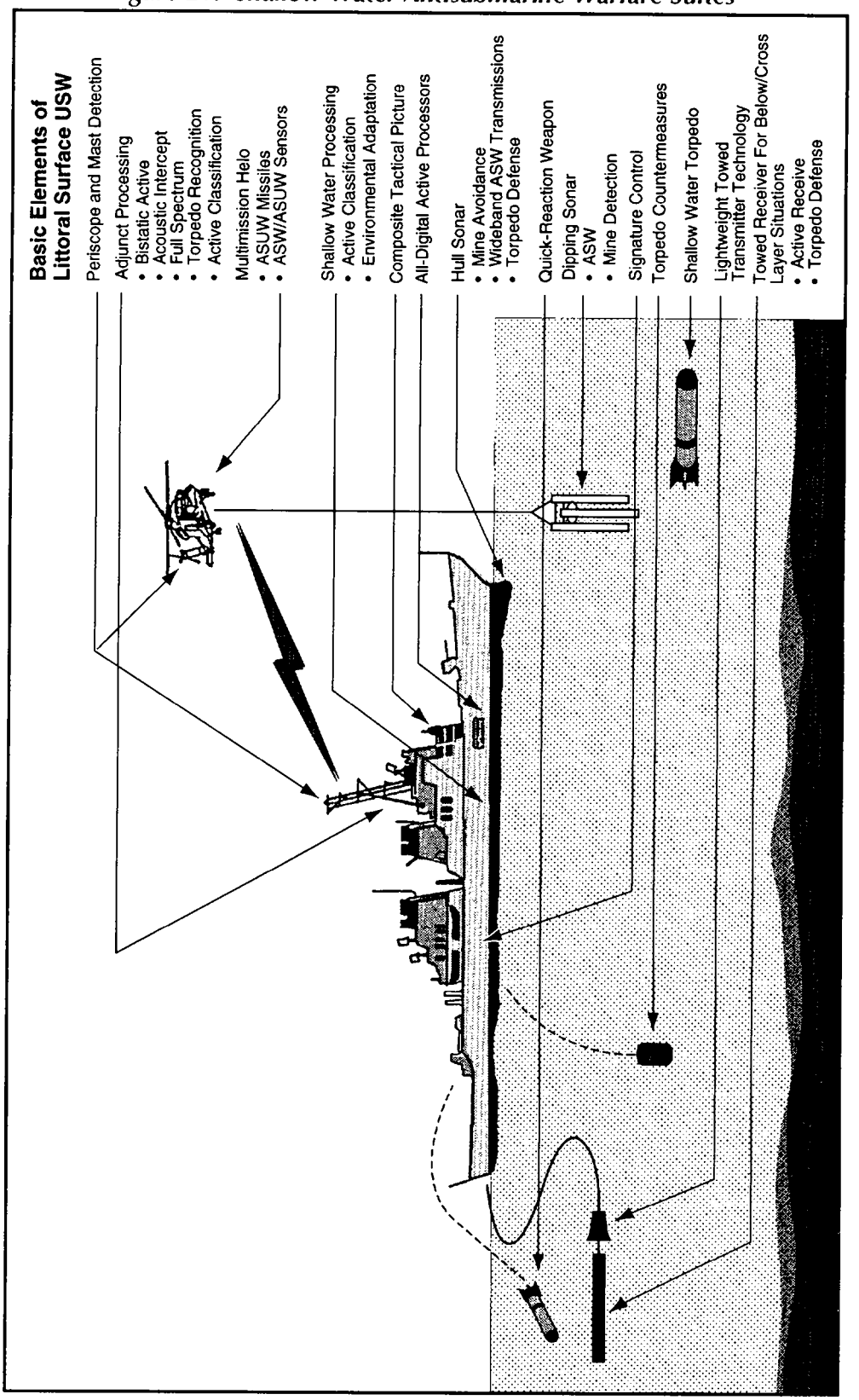
Power projection missions along littorals and in small seas prominently feature sea control and amphibious assaults. Shallow water mines figure positively in the first instance and negatively in the second.

Shallow Water Sea Control. Sea control in some respects is more difficult to achieve along littorals than on open oceans, because enemy forces can bring land-based as well as naval combat power to bear. Shallow waters, however, simplify the accomplishment of less demanding *sea denial* missions, which seek to suppress enemy maritime commerce and limit options open to enemy naval commanders.

Blockades customarily are considered acts of war under international law, but they also are the most economical way to bottle up opposing navies and merchant marines in port, prevent enemy ships at sea from returning for rest, recuperation, maintenance, and replenishment, seal off seaborne support by sympathizers, and generally deny foes freedom of the seas. *Cordons sanitaire* that employ men-of-war to deter, deflect, stop, board, search, seize, or sink blockade runners expose implementing crews to considerable risk. A cheaper, equally or more effective technique relies on bottom, floating, or tethered mines that variously activate on command, on contact, or in response to magnetic, acoustic, or pressure stimuli. They are easy to install and hard to avoid in coastal channels, but only if seeded en masse. Mines that Iran deposited piecemeal in the Persian Gulf to impede petroleum tankers and their escorts (1987-88) therefore proved to be more of a nuisance than a menace, whereas traffic into and out of Haiphong harbor ceased for 10 months after U.S. carrier-based aircraft laid 8,000 influence mines across its entrance in April 1972.[103]

Transit from Sea to Shore. The transit from ships onto heavily defended shores is a traumatic experience in large part because geographic features favor defenders and oppose waterborne assault forces who must fight rough surf, long-shore currents, and occasionally strong winds on their way to designated beaches over routes devoid of natural cover or concealment. Mine hunters and mine sweepers whose dangerous duty is to detect, mark, and clear lanes through the "foam zone" need one set of implements for use where shifting sands or soft mud bury bottom mines, another set where sediments suspended in breaking waves act as obscurants, and yet another where rocky approaches cause sonar signals to bounce about. Some naval inventories already include sizable helicopter fleets and a few ship-to-shore vehicles that ride on or above rather than in the water, but unmanned submersibles and remote control systems that eventually may be able to elude shallow water mines are still in early stages of development.[104]

Figure 21. *Shallow Water Antisubmarine Warfare Suites*



Source: Nathaniel French Caldwell, "Are We Shortchanging ASW?," *Armed Forces Journal*, July 1996, p 25.

KEY POINTS

- Every geographical region displays singular characteristics that demand specialized military plans, operations, and programs.
- Armed forces that are organized, equipped, and trained to function in any given geographical environment perform less well elsewhere until they complete essential adjustments.
- Preparations can be complex, costly, and time-consuming, because each of the seven distinctive regions described herein contains subdivisions such as hot-wet, hot-dry, cold-wet, cold-dry, sandy deserts, rocky deserts, and so on.
- Each region requires tailored strategies, tactics, and techniques.
- Each region uniquely influences the capabilities of military personnel, weapons, munitions, and telecommunication systems.
- Each region uniquely influences requirements for food, clothing, shelter, maintenance, and medical support.

NOTES

1. Nine Principles of Preparedness are available in John M. Collins, *Military Preparedness: Principles Compared with U.S. Practices*, Report No. 94-48 S (Washington, DC: Congressional Research Service, January 21, 1994), 41-49.

2. Charles M. Daugherty, *City Under the Ice: The Story of Camp Century* (New York: Macmillan, 1963); Trevor Hatherton, ed., *Antarctica* (New York: Praeger, 1965), references to Little America 1, 2, 3, and 4: 35-39, 68-69, 91, 193, 205-206, 211-216, 233-235, 248-249, 280, 443, 469, 474-478, 484-486, 501.

3. For a few historical examples, see A. W. Abbott, "Lapland 1918-19, The British Army's Farthest North," *Army Quarterly* 84 (1962): 236-243; Charles S. Stevenson, "The 40-Below-Zero Campaign" [U.S. forces in European Russia and Eastern Siberia, 1918-1920], *Army* 19, no. 2 (February 1969): 49-50; Charles O. Lerche, Jr., "Norway (1940-1945)," in *Challenge and Response in Internal Conflict*, vol. 2, *The Experience in Europe and the Middle East*, eds. D. M. Condit, Bert H. Cooper, Jr., et al. (Washington, DC: Center for Research in Social Systems, American University, March), 225-249; Alex Bruckner, "Attack in the Tundra," *Military Review* 36, no. 1 (April 1956): 98-109.

4. Robert W. Service, "The Cremation of Sam McGee," in *The Spell of the Yukon* (New York: Dodd Mead and Co. 1907), 66.

5. Personal survival problems are described in *The Arctic Basin*, coordinated by John E. Slater, (Centerville, MD: Tidewater Publishing for The Arctic Institute of America, 1963), 278-289; FM 31-70: *Basic Cold Weather Manual* (Washington, DC: Dept. of the Army, April 1968, 43-50; Robert D. Cheney, "Cold Weather Medicine: An Ounce of Prevention," *Marine Corps Gazette*, February 1981, 43, 44-45, 47.

6. FM 31-70: *Basic Cold Weather Manual*, chap. 2 and appendix E; Carl W. Riester, "Cold Weather Operations," *Special Warfare*, January 1994, 9-10.

7. Rowan Scarborough, "High-Tech Clothing Gives GIs Weather Protection," *Washington Times*, December 28, 1995, 1.

8. FM 31-70: *Basic Cold Weather Manual*, 16-17, 22-27, 29-35.

9. Ibid., 36-39, 42-43; Jonathan D. Thompson, "Infantry Company Operations in an Extremely Cold Environment," *Infantry* (September-October 1995): 31-32; "Cold Weather Operations," part 2, *Infantry* (November-December 1980): 29.

10. FM 9-209/Technical Order 36-1-40: *Operation and Maintenance of Equipment in Cold Weather (0^0 to -60^0)* (Washington, DC: Dept. of the Army and Dept. of the Air Force, August 10, 1989, 1-2 through 1-5, 1-7 through 1-9, 5-1 and 5-2, 6-1 through 6-4; FM 31-70: *Basic Cold Weather Manual*, 177; "Cold Weather Operations," part 3, *Infantry* (January-February 1981): 23-24.

11. Guy Murchie, *Song of the Sky* (Boston, MA: Houghton Mifflin, 1954), 238.

12. FM 31-70: *Basic Cold Weather Manual*, chapter 4, plus 105-115 and appendix C; Thompson, "Infantry Company Operations in an Extremely Cold Environment," 29-31.

13. FM 31-70: *Basic Cold Weather Manual*, 115-121; Francis King, "Cold Weather Warfare: What Will Happen?," *Military Review* 57, no. 11 (November 1977): 86, 92; "Cold Weather Operations," part 3, *Infantry*, 24, 25.

14. William P. Baxter, "Soviet Norms for Driving Tanks," *Military Review* 60, no. 9 (September 1980): 5-8; Alexander Werth, *Russia at War*, 1941-1945 (New York: E. P. Dutton, 1964), 321-335.

15. Guy Murchie, *Song of the Sky*, 233-234, 238-239; Francis King, "Cold Weather Warfare: What Would Happen?," 87, 90-91; Lewis E. Link, "Cold Regions Impacts on Army Operations," *Readings in Military Geography*, vol. 1, *Tactical* (West Point, NY: Dept. of Geography, U.S. Military Academy, 1990), 80,82.

16. Rudolph M. Tamez, who was Operations Officer for the composite battalion of the 504th Parachute Infantry Regiment that participated in Operation Arctic Night.

17. John C. Scharfen, "Cold Weather Training: the Absolute Necessity." *Marine Corps Gazette*, February 1981, 66, 67, 68, 69; Francis King, "Cold Weather Warfare: What Would Happen?" 87, 90; *The Arctic Basin*, 237-249, 263-277.

18. *Encyclopedia Britannica*, vol. 12, 1962, 41-42.

19. *U.S. Navy Cold Weather Handbook for Surface Ships* (Washington, DC: Chief of Naval Operations, Surface Ship Survivability Office (OP O3C2), May 1988), 2-2, 2-3, 2-12, 3-1, 3-8 and 3-9, chap. 5, appendices B, D, F.

20. Ibid., 2-8, 3-7.

21. Ibid., chapters 2 and 3.

22. Brian Garfield, *The Thousand-Mile War: World War II in Alaska and the Aleutians* (Garden City, NY: Doubleday, 1969), 119-120.

23. Thomas B. Curtain, Norbert Untersteiner, and Thomas Callahan, "Arctic Oceanography", *Oceanus* (Winter 1990/91): 58-66; *U.S. Cold Weather Handbook for Surface Ships*, 4-4 through 4-10, 6-5 and 6-6.

24. Barrie Pitt, *The Battle of the Atlantic* (Alexandria, VA: Time-Life Books, 1977), 157-159, and John R. Elting, *Battles for Scandinavia* (Alexandria, VA: Time-Life Books, 1981), 146-148.

25. John R. Hale, *Age of Exploration* (New York: Time Inc., 1966), 101-102, 118-126; William D. Smith, *Northwest Passage* (New York: American Heritage Press); Constantine Krypton, *The Northern Sea Route and The Economy of the Soviet Union* (New York: Praeger, 1956).

26. William R. Anderson with Clay Blair, Jr., *Nautilus 90 North* (Blue Ridge Summit, PA: TAB Books, 1959), 212-239.

27. Waldo K. Lyon, "Submarine Combat in the Ice," *U.S. Naval Institute Proceedings* 118, no. 2 (February 1992): 33-40; *U.S. Cold Weather Handbook for Surface Ships*, 1-6.

28. Ibid., 38-39; H. A. Jackson et al., "Bottom Bounce Array Sonar Submarines," *American Society of Naval Engineers Journal* (September 1989): 59.

29. Lorus J. and Margery Milne, *The Mountains*, Time-Life Nature Library, rev. ed. (New York: Time Inc., 1967); FM 90-6: *Mountain Operations* (Washington, DC: Dept. of the Army, June 30, 1980, I-ii, 1-1 through 1-3, and appendix G

30. John Heins, "Cuba (1953-1959)," in *Challenge and Response in International Conflict*, vol. 3, *The Experience in Africa and Latin America*, eds. D. M. Condit, Bert H. Cooper, Jr., et al. (Washington, DC: Center for Research in Social Studies, American University, April 1968), 435-461.

31. Field-Marshal Viscount Slim, *Defeat into Victory* (New York: David McKay, 1961), 6.

32. FM 90-6: *Mountain Operations*, 1-14 and 1-15, 3-2, 3-3, D-1, D-3; Morgan B. Heasley, "Mountain Operations in Winter," *Military Review* 32, no. 6 (June 1952): 10, 11, 12, 14, 15, 16.

33. FM 90-6: *Mountain Operations*, 1-6 through 1-8.

34. Julie Kim and Steven Woehrel, *Bosnia—Former Yugoslavia and U. S. Policy*, Issue Brief 91089 (Washington, DC: Congressional Research Service, July 23, 1996), updated periodically.

35. FM 90-6: *Mountain Operations*, 4-1, 5-2, 5-3; Heasley, "Mountain Operations in Winter," 14, 15.

36. Robert Wallace, *The Italian Campaign* (New York: Time-Life Books, 1978), 108-109, 184-185. For military mountaineering equipment and techniques, see FM 90-6: *Mountain Operations*, B-4, B-5, B-7, and appendix C.

37. FM 90-6: *Mountain Operations*, chapter 2. *Challenge and Response in International Conflict* addresses 20th-century mountain operations by irregular forces: vol. 1, *The Experience in Asia*, February 1968, Burma (1942-1945), Indonesia (1946-1948), Jammu and Kashmir (1947-1949), Korea (1948-1954), Tibet (1951-1960); vol. 2, *The Experience in Europe and the Middle East*, March 1967,Greece (1942-1949), Italy (1943-1945), Norway (1940-1945), Yugoslavia (1941-1944); vol. 3, *The Experience in Africa and Latin America*, April 1968, Ethiopia (1937-1941), Nicaragua (1927-1933), Colombia (1948-158); Supplement, September 1968, Dominican Republic (1916-1924), Haiti (1918-1920, 1958-1964), Laos (1959-1962).

38. FM 90-6: *Mountain Operations*, 4-8 through 5-5.

39. Ibid., 4-5, 4-6, and appendix D.

40. Neville G. A. Maxwell, *India's China War* (New York: Pantheon Books, 1970).

41. Wayne O. Evans and James E. Hansen, "Troop Performance at High Altitudes," *Army* (February 1966): 55-58; James R. Pulver, "Fight Against Mountain Sickness," *Army Digest* (June 1970): 45-46; FM 90-6: *Mountain Operations*, 1-9, 5-6 through 5-9.

42. DA Pamphlet 95-8: *Mountain Flying Sense* (Washington, DC: Dept. of the Army, 1962); Will F. Thompson, "Airmobile Warfare in the Mountains," *Military Review* 50, no. 7 (July 1970): 57-62; FM 90-6: *Mountain Warfare*, 1-15.

43. William H. Tunner, *Over the Hump* (Washington, DC: Office of the Air Force Historian, 1985); Otha Cleo Spencer, *Flying the Hump: Memories of an Air War* (College Station, TX: Texas A&M Press, 1992); and Don Moser, *China-Burma-India*, "Vaulting the Himalayas" (Alexandria, VA: Time-Life Books, 1978), 78-91.

44. FM 90-6: *Mountain Operations*, appendix F.

45. See, for example, John Warry, *Warfare in the Classical World* (New York: St. Martin's Press, 1980), which covers 2,400 years from 1,600 B.C. to 800 A.D.

46. Keith E. Bonn, *When the Odds Were Even: The Vosges Mountains Campaign, October 1944-January 1945* (St. Rafael, CA: Presidio Press, 1994).

47. Wallace, *The Italian Campaign*, 100-117, 130-145, 151-164.

48. Matthew B. Ridgway, *The Korean War* (Garden City, NY: Doubleday, 185-225; and T. R. Fehrenbach, *This Kind of War* (New York: Macmillan, 1963), 478-645.

49. Carl von Clausewitz, *On War*, eds. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 417-432, 537-539. The quotation is on 427.

50. For overviews of wars in the Cradle of Western Civilization, see Yigal Yadin, *The Art of Warfare in Biblical Lands* (Norwich, England: Jarrold and Sons, International Publishing, 1963); a broader view of combat in arid regions is contained in Bryan Perrett, *Desert Warfare: From Its Roman Origins to the Gulf Conflict* (New York: Sterling Publishing, 1988.

51. A. Starker Leopold, *The Desert*, Life Nature Library (New York: Time-Life Books, 1961); FM 90-3/Fleet Marine Force Manual 7-27: *Desert Operations* (Washington, DC: Dept. of the Army, August 19, 1977), 2-3 through 2-5 and appendix A.

52. Richard Collier, *The War in the Desert* (New York: Time-Life Books,1977), 171-172; Leopold, *The Desert*, 101-102, 105, 108-109; FM 90-3: *Desert Operations*, 2-7.

53. *Winning in the Desert*, Newsletter No. 90-7, Special Edition (Fort Leavenworth, KS: U.S. Army Combined Arms Training Activity, Center for Lessons Learned, August 1990), 12, 21; Kendall L. Peterson, "Automotive Testing in the Desert," *Military Review* 50, no. 11 (November 1970): 56-61; William G. ("Gus") Pagonis, *Moving Mountains: Lessons in Leadership and Logistics from the Persian Gulf War* (Boston, MA: Harvard Business School Press, 1992), 86, 96; Leopold, *The Desert*, 13-14; FM 90-3: *Desert Operations*, 2-21 and 2-22.

54. Collier, *The War in the Desert*, 50, 52-53; Glenn R. Locke, "Dust," *U.S. Army Aviation Digest* (August 1970): 34-35.

55. FM 90-3: *Desert Operations*, 2-20, 2-22 and 2-23; Pagonis, *Moving Mountains*, 86; *Infantry*, July-August 1981, 168-169.

56. Pagonis, *Moving Mountains*, 108.

57. FM 90-3: *Desert Operations*, 2-9 and 2-10, 4-20; Leopold, *The Desert*, 31, 102, 146-150.

58. Richard Collier, *The War in the Desert*, 54.

59. FM 90-3: *Desert Operations*, 2-15 through 2-18, 5-9, 5-10, F-6, appendix G; Pagonis, *Moving Mountains*, 96, 205; Leopold, *The Desert*, 32, 128.

60. Martin Blumenson, *Kasserine Pass* (Boston, MA: Houghton Mifflin, 1967); Moorehead's analogy is quoted in Collier, *The War in the Desert*, 21.

61. Fluid maneuvering throughout history is typified in Sir John Bagot Glubb, *The Great Arab Conquests* (Englewood Cliffs, NJ: Prentice-Hall, 1963); Leo de Hartog, *Genghis Khan: Conqueror of the World* (New York: St. Martin's Press, 1989),78-148; T. E. Lawrence, *Seven Pillars of Wisdom* (New York: Dell Publishing, 1962); Edgar O'Ballance, *Afghan Wars 1839-1992* (New York: Brassey's, 1993); Robert H. Scales, Jr., *Certain Victory: The U.S. Army in the Gulf War* (Washington, DC: Office of the Chief of Staff, U.S. Army, 1993).

62. Collier, *The War in the Desert*, 12-29.

63. *Gulf War Air Power Survey*, vol. I-5, Eliot A. Cohen, Director (Washington, DC: Government Printing Office, 1993); Frank N. Schubert and Theresa Kraus, eds., *The Whirlwind War* (Washington, DC: U.S. Army Center of Military History, 1995).

64. Leopold, *The Desert*, 18-19, 32, 34; *Winning in the Desert*, 16-17.

65. William Matthews, "Forecaster Helps Pilots Find Targets," *Air Force Times*, July 1, 1996, 16; FM 90-3: *Desert Operations*, 2-8, 4-4 and 4-5; *Winning in the Desert*, 18, 23; "The Desert: Its Effect on Soldiers," part 2, *Infantry* (September-October 1981): 31.

66. Ibid.

67. Virginia Cowles, *The Phantom Major* (New York: Harper and Brothers, 1958).

68. Byron Farwell, *Queen Victoria's Little Wars* (New York: Harper and Row, 1972); Charles Miller, *Khyber, British India's Northwest Frontier: The Story of an Imperial Migraine* (New York: Macmillan, 1977); David C. Isby, *War in a Distant Country: Afghanistan Invasion and Resistance* (London: Arms and Armor, 1989).

69. FM 90-3: *Desert Operations*, appendix D.

70. Ibid.

71. Pagonis, *Moving Mountains*; *Winning in the Desert*, 12-13, 16-20; FM 90-3: *Desert Operations*, 2-20 through 2-25, 5-1, 5-6 through 5-11.

72. Masanobu Tsuji, *Singapore: The Japanese Version* (New York: St. Martin's Press, 1960), appendix 1; U.S. Marine Corps, *Small Wars Manual* (Washington, DC: Government Printing Office, 1940); FM 31-20: *Basic Field Manual, Jungle Warfare* (Washington: U.S. War Department, December 1941).

73. Eric Bergerud, *Touched With Fire: The Land War in the South Pacific* (New York: Viking, 1996), 62-68; Joseph W. Stilwell, *The Stilwell Papers* (New York: Schocken Books, 1972), 293.

74. FM 90-5: *Jungle Operations* (Washington, DC: Dept. of the Army, August 16, 1982), 1-3 through 1-6.

75. John. L. Zimmerman, *The Guadalcanal Campaign* (Washington, DC: Historical Division, Hqtrs., U.S. Maine Corps, 1949), 15-17; Bergerud, *Touched With Fire*, 69-83.

76. FM 90-5: *Jungle Operations*, 5-2 through 5-4, 5-10, 5-15: *Winning in the Jungle* (Fort Leavenworth, KS: U.S. Army Combined Arms Center, Center for Army Lessons Learned, May 1995), I-1, I-5, I-8, II-2, III-2 through III-4, III-8.

77. Rafael Steinberg, *Island Fighting* (New York: Time-Life Books, 1978), 20, 38-45 (Admiral Halsey is cited on 38); FM 90-5: *Jungle Warfare*, 5-6, 5-14, appendix B (Navigation and Tracking); *Winning in the Jungle*, I-2; Zimmerman, *The Guadalcanal Campaign*, 16.

78. Steinberg, *Island Fighting*, 46-71, 82, 134-136; Bergerud, *Touched With Fire*, 80-84; *Winning in the Jungle*, I-2 through I-5, I-9; FM 90-5: *Jungle Operations*, appendix G.

79. Ian Henderson, *Man Hunt in Kenya*, with Philip Goodhart, portrays counterinsurgency problems in jungle-like terrain (Garden City, New York: Doubleday, 1958). See also *Challenge and Response in International Conflict*, vol. 1, Philippines (1899-1902, 1942-1945, 1946-1954), Burma (1942-1945), Malaya (1942-1945, 1948-1960), Indochina and South Vietnam (1946-1954, 1956-1963), Indonesia (1946-1949, 1958-1961); vol. 3, Nicaragua (1927-1933), Madagascar (1947-1948), Portuguese Guinea (1959-1965); Supplement, Dominican Republic (1916-1924), Haiti (1918-1920, 1958-1964), Laos (1959-1962).

80. FM 90-5: *Jungle Operations*, 6-5 through 6-17 and appendix I, Adjustment of Fire by Sound; *Winning in the Jungle*, I-14 through I-17.

81. Field-Marshal Viscount Slim, *Defeat Into Victory*, 119-200, 275.

82. Bernard Fall, *Hell in a Very Small Place* (Philadelphia, PA: Lippincott, 1958).

83. FM 90-5: *Jungle Operations*, chapter 7, Combat Service Support; Don Moser, *China-Burma-India* (New York: Time-Life Books, 1978), 196-203; Steinberg, *Island Fighting*, 64-67.

84. FM 90-5: *Jungle Operations*, 2-2 through 2-8; Bergerud, *Touched With Fire*, 90-101, 452-467.

85. Bergerud, *Touched With Fire*, 72, 84, 85,86, 418, 420, 467-468.

86. W. Gilmore Simms, *The Life of Francis Marion* (New York: H. G. Langley, 1844).

87. Former German generals and staff officers prepared four pamphlets for publication by Dept. of the Army in Washington, DC: DA Pamphlet 20-201, *Military Improvisations During the Russian Campaign*, August 1951, 53-55; DA Pamphlet 20-231, *Combat in Russian Forests and Swamps*, July 1951, 1-3, 5, 7-8, 13, 32-33; DA Pamplet 20-290, *Terrain Factors in the Russian Campaign*, July 1951, 30, 38; DA Pamphlet 20-291, *Effects of Climate on Combat in European Russia*, February 1952, 29, 49, 50.

88. *Combat in Russian Forests and Swamps* (all); *Terrain Factors in the Russian Campaign*, 28-45; *Effects of Climate on Combat in European Russia*, 29-35, 49-55.

89. David and Jeanne Heidler, *Old Hickory's War: Andrew Jackson and the Quest for Empire* (Mechanicsburg, PA: Stackpole Books, 1996); John K. Mahon, *History of the Second Seminole War,1835-1842* (Gainesville, FL: University of Florida Press, 1967); *Soldiers of Florida in the Indian, Civil, and Spanish American Wars* (Tallahassee, FL: Board of State Institutions, undated).

90. Kenneth Katzman, *Iraq: Marsh Arabs and U.S. Policy*, Report No. 94-320F (Washington, DC: Congressional Research Service, April 13,1994); "Once a Wetland, Now a Desert," *Boston Globe*, September 8, 1994, 20.

91. William B. Fulton, *Riverine Operations, 1966-1969* (Washington, DC: Dept. of the Army, 1985,17-19.

92. Ibid., 47-49, 57-58, 68-71; *Engineering Concepts for Construction in the Mekong Delta Region of the Republic of Vietnam*, U.S. Army Engineer Command, Vietnam (Provisional), undated

(1967). James H. Nash, Special Projects, Engineering Division, U.S. Army Vietnam Engineer Section, orally furnished Dong Tam cost figures in 1968.

93. Richard M. Meyer, "The Ground-Sea Team in River Warfare," *Military Review* 46, no. 9 (September 1966): 54-61.

94. Fulton, *Riverine Operations*, 21, 26-67, 89-102; FM 90-5: *Jungle Operations*, appendix D; John B. Spore, "Floating Assault Force: Scourge of the Mekong Delta," *Army* (February 1958): 28-32; "Paths Across the Mekong" and "Monsters That Float on Air," *Army* (June 1968): 72-73, 80-81; John W. Baker and Lee C. Dickson, "Army Forces in Riverine Operations," *Military Review* 47, no. 8 (August 1967): 64-74.

95. Jay Luvaas, "Buna, 19 November 1942-2 January 1943," in *America's First Battles*, eds. Charles E. Heller and William A Stofft (Lawrence, KS: University of Kansas Press, 1986), 201, 209-210; Bergerud, *Touched With Fire*, 73-74.

96. S. L. A. Marshall, *Ambush* (New York: Cowles,1969), 186-199; *Area Wide Analysis of the Rung Sat Special Zone*, U.S. Army Vietnam, undated (1967), twenty-one 21x 26-inch sheets of text, maps, and photographs; recollections of Edwin W. Chamberlain, Jr., a Rung Sat veteran, July 10, 1969.

97. . . . *From the Sea: Preparing the Naval Service for the 21st Century* (Washington, DC: Department of the Navy, September 1992), 6.

98. Charles H. Sinex and Robert S. Winokur, "Environmental Factors Affecting Military Operations in the Littoral Battlespace," *Johns Hopkins APL Technical Digest* 14, no. 2 (1993): 112-124; Charles W. Koburger, Jr. *Narrow Seas, Small Navies, and Fat Merchantmen* (New York: Praeger, 1990), 137-145.

99. For some cost-benefit figures, see George R. Worthington, "Combat Craft Have a Role in Littoral Warfare," *U.S. Naval Institute Proceedings* 120, no. 8 (August 1994): 24-25.

100. John W. McGillvray, Jr. "Stealth Technology in Surface Warships," *Naval War College Review* 47, no. 1 (Winter 1994): 29-30; Yedidia "Didi" Ya'ari, "The Littoral Arena: A Word of Caution," *Naval War College Review* 48, no. 2 (Spring 1995): 9, 10, 12, 17; Ronald O'Rourke, *Navy DD-51 Destroyer Procurement Rate: Issues and Options for Congress*, Report No. 94-343F (Washington, DC: Congressional Research Service, April 25, 1994), 25-26.

101. McGillvray, "Stealth Technology in Surface Warships," 33-39; Ya'ari, "The Littoral Region," 14.

102. Norman Friedman, "Littoral Anti-Submarine Warfare: Not As Easy As It Sounds," *International Defense Review* (June 1995): 53-57; Worthington, "Combatant Craft Have a Role in Littoral Warfare."

103. Koburger, Jr., *Narrow Seas, Small Navies, and Fat Merchantmen*, 43-44, 46-48, 69, 89-90, 107, 112-113; Maurice Griffiths, *The Hidden Menace* (Greenwich, CT: Conway Maritime Press, 1981), 127.

104. Arthur P. Brill, Jr., "The Last Twenty Feet," *Sea Power* (November 1995): 43-46; Sinox and Winokur, "Environmental Factors Affecting Military Operations in the Littoral Battlespace," 114, 115-117, 121.

7. INNER AND OUTER SPACE

Icarus was a brave boy,
feathered wings his pride and joy.
He flew high and had fun
'til he neared the hot sun,
which melted his fragile toy.

Anonymous
The First Space Flight
A Cautionary Limerick

MILITARY SPACE FORCES, UNLIKE MYTHOLOGICAL ICARUS WHO FLEW TOO CLOSE TO THE SUN, CURRENTLY confine their activities to inner space, where they perform crucially important reconnaissance, surveillance, target acquisition, tracking, communications, navigational, meteorological, missile warning, and verification missions in a medium quite different than land, sea, or air.[1] Combat operations eventually may occur[2] but interplanetary warfare seems far in the future for political, economic, military, and technical reasons. Round trips to Mars, for example, would take 2 or 3 years. The following discussions therefore concentrate on four distinctive regions within the Earth-Moon System: Aerospace Interfaces, Circumterrestrial or Inner Space, the Moon and Its Environs, and an amorphous Outer Envelope, beyond which outer space begins (map 23).

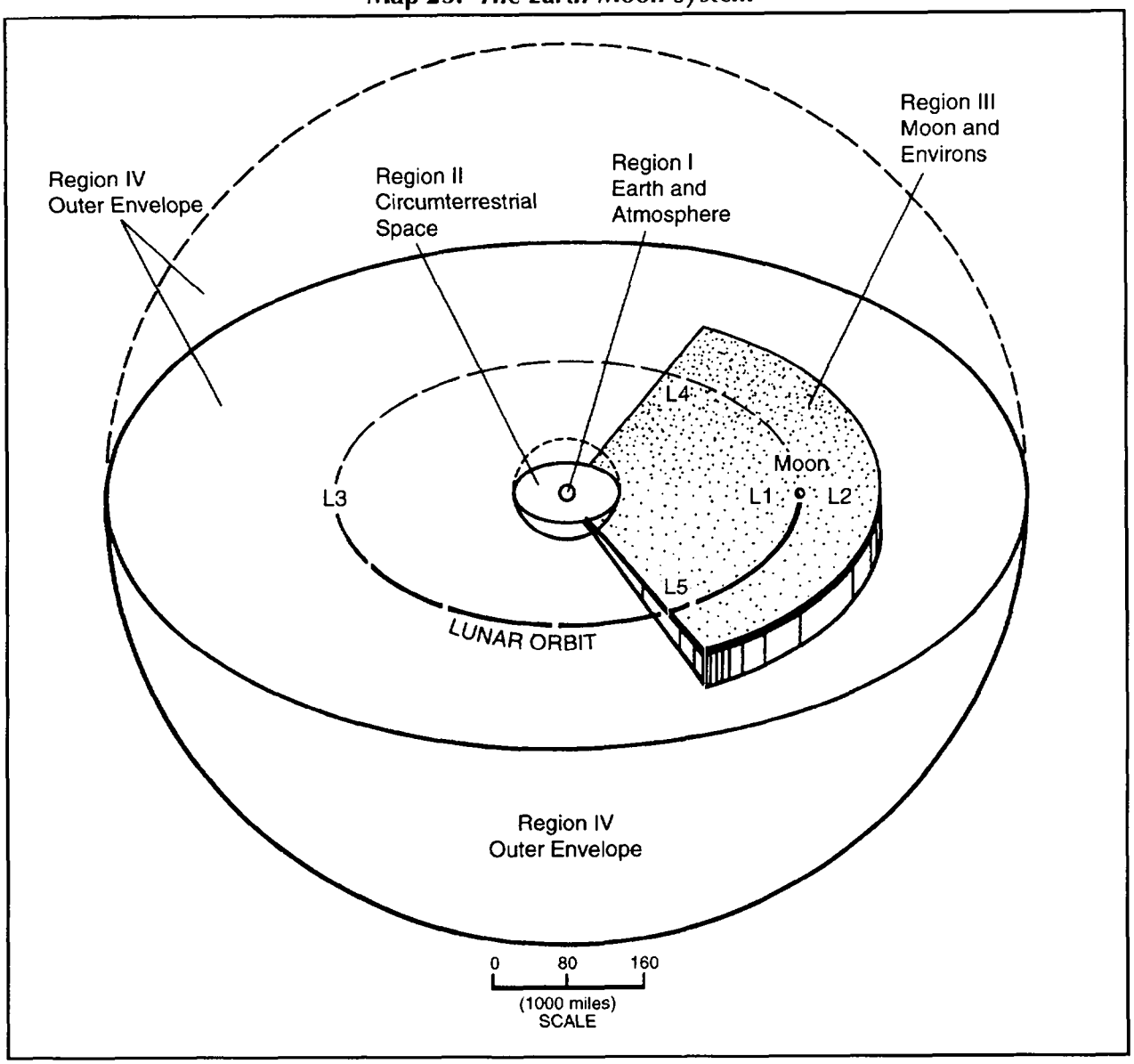
SPACE COMPARED WITH LAND AND SEA

Air, water, weather, climate, and vegetation within the Earth-Moon System are exclusively indigenous to this planet.[3] Land forms and natural resources are restricted to the Earth, Moon, and asteroids. Cosmic radiation, solar winds, micrometeorites, and negligible or neutralized gravity are unique properties of space. Near vacuum is present everywhere except on Earth and vicinity.

Space and the seas are superficially similar, but differences are dramatic:

- Continents bound all five oceans, which are liquid and almost opaque, whereas space has no shape and little substance.
- Earth's curvature limits sea surface visibility to line-of-sight, whereas visibility as well as maneuver room are virtually limitless in space.

Map 23. *The Earth-Moon System*



Distance in Miles			
From Earth		**From Moon**	
Region I	Surface to 60	L1	45,000
II	60 to 50,000	L2	42,000
III	50,000 to 240,000	L3	480,000
IV	240,000to 480,000	L4	60° ahead of moon
Lunar Orbit	240,000	L5	60° behind moon

NOTE: Regions I, II, and IV are globe-shaped. Region III is like a quarter slice of pie, with little depth in comparison. L1 through L5 are lunar libration points.

- Acoustics, an antisubmarine warfare staple, play no part in space, because sound cannot survive in a vacuum.
- Space welcomes electromagnetic radiation, whereas water is practically impervious to radio and radar waves.
- Day-night cycles and shock waves, which are prevalent everywhere on Earth, are nonexistent in space.
- Atmospheric phenomena and salt water interfere with light and focused energy rays on Earth, but neither refract in space.

Space moreover has no north, east, south, or west to designate locations and directions. A nonrotating celestial sphere of infinite radius, with its center at Earth's core, is the reference frame. Declination, the astronomical analog of latitude, is the angular distance north or south of the celestial equator, right ascension is the counterpart of longitude, and the constellation Aries, against which spectators on Earth see the sun when it crosses Earth's Equator in springtime, defines the prime meridian. Angular positions in space are measured from that celestial counterpart of Greenwich Observatory.

Distances in space are meaningful mainly in terms of time. Merchant ships en route from the U.S. Pacific coast to the Persian Gulf typically take about a month to sail 12,000 nautical miles (22,240 kilometers). Apollo 11 flew to the Moon, 20 times as far, in slightly more than 3 days. Real time communications, transmitted at 186,000 miles per second (the speed of light on Earth and in space) are possible despite great distances—the delay between Earth and Moon amounts to about 1 second.

REGION I: AEROSPACE INTERFACES

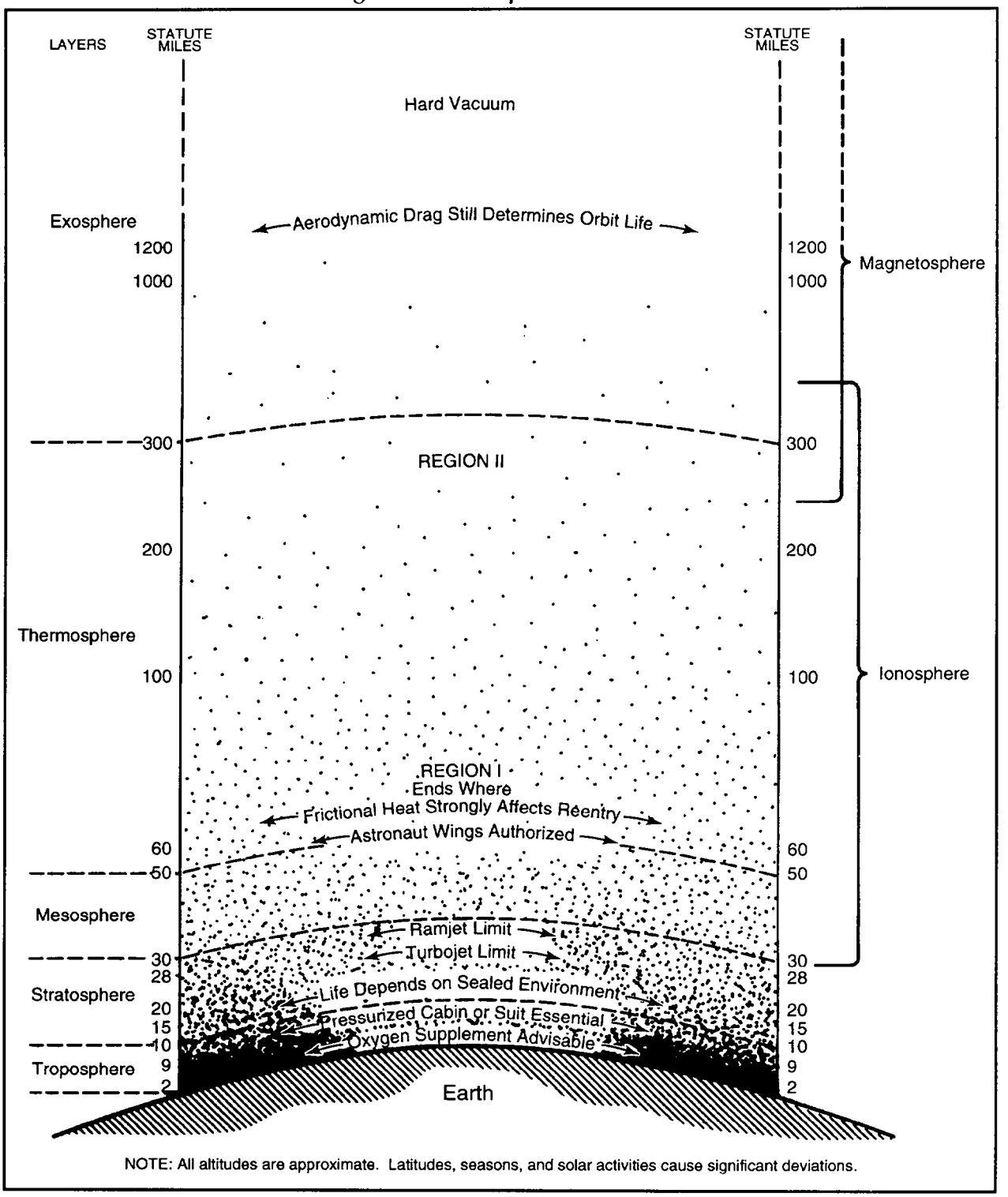
Four geographic factors in Region I influence transits to and from space: atmosphere and gravity, together with Earth's rotation and inclination. Some effects are militarily adverse, whereas others are advantageous.

ATMOSPHERE

Half of Earth's atmosphere is located less than 3 miles above sea level (4.6 kilometers), in the bottom of the troposphere (figure 22).[4] Most humans need supplemental oxygen to sustain efficient performance well before they reach that elevation. Pressurized suits or cabins become obligatory at about 9 miles, because crew members, unable to expel carbon dioxide and water vapor from their lungs unassisted, otherwise would suffocate. Their blood literally would boil above 12 miles in the absence of such protection. Military aircraft and space vehicles depend on pure air produced in a sealed environment after they approach altitudes that approximate 15 miles, where heat transfer is excessive and poisonous ozone is present. Turbojet engines refuse to function much above 20 miles; ramjets sputter and stop when altimeters register 28 miles (45 kilometers); rockets are required beyond that point.

High winds, extreme turbulence, lightning, and ice often cause launch and landing delays, even for remotely-piloted aircraft and unmanned space vehicles on tight military schedules. The top-heavy U.S. piggyback space shuttle, which often transports sensitive cargo for the U.S. Department of Defense, might capsize if it tried to take off

Figure 22. *Aerospace Interfaces*



NOTE: All altitudes are approximate. Latitudes, seasons, and solar activities cause significant deviations.

when crosswinds exceed the currently permissible 15 miles per hour (24 kph). Thunderbolts, such as the one that destroyed a U.S. Atlas-Centaur rocket laden with a multimillion dollar communications satellite in March 1987, pose similar hazards.

Spacecraft must overcome strong aerodynamic drag immediately after launch, but resistance becomes progressively weaker as they rise through the troposphere, because thinner air bears down with less pressure and the amount of fuel expended lightens the load they must lift. They break free for practical purposes where the mesosphere and thermosphere merge at an altitude that averages about 60 miles (95 kilometers). Frictional heat consumes space vehicles of all kinds when they reenter Earth's atmosphere at high velocities unless a shield protects exteriors and insulation keeps crews (if any) and other contents acceptably cool. Apollo command modules returning from the Moon, for example, had to offset 5,000 °F (1,900 °C), four times that of blast furnaces.

Friction nevertheless exerts some positive effects. Aerodynamic drag at the interface where atmosphere and space imperceptibly merge can act as a brake or alter orbit configurations without burning fuel, provided computers calculate reentry angles correctly. Spacecraft skip or bounce back erratically when trajectories are too shallow and incineration results when they are too steep, but reentry windows as a rule open wider for powered vehicles than for those that glide.

GRAVITY

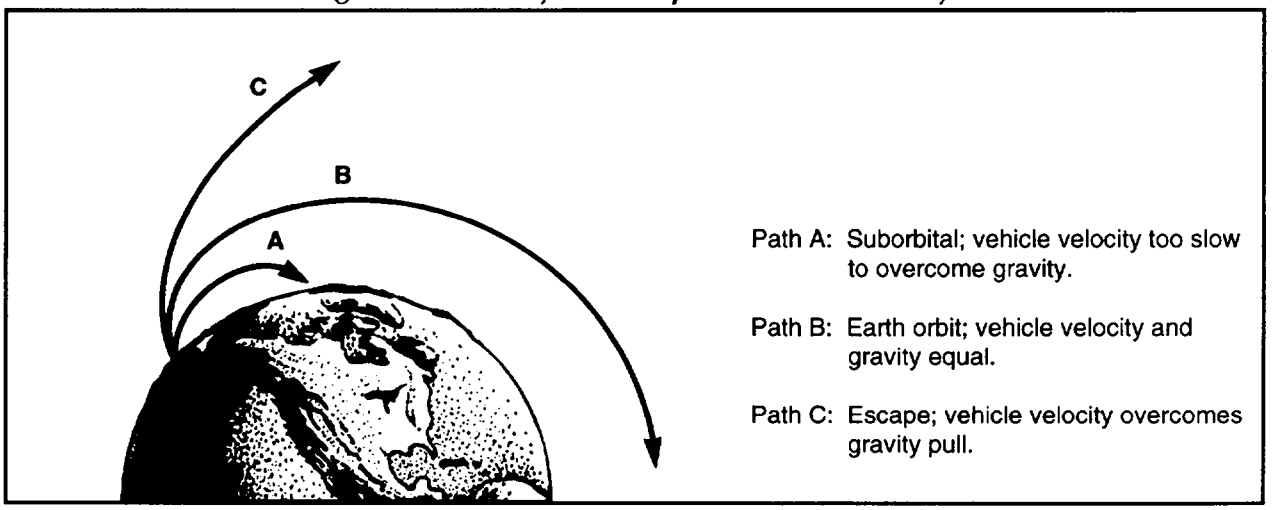
Propulsion systems must be powerful enough to boost military spacecraft into orbit, despite atmospheric drag and gravity (g), which keeps objects on Earth without an anchor and pulls unsupported bodies from atmosphere or space toward the surface.[5] Astronauts and payloads both experience enormous stress during vertical liftoffs, because net force, acceleration, and velocity all increase rapidly when engines consume propellants (about 90 percent of the original weight) and expel mass in the form of exhaust. Gravitational attraction decreases with altitude, but is still 1 full g at 100 miles (160 kilometers), well beyond the upper boundary of Region I.

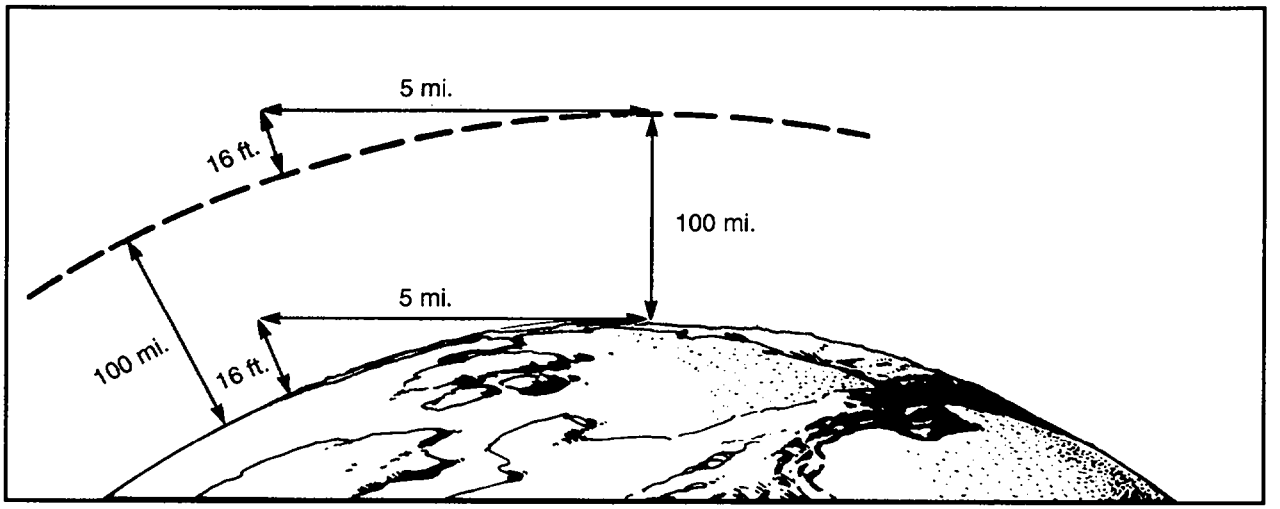
Spacecraft in orbit maintain constant speeds that are little affected by atmospheric drag or gravity. Those that follow circular paths fall the same distance every second that Earth's curved surface seems to recede and thus stay in proper position, aided only by minor adjustments to prevent drifting (figure 23). Braking enables them to attain lower orbits or return to Earth, whereas additional energy propels them farther out. All spacecraft and contents not battened down become "weightless" unless slow rotations create artificial gravity, because they free fall constantly at the same rate.

ROTATION AND INCLINATION

The entire Earth-Moon System, with its center of mass 1,000 miles beneath Earth's surface, completes one elliptical orbit around the sun every 365.25 days at a mean linear velocity of 666,000 miles per hour (1+ million kph).[6] The Earth, tipped on its axis 23 degrees 27 minutes with respect to that orbit, rotates (spins) west to east 1,040 miles per hour at the Equator (1,675 kph), half as fast at the 60th parallels, and remains stationary only at the North and South Poles. One complete turn equals one day. Military spacecraft launched due east get a flying start from Earth's rotation, which makes it easier to attain orbital velocities. Benefits are greatest for vehicles near the Equator and progressively less toward each pole,

Figure 23. *Gravity Versus Space Vehicle Velocity*





The Earth's curvature, on the average, dips 16 feet in a little less than 5 miles. Spacecraft circling the globe fall that same distance in the first second, wherever gravitational pull is 1g. A velocity of 5 miles per second (18,000 mph) therefore produces perpetual orbit, unless perturbations prohibit. The 100-mile altitude displayed is exemplary. It could be higher or lower, as long as gravity is about 1g.

where advantages are nil. Rotation neither assists nor resists launches that point north or south.

Orbital altitudes determine the time it takes to complete one circuit around Earth. The period is 90 minutes for circular orbits at 125 miles (200 kilometers), less at lower altitudes, and longer higher up where paths are lengthy and less velocity is needed to counteract gravity. The period of elliptical orbits averages the nearest and farthest distances from Earth. Spacecraft achieve geosynchronous orbits at a mean altitude of 22,300 miles (35,885 kilometers), where their 24-hour flight around the world corresponds precisely with the time it takes Earth to rotate once on its axis. Geosynchronous orbits that are circular and

equatorial are called geostationary, because they seemingly hover over a single spot, while other Earth orbits make figure eights from center lines over the Equator. Sun synchronous orbits pass over prescribed spots at the same local time every day, come winter, summer, spring, or fall. Such options are useful for many military purposes, especially intelligence collection and communications.

REGION II: CIRCUMTERRESTRIAL SPACE

Circumterrestrial or inner space, as defined herein,[7] is a harsh region that begins about 60 miles above Earth, where aerodynamic drag and frictional heat lose most of their significance. Asteroids and meteoroids that weigh many tons hurtle through the void at 30,000 to 160,000 miles per hour. Catastrophic collisions with spacecraft seem improbable, although manmade "trash" is potentially troublesome and high-speed particles that pepper capsules and space suits over long periods not only pit optical lenses but chip temperature control surfaces. The latter are particularly important, because surface temperatures of objects in the thermosphere sometimes exceed 2,500 ^{0}F (1,400 ^{0}C). Sunlit sides anywhere in circumterrestrial space figuratively fry, while shady sides freeze, unless reflectors and insulating shields protect them. Moreover, systems must be designed to expel excessive heat generated on board.

Space, which lies beyond "the wild blue yonder," is absolutely black because light cannot scatter in very thin air or hard vacuums. Total silence also prevails, and there are no shock waves or sonic booms, regardless of vehicle velocities. Earth's gravity, in combination with other perturbations such as solar winds, electromagnetic forces, and lunisolar gravitation above geosynchronous levels, radically warps spacecraft orbits over time unless corrected. "Cold welding" can occur if metals touch accidentally, because no film of air separates exposed surfaces, while structures that are frigid on one side and torrid on the other undergo great stress.

X-rays, ultraviolet light, and infrared flood the ionosphere and magnetosphere. Two Van Allen radiation belts, separated by a low-density slot, girdle the globe with magnetic fields between latitudes 45 degrees north and south. The inner belt begins between 250 and 750 miles above Earth and tapers off at about 6,200 miles. The outer belt expires at 37,000 to 52,000 miles, depending on solar activity. Adequate shielding, coupled with prudent flight planning that reduces time in the most dangerous zones, is the best way to avoid overdoses and electronic disruptions that could interfere with important military missions.

Cosmic rays beyond the Van Allen belts pose additional problems. Sporadic solar flares cause proton storms that project high-energy, high-charge, high-density, long-range flux a million times more powerful than particles in routine solar winds. Less potent doses can damage or destroy human cells, including components of the central nervous system, cause communication blackouts, and discombobulate poorly protected guidance systems. Forecasts that defer flights or recall them in time to avoid solar flares consequently are crucial.

REGION III: MOON AND ENVIRONS

The voyage from Earth to the Moon averages 240,000 miles (386,000 kilometers) of cislunar space that is environmentally much the same as circumterrestrial space above the Van Allen belts (map 24). Lunar attributes and the significance of lunar libration points, however, merit special mention.

EARTHLY AND LUNAR GRAVITY WELLS

Military space forces at the bottom of Earth's "gravity well" need immense energy to leave launch pads and climb quickly into space. Adversaries at the top, in positions analogous to "high ground," have far greater maneuver room and freedom of action. Put simply, it is easier to drop objects down a well than to throw them out. Gravitational pull on the Moon is one-sixth as strong and related launch problems consequently are miniscule in comparison, as figure 24 shows.[8]

LUNAR TERRAIN

The Moon's square mileage is essentially the same as Africa's. The diameter at its Equator is 2,160 miles (3,475 kilometers), a little more than one-fourth that of Planet Earth. That bleak orb rotates once on its axis in 27.3 days, the same time it takes to complete one revolution around our world, so lunar days and nights each last 2 weeks, and the Moon eternally presents the same face to observers on Earth. Temperatures at a depth of 3 feet or so consistently register about -46 °F, but sunlit equatorial surfaces sizzle well above the boiling point on Earth, 212 °F (86 °C), and dip below -245 °F (-104 °C) after dark.[9]

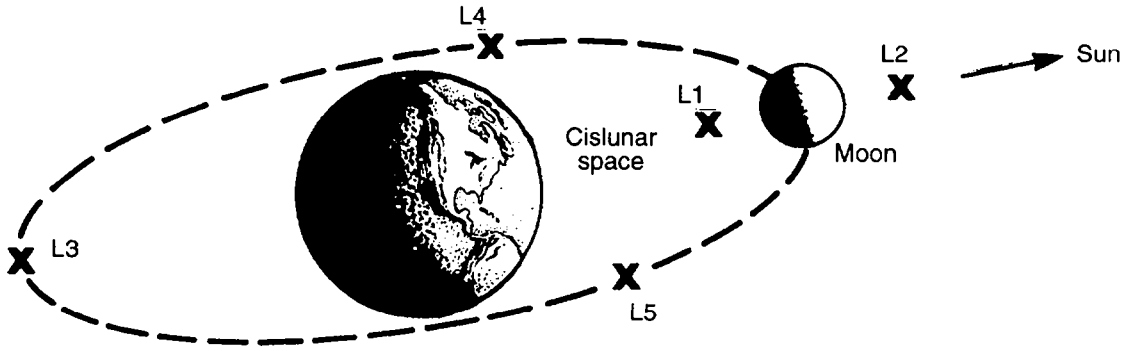
Lunar terrain, devoid of atmosphere, vegetation, and water (except perhaps for ice at the poles), features rough highlands on the far side, while huge shallow saucers predominate on the side we see—Galileo called them *maria*, because they looked like seas through his telescope. Ridges and canyons known as rilles cross-hatch to form a lunar grid. Bowl-shaped craters, some of which have extremely steep sides, boulders, blocks, dimples, and hummocky debris make smooth topography hard to find. Lunar dust, called fines, mantles most of the level land, but abundant natural resources such as iron, titanium, aluminum, manganese, calcium, and silicon lie just beneath the surface. Construction materials also are accessible.

Map makers and armed forces lack any criterion comparable to sea level from which to define elevations and depths. Each molehill and mountain therefore must be measured from base to crest, each canyon and crater from top to bottom. Pike's Peak in the Colorado Rockies would loom slightly less than 9,000 feet instead of 14,110 if calculated in that fashion, because its base is more than a mile above sea level.

LUNAR LIBRATION POINTS

Five so-called lunar libration points are not points at all, but three-dimensional positions in space, shaped somewhat like kidney beans 10,000 miles (16,000 kilometers) long (map 24).[10] Spacecraft theoretically could linger there indefinitely without expending much fuel if calculations are correct, because Earthly and lunar gravitational fields seem to cancel each other. Mathematical models and computer simulations conclude that free-floating objects at semistable L1 through L3, on a line with Earth and Moon, would gradually wander away, while substances at stable L4 and L5, which are 60 degrees ahead and behind the Moon in

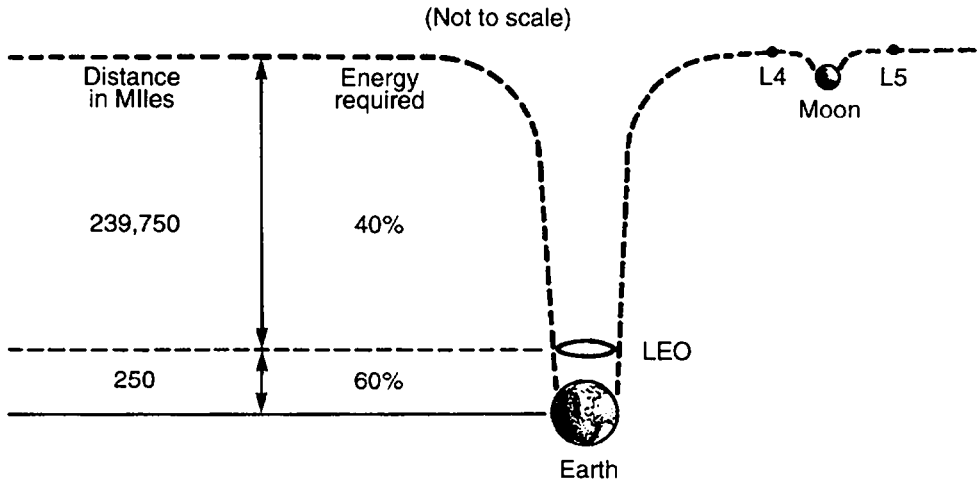
Map 24. *Cislunar Space*



Distance in Miles

From Earth	Lunar Orbit	240,000
From Moon	L1	45,000
	L2	42,000
	L3	480,000
	L4	60° ahead of moon
	L5	60° behind moon

Figure 24. *Earthly and Lunar Gravity Wells*



Low earth orbits, near the bottom of Earth's gravity well in terms of distance (60-250 miles), are more than half way up in terms of energy required to reach that altitude. Spacecraft velocity must be about 4.5 miles per second (mps) to attain LEO. A mere 2.4 mps more is enough to reach the top, nearly 240,000 miles higher.

its orbit, would resist drift more vigorously and thus remain in the general region. Those hypotheses, however, have not yet been verified. There are no known counterparts of the Trojan Asteroids that inhabit areas similar to L4 and L5 along Jupiter's orbit, nor have captive particle clouds been proven.

REGION IV: OUTER ENVELOPE

Region IV, which radiates from Earth in all directions, shares most characteristics of cislunar space. Its immense volume affords valuable maneuver room devoid of sizable matter, except for small asteroids (some rich in raw materials) that cross Earth's orbit. Region IV terminates at twice the distance to the Moon, beyond which solar and other planetary influences dominate.

TIPS FOR MILITARY SPACE PLANNERS

ORBITAL OPTIONS

Orbital options, which are virtually limitless, hypothetically could connect all points in the Earth-Moon System, but atmospheric interfaces, gravity, and radiation in fact confine flexibility.[11] Aerodynamic drag and gravitational pull rule out high-speed Earth-to-space launches with currently envisioned vehicles, even in perfect weather. Enemy land-based defenses may straddle well-known launch trajectories that take advantage of Earth's rotation. Routes in space are relatively easy for opponents to predict, sharp altitude and inclination changes are costly to make in terms of fuel and time, and even minor deviations demand fine-tuned activation by auxiliary thrusters. Loop-the-loops, barrel rolls, violent evasive actions, and other flamboyant tactics popularized in movies like *Star Wars* will remain science fiction until technologists develop new ways to maneuver in a vacuum. Polar orbits could bypass both Van Allen radiation belts, which further restrict the choice of routes for manned flights, but in so doing would encounter parts of the magnetosphere that serve as funnels for intermittent solar flares that could cripple military operations in the absence of better shielding than currently is available. Reentry angles that avoid excessive frictional heat when spacecraft hit Earth's atmosphere also canalize approaches, and thereby reduce prospects for strategic or tactical surprise.

STRATEGIC LOCATIONS IN SPACE

A few fixed orbits confer valuable advantages in space. Three geostationary communications satellites positioned equidistantly around the circular track that runs 22,300 miles (35,885 kilometers) above our Equator can receive signals from, and relay them to, any place on Earth except the poles. Reconnaissance and surveillance satellites that make north-south great circles around the world sooner or later get a good look at every place on this globe.

All five lunar libration points constitute strategic locations in space. L1, the lowest energy transfer site for 230 million mile trips between Earth and Mars, could be fitted with military facilities as well as the "motel/gas station/warehouse/restaurant/garage" that the U.S. National Commission on Space once envisaged.[12] L2 is a potentially important clandestine assembly area, since cislunar and Earth-based sentinels cannot see it. L3 could become a semi-stable staging base for military operations directed against Earth or spacecraft in orbit around it Nature, however, has reserved decisive advantages for L4 and L5, the two stable libration

points, which theoretically could dominate Earth and Moon because they look down both gravity wells. No other location is equally commanding.

Occupying armed forces would possess great strategic leverage with which to mount operations *from the Moon*. Offensive and defensive warfare *on the Moon*, however, would be a catch-as-catch-can proposition until technologists produce the equivalent of a Global Positioning System (GPS) for lunar use or cartographers develop large-scale maps that identify precise elevations and include a military grid upon which to plot ranges and pinpoint positions.

WEAPON EFFECTS

Geographic influences on nuclear, directed energy, chemical, biological, and conventional weapon effects are far-reaching and fundamental. Atmospheric interfaces, gravity, and vacuum are the most important factors.

Nuclear Weapon Effects. Nuclear weapons detonated in Earth's atmosphere create shock waves, violent winds, and intense heat that inflict severe damage and casualties well beyond ground zero.[13] No such effects would occur in space, because winds never blow in a vacuum, shock waves cannot develop where no air, water, or soil resists compression, and neither fireballs nor superheated atmosphere could develop more than 65 miles (105 kilometers) above Earth's surface. Consequently, it would take direct hits or near misses to achieve required results with nuclear blast and thermal radiation.

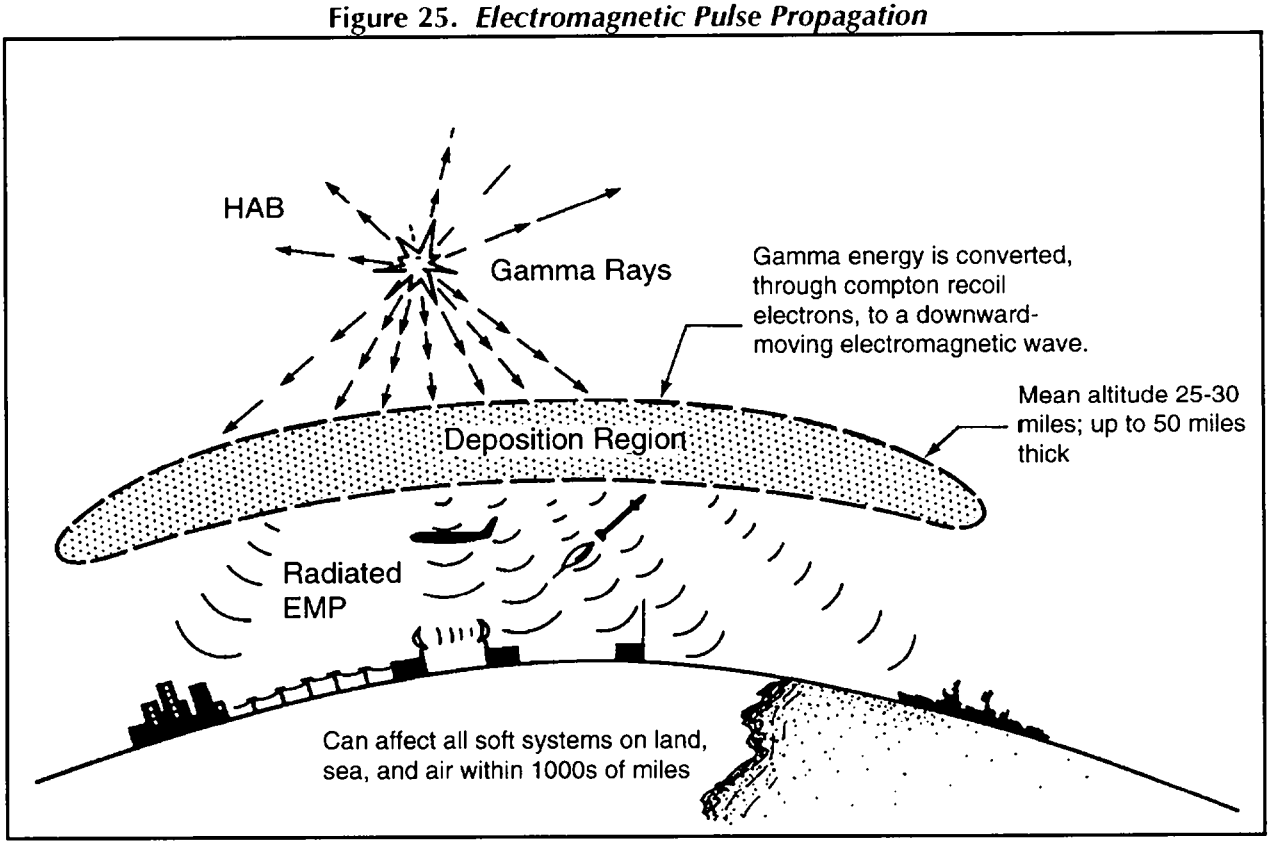
Initial nuclear radiation from beta particles and gamma rays would radically alter the ionosphere, warp or weaken radio and radar waves, and cause lengthy high frequency (HF) blackouts over vast areas on Earth (the megaton-range TEAK test shot, detonated in the mesosphere over Johnson Island on August 1, 1958, degraded HF radio traffic for several thousand miles in every direction from shortly after midnight until sunrise). X-rays, which Earth's atmosphere absorbs within a few feet, travel thousands of miles at the speed of light in space. Strong doses can peel spacecraft skins and destroy delicate mechanisms. Electromagnetic pulse (EMP), widespread and potentially paralyzing to electronics on land, at sea, or in the air, would occur if a cascade of gamma rays from any high altitude nuclear explosion collided with Earth's upper atmosphere (figure 25). A prodigious surge that peaks 100 times faster than lightning would bolt toward ground, then attack unshielded electronics. Solid state circuitry would be especially vulnerable, because miniature components cannot tolerate high currents and immense voltages able to melt semiconductors would instantaneously turn sophisticated systems into trash.

Directed Energy Weapon Effects. Directed energy weapons, if and when perfected, will project energy at or near the speed of light over great distances, but none now under serious consideration could perform equally well on Earth and in space. Problems consequently will arise if they try to cross the interface.[14]

Space is a nearly perfect environment for high-energy lasers, because light propagates unimpeded in a vacuum. Power output is the principal range limitation. Diffraction is significant over long distances, but is controllable. High-powered microwave weapons in experimental stages reportedly would work well in space, but break down dielectrically in atmosphere at relatively low energy levels, which would fatally impair space-to-Earth or Earth-to-space lethality. Particle beams suffer from similar shortcomings, because charged particles propagate well only in Earth's atmosphere and neutral particles only in a vacuum.

The boundary between will remain a barrier to both unless scientists and technologists facilitate better conduction. Vehicles designed to survive intense reentry heat, however, would be vulnerable in space, where charged particle beams could penetrate hardened exteriors without burning a hole, then successfully attack components, propellants, and explosives not specifically protected.

Figure 25. ***Electromagnetic Pulse Propagation***



Chemical and Biological Weapon Effects. Self-contained biospheres in space afford a superlative environment for chemical and biological warfare compared with Earth, where weather and terrain virtually dictate delivery times, places, and techniques.[15] Most spacecraft and installations on the Moon, which must rely on closed-circuit life support systems that continuously recirculate air and recycle water, are conceivable targets for special operations forces armed with colorless, odorless, lethal, or incapacitating agents that would be almost impossible to spot before symptoms appear. Cumbersome masks and suits could protect individuals only if worn constantly. Sanctuaries comparable to the toxic-free citadels that eat up precious room on some ships would be infeasible for most spacecraft and safeguard only a few selected personnel. Any vehicle or structure victimized by persistent chemicals probably would become permanently uninhabitable, because vast quantities of water and solvents required for decontamination would be unavailable.

Conventional Weapon Effects. Tanks, cruise missiles, and other systems with "air-breathing" engines would be inoperative on the Moon's airless surface.[16] Alternatives currently under exploration include battery-powered motors and rocket-propelled engines

that oxidize fuel on board. Newton's Third Law of Motion (to every action there is an equal and opposite reaction) establishes requirements for recoilless weapony in the vacuum of space, because blast otherwise would propel spaceborne firing platforms backward with momentum equal to that of the ammunition in flight. Newton's First Law of Motion (bodies in motion move in a straight line until another force intervenes) would basically regulate projectile trajectories on the Moon, where velocity and low lunar gravity unopposed by atmospheric drag make "fire-and-forget" systems attractive. Conventional explosives would have to hit targets directly or detonate nearby, because no shock waves amplify blast effects in a vacuum, but even bird shot-size fragments could easily puncture the thin walls of pressurized lunar facilities built to repel nothing much larger than micrometeoroids.

PERSONNEL PROFICIENCY

Humans in space need support systems that not only provide air, food, and water but regulate temperatures, humidity, pressures, light, noise, vibrations, and radiation. Such requirements would be difficult to satisfy for armed forces on extended deployments.[17]

Subsistence and Sanitation. A one-month supply of oxygen, food, and drinking water just for a crew of three amounts to more than a ton stored at the expense of precious propellant and military payloads. Each crew member in turn would deposit an equal amount of waste in the form of feces, urine, perspiration, internal gases, carbon dioxide, and other exhalation vapors that could quickly reach toxic proportions in a sealed capsule unless quelled, expelled, or sterilized. Life support systems currently dump or stow organic waste on short missions, but such practices do little to alleviate long-term resupply problems. High-priority research projects consequently emphasize alternative techniques.

Radiation Risks. Military space forces would enter a perilous realm of radiant energy as soon as they leave Earth's protective atmosphere. Risks would be least in low Earth orbits but rise rapidly in the Van Allen belts and beyond, where high-energy, high-charge cosmic flux poses persistent hazards, while solar flares and other eruptions on the sun, always of concern, reach peak intensities every eleven years. Human central nervous, blood, digestive, and reproductive systems are particularly vulnerable to such radiation, which assaults reproductive cells. Delayed effects that could include leukemia, solid tumors, cataracts, and infertility might retard military recruitment and retention programs. Flight plans that limit time in the Van Allen belts and forecasts that warn of acute solar activity would reduce military flexibility along with radiation dangers, but permissible exposure may have to fit on a sliding scale, because personnel under age 35 apparently can tolerate higher levels and recuperate more quickly than older persons, who seem better able to withstand moderate overloads for longer periods.

Motion Sickness and Weightlessness. Motion sickness, somewhat like an aggravated form of sea sickness, afflicts about half of all space travelers whose responses to medical suppressants are unpredictable. It conceivably might undermine mission proficiency enough during the first few days of each flight to mark the difference between military success and failure, depending on which crew members suffer worst from symptoms that variously include drowsiness, indifference, and severe vomiting.

Weightlessness impairs response times, precision movements, and the work capacities of the best-trained, best-conditioned spacecraft crews. Dehydration occurs when the brain tells bodily organs to discharge fluids that pool in the chest. Blood, which thereafter thickens and

flows less freely, supplies needy tissues with smaller than usual amounts of fresh nutrients and oxygen. Reduced abilities to exercise in turn cause muscles to lose mass and tone. Evidence so far suggests that most physically fit humans tolerate weightlessness reasonably well and recover completely after they return to a 1-g environment, although irreversible bone demineralization may be a significant exception. Artificial gravity may some day alleviate or eliminate the most debilitating aspects of weightlessness in large, slowly rotating space stations, but not in small, tactical space vehicles.

Group Proficiency. "Cabin fever" might affect teamwork adversely during very long military deployments, unless commanders took positive steps to limit and control psychological stresses caused by close confinement in space vehicles where the absence of identifiable days and nights deranges work-rest schedules like jet lag magnified many times. Manifestations range from emotional instability, fatigue, and short attention spans to impaired vital functions such as heartbeat, pulse, brain activity, body temperature, and metabolism. Some individuals perform best before breakfast, others after supper. Optimum unit efficiency therefore is possible only if crews contain a beneficial mix of biorhythms and schedules assign each member duties during his or her period of peak proficiency, because many military tasks make it impossible for all to work and relax simultaneously.

KEY POINTS

- The term "aerospace" is a misnomer, because air and space are distinctively different geographic mediums.
- Military space activities currently are confined to unmanned reconnaissance, surveillance, target acquisition, tracking, communications, navigational, meteorological, missile warning, and arms control missions in support of armed forces on Earth.
- Many items needed to mount and sustain large-scale, extended military operations on the Moon and elsewhere in space remain to be invented, but could soon become technologically feasible.
- Few strategies, tactics, organizations, weapon systems, equipment, and little training designed for use by armed forces on Earth would be suitable for military operations in space.
- Orbital options will remain predictable until technologists devise innovative ways to maneuver spacecraft in a vacuum.
- The Moon, lunar libration points L-4 and L-5, and the geostationary orbital path above Earth's Equator are strategic locations within the Earth-Moon System.
- Military space operations of any kind will demand extensive Earth-based command, control, communications, logistical, and administrative support for the foreseeable future.

NOTES

1. Chapter 7 modifies the text and consolidates source notes in John M. Collins, *Military Space Forces: The Next Fifty Years* (Washington, DC: Congressional Research Service, October 12, 1989), especially 3-36, reprinted by Pergamon-Brassey's, same title, 1989, 5-39.

2. William B. Scott, "Pentagon Considers Space As a New Area of Responsibility," *Aviation Week and Space Technology*, March 24, 1997, 54. For war fighting in and from space, see G. Harry Stine, *Confrontation in Space* (Englewood Cliffs, NJ: Prentice-Hall, 1981); Daniel O. Graham, *High Frontier* (Washington, DC: High Frontier, 1982).

3. Curtis D. Cochran, Dennis M. Gorman, and Joseph D. Dumoulin, eds., *Space Handbook* (Maxwell Air Force Base, AL: Air University Press, January 1985), 2-27 through 2-29.

4. Ibid., 1-3, 1-4, chap. 8, and appendix A; G. Harry Stine, *Handbook for Space Colonists* (Holt, Rinehart and Winston,1985), 47-79; Robert G. Fleagle, "Atmosphere," *Encyclopedia Americana* (International Edition, 1978).

5. *Space Handbook*, 3-1 through 3-12; William M. Kaula, "Earth, the Gravitational Field of," and Jesse M. Beams, "Gravitation," in *New Encyclopedia Britannica*, 15th ed.; *Handbook for Space Colonists*, 81-95.

6. Frederick C. Durant," Space Exploration," *New Encyclopedia Britannica*; David Baker, *The Shape of Wars to Come* (New York: Stein and Day, 1982), 35-39.

7. *Space Handbook*, 1-5 through 1-14 passim, 2-41 through 2-47, and chapter 7; Isaac Asimov, "Sound" and N. C. Gerson, "Van Allen Radiation Belts," in *Encyclopedia Americana*.

8. Confrontation in Space, 56-58, 86; *Pioneering the Space Frontier: Report of the National Commission on Space* (New York: Bantam Books, 1986), 60-61.

9. Gilbert Fielder, "Moon," and Victor G. Szebehely, "Mechanics, Celestrial," *New Encyclopedia Britannica*; James D. Burke, "Moon," *Encyclopedia Americana*.

10. *Pioneering the Space Frontier*, 131-132; Gerard K. O'Neill, *The High Frontier: Human Colonies in Space* (New York: Morrow, 1977), 128-130.

11. Ashton B. Carter, "Satellites and Anti-Satellites," *International Security* 10, no. 4 (Spring 1986): 48-66; Robert B. Giffen, *U.S. Space System Survivability: Strategic Alternatives for the 1990s* (Washington, DC: National Defense University Press,1982), 6-8,12; *Space Handbook*, 2-37 through 2-40.

12. *Pioneering the Space Frontier*, 133-13.

13. Samuel Glasstone and Philip J. Dolan, eds., *The Effects of Nuclear Weapons*, 3d ed. (Washington, DC: Dept. of Defense and Dept. of Energy, 1977).

14. Dietrich Schroder, *Directed Energy Weapons and Strategic Defense: A Primer*, Adelphi Paper 221 (London: International Institute for Strategic Studies, Summer, 1987); *Space Handbook*, 9-1 through 9-21, 9-25 through 9-42, 9-50, 9-51, 9-54.

15. *Proliferation of Weapons of Mass Destruction: Assessing the Risks* (Washington, DC: Government Printing Office, August 1993); *The Problem of Chemical and Biological Warfare*, vol. 2, *CB Weapons Today* (New York: Stockholm International Peace Institute, 1973), 37-43, 61-72; FM 21-40: *NBC Defense* (Washington, DC: Dept. of the Army, October 14,1977), chapter 5 and appendix B.

16. *Confrontation in Space*, 78-80, 95-6; O'Neill, *The High Frontier*, 138-140.

17. Roy L. DeHart, ed., *Fundamentals of Aerospace* Medicine (Philadelphia, PA: Leas and Febiger, 1985); Arnold E. Nicogossian and James F. Parker, Jr., *Space Psychology and Medicine* (Washington, DC: National Aeronautical and Space Agency, 1982).

8. NATURAL RESOURCES AND RAW MATERIALS

In the beginning God created the heaven and the earth. And the earth was without form, and void. . . . And God said, "Let the waters under the heaven be gathered together unto one place, and let the dry land appear": and it was so. And God called the dry land Earth; and the gathering together of the waters called he Seas; and God saw that it was good.

Genesis 1:1

GOD CREATED EVERYTHING FROM NOTHING IN THE BEGINNING, ACCORDING TO *THE OLD TESTAMENT.* Everything since then has been created from something. Natural resources are the basic ingredients of all raw materials which, in turn, are the building blocks of all finished products, including military arms, equipment, and supplies. Sources, shortages, and compensatory programs are relevant to every nation. So are vulnerabilities to economic warfare and armed interdiction.

SOURCES AND SHORTAGES

The world community is divided inequitably into "have" and "have not" nations with regard to natural resources and raw materials. Even the best endowed countries suffer deficiencies that adversely affect military capabilities, but the criticality of any given shortage depends on the technological sophistication of armed forces in question, expansion and replenishment requirements, relationships with foreign suppliers, alternative providers, and the security of long-haul transportation lanes between sources and consumers.

MINERALS AND METALS

More than 90 minerals, metals, and materials are critically useful for military purposes.[1] Relative importance depends on present and projected needs, but iron plus the dozen items listed on table 11 possess properties that are universally in demand. Most of them form ferrous and/or nonferrous alloys of great utility.

Table 11. ***One Dozen Militarily Useful Minerals and Metals***

Minerals and Metals	*Representative Properties*	*Typical Military Products*
Bauxite (Aluminum)	Light Weight Castability	Aircraft Frames Hydraulic Cylinders
Chromium	Corrosion Resistance Oxidation Resistance	Gun tubes Landing Gear
Cobalt	Heat Resistance Abrasion Resistance	Jet Engine Alloys Cutting Tools
Columbium	Malleability Acid Resistance	Petroleum Tankers Jet Engines
Copper	Malleability Ductility	Electric Wiring Cartridge Brass
Manganese	Hardness Toughness	Ship Propellers Torpedoes
Nickel	Corrosion Resistance Hardness	Electroplated Aircraft Parts Axles, Gears, Valves, Rods
Platinum	Catalytic Abilities High Melting Point	High Octane Fuels Electronics
Tantalum	Corrosion Resistance Acid Resistance	Armor Penetrators Electronics
Titanium	High Strength Light Weight	Armor Plate Space Capsules
Tungsten	Heat Resistance Hardness	Spark Plugs Electrical Contacts
Uranium	Radioactivity	Nuclear-Powered Naval Ships Nuclear Weapons

IMPORTANT PROPERTIES

Hardness, toughness, and lightness of weight are highly valued properties. Aluminum, which weighs one-third less than steel, is a mainstay of military aircraft manufacturers. Like stainless steel, which amalgamates iron with chromium, it resists corrosion. Manganese is among the most important of all metallic elements, because no other substance so effectively controls oxidation and sulfur content during steel production processes. Manganese also strengthens iron alloys, helps aluminum ward off rust, and combines with copper or nickel to make marine propellers, fittings, gears, and bearings that wear well in salt water. Copper

additionally is in demand for telecommunication wires of great tensile strength and high conductivity, while nickel alloys make first-class electroplated aircraft parts and air frames. Cobalt alloys tolerate high temperatures that jet engines generate and furnish the metal matrix for carbides in cutting tools, bulldozers, shovels, and scrapers that must keep sharp edges despite abrasion. High strength-to-weight ratios make titanium useful for space capsule skins, aircraft fire walls, jet engine components, and landing gears. Super hard tungsten, which boasts the highest melting point of any metal (6,170 ^{0}F, 3,410 ^{0}C), is the basic constituent of tenacious steel alloys, spark plugs, and electrical contact points.[2]

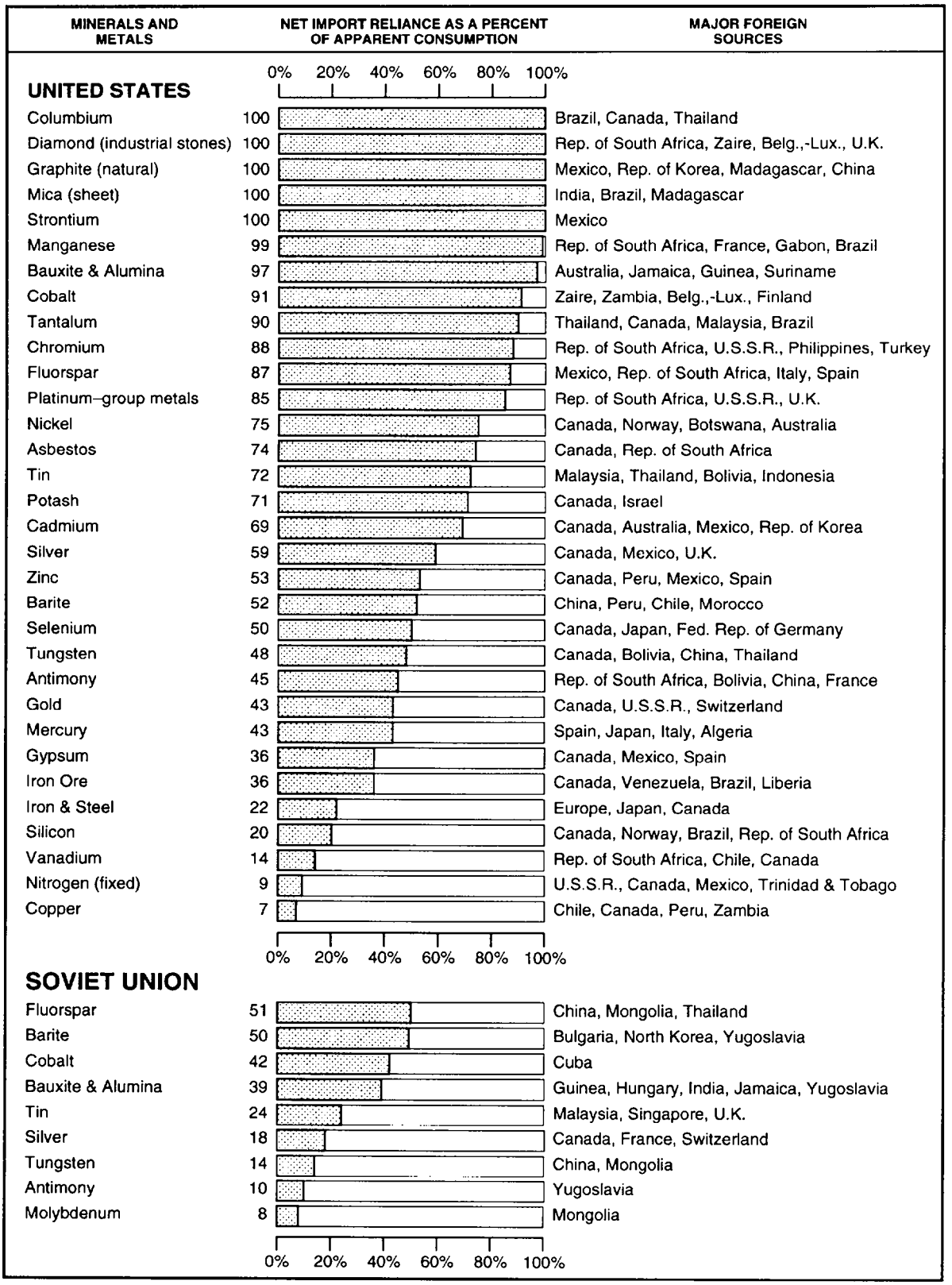
Properties in addition to or other than hardness and toughness make several minerals and metals quite valuable. Scarce platinum, noted for extraordinary catalytic activity and high melting points, not only raises octane ratings during petroleum refinement but makes sensitive electronic relay switches. Versatile tantalium, which resists corrosion more effectively than platinum, is the basic ingredient of many electronic components and, in oxide form, mingles with other materials that make sharp aerial camera lenses. Acid-resistant columbium alloys are ideal for gasoline and oil tankers.[3] Radioactive uranium, in a class by itself, fuels reactors that furnish nuclear power for high-performance naval surface ships and submarines. Nuclear bombs, missile warheads, and demolitions all contain highly enriched isotope U-235 or weapon-grade plutonium at their core.[4]

IMPORTANT SUPPLY PROBLEMS

Comparative U.S. and Soviet sources of supply and shortages in the mid-1980s graphically illustrate relative strengths and weaknesses when competition between those two superpowers was at its zenith (figure 26). Both nations had sufficient uranium for military purposes, but the United States was far from self-sufficient in many other respects. Widely scattered suppliers provided 90 percent or more of nine important minerals and metals that included bauxite, cobalt, columbium, manganese, and tantalum. Chromium, nickel, and platinum imports exceeded 75 percent.[5] Major U.S. allies in NATO Europe and the Far East were worse off. The Federal Republic of Germany, for example, relied entirely on outsiders for 16 industrial minerals, while Japan drew on distant sources for nine-tenths of its total mineral needs.[6] The Soviet Union, in contrast, was reasonably well off, because Warsaw Pact partners supplied most demands. Flourspar, bauxite, tin, silver, and tungsten were the only commodities available solely or in large part from sworn enemies or countries whose assistance was by no means assured.[7] Moscow in fact exported large amounts of titanium in exchange for hard cash until Alfa class attack submarine hulls consumed so much of that metal that shipments ceased.

Bureaucratic bungling and technological obsolescence nevertheless reduced Soviet advantages considerably. Vast reserves, depleted at abnormally rapid rates, not only were (and still are) far removed from industrial centers but underlay harsh climatic regions that made extraction expensive. Molybdenum from Noril'sk, above the Arctic Circle in central Siberia, traveled more than 4,000 miles (6,435 kilometers) by river, road, and rail to reach metallurgical furnaces in Donetsk—600 miles (965 kilometers) farther than the land route from Miami, Florida, to Seattle, Washington. Norsk, an immense mining complex near northeastern Siberia's "Cold Pole," was even more isolated.

Figure 26. *U.S. and Soviet Mineral and Metal Imports* (Mid-1980s)



PETROLEUM

Petroleum in various forms currently propels most aircraft, ships, tanks, trucks, and other military machines. Countries and cartels that produce crude oil and possess large proven reserves thus can exert strong political and economic leverage, particularly if they ship refined products as well. Table 12 lists oil owners who pumped more than 1,000 barrels per day from subterranean reservoirs that contained more than 8 billion barrels in 1990, when Iraq occupied Kuwait and threatened to overrun Saudi Arabia.

It is easy to understand why the Persian Gulf War caused shudders throughout the industrialized world: Iraq, Kuwait, Saudi Arabia, and the United Arab Emirates (UAE) furnished more than half of Japan's petroleum imports, almost one-fifth of Western Europe's requirements, and enough to satisfy well over one-tenth of stated U.S. needs. Not all was replaceable from other sources, and most crude oil from other countries was somewhat heavier. The latter fact was significant, because Saddam Hussein's takeover coupled with a retaliatory embargo denied former recipients access to several sophisticated Iraqi and Kuwaiti refineries that specialized in such light products as gasoline, jet fuel, and distillate fuel oil.[8] Intolerable situations, in short, demanded strong counteractions.

Table 12. *Crude Oil Producers and Proven Reserves* (1990)

Country	*Barrels per Day (thousands)*	*Percent of World Production*	*Proven Reserves (billions of barrels)*
Soviet Union	12,475	19.6	58.4
United States	9,175	14.4	34.1
Saudi Arabia	5,260	8.3	255.0
Mexico	2,875	4.5	56.4
Iran	2,865	4.5	92.9
Iraq	2,825	4.4	100
China	2,790	4.4	24.0
United Arab Emirates	2,070	3.3	98.1
Venezuela	1,980	3.1	58.5
United Kingdom	1,905	3.0	4.4
Canada	1,725	2.7	8.3
Nigeria	1,605	2.5	16.0
Kuwait	1,600	2.5	94.5
Norway	1,530	2.4	11.6
Indonesia	1,395	2.2	8.2
Algeria	1,170	1.8	9.2
Libya	1,145	1.8	22.8

NATURAL RUBBER

The U.S. Army and Navy Munitions Board listed natural rubber as a strategic and critical material as of January 30, 1940, with good reason: every military service on the Axis as well as the Allied side was heavily dependent on sources concentrated in southern Asia from India

and Ceylon to Indonesia and Indochina. U.S. imports from the Far East increased at such a frenzied pace after Japan attacked Pearl Harbor that virtually all readily available supplies had been shipped before British Armed Forces in Singapore surrendered on February 15, 1942. Attention thereafter turned to rubber plantations in Liberia, along with underdeveloped stands in Central and South America, none of which proved adequate.[9]

COMPENSATORY PROGRAMS

Several avenues short of military operations to seize supplies are open to nations that need more natural resources than they possess. Recycling and conservation reduce import requirements; stockpiles hedge against shortages if crises should arise; synthetics and substitutes sometimes relieve nature's stinginess or render it irrelevant. Strong countries, however, may also choose to take what they want by force of arms.

STRATEGIC STOCKPILES

U.S. national stockpile programs started in 1939, but domestic politics, special interest groups, inconsistent policies, and costs made efficient administration almost impossible for the first 40 years. Backup supply goals slumped from 5 years to 1 during the 1970s. Congress then passed the Strategic and Critical Minerals Stockpiling Act of 1979 which, among other provisions, earmarked reserves specifically for national defense contingencies and prescribed selected items "sufficient to sustain the United States for a period of not less than 3 years in the event of a national emegency."[10] Proper management concurrently became a pressing mission, because U.S. stockpiles at that time were rife with wasteful excess, especially silver and tin, which tied up several billion dollars that could have been put to better use. Some reserves had lolled in the inventory for so long that original rationales were invalid. Bauxite, chromium, manganese, and other ores would have been more readily usable if converted to primary metals and alloys.[11] The moral is clear: untended stockpiles are apt to disappoint when owners need them most.

Congress further established the U.S. Strategic Petroleum Reserve after a brief Arab oil embargo from mid-October1973 to mid-March 1974 showed how susceptible the United States and many other nations were to what Secretary of State Henry A. Kissinger called possible "strangulation of the industrialized world."[12] Caverns in Texas and Louisiana contained more than 580 million barrels when Iraq overran Kuwait 17 years later, but all was crude oil that required refining before it could fuel armed forces or defense industries.[13] Fortunately, very little had to be withdrawn, because Saudi Arabia increased its production considerably as long as the crisis lasted.

SYNTHETICS AND SUBSTITUTES

Neither synthetics nor substitutes currently can replace petroleum as a fuel and lubricant for most military purposes. Nuclear reactors currently propel selected surface ships and submarines, but serious attempts to produce nuclear-powered aircraft ceased several decades ago. Navies early in the 21st century likely will still rely mainly on fossil fuels, military motor vehicles will still burn gasoline or diesel, oil and lubricants likely will remain in demand. Manmade materials, however, already supplement or supplant natural rubber and many mineral resources.

Recycled rubber was prized in the United States after Japan seized or blocked access to all plantations in Southeast Asia during World War II. President Franklin D. Roosevelt in June 1942 asked patriotic Americans to turn in "old tires, old rubber raincoats, old garden hose, rubber shoes, bathing caps, gloves." A carload of chorus girls in New York City donated girdles as their contribution to 450,000 tons of scrap rubber collected during the next month, but most submissions had previously been reclaimed at least once and proved unsuitable for further processing. Synthetics, however, sufficed. Fifty-one new factories produced 800,000 tons annually by 1944, an output roughly equivalent to the harvest from 150 million rubber trees.[14]

All manmade materials, like natural minerals and metals, possess weaknesses as well as strengths, but many prospects appear promising. Experimental composites, alloys, and fibers that possess revolutionary properties are becoming ever more important. Some are stronger, lighter, and more durable than the best steel.[15] Carbon-carbon polymers can tolerate temperatures up to 3,000 ^{0}F (1,650 ^{0}C) without expanding or weakening significantly.[16] Super-hard ceramics mold readily into complex shapes. The search for superconductor materials that can function at room temperatures without constant bathing in costly liquid helium may benefit fairly soon from ceramics mixed primarily with off-the-shelf bismuth and thallium (a metal used in rat poison) rather than expensive rare-earth metals like lanthanum, strontium, yttrium, and barium.[17] Halide glass fibers, which are far superior to copper wires, combine immunity to electromagnetic interference with great tensile strength.

RESOURCE DEPRIVATION

Resource deprivation occurs whenever requirements exceed stocks on hand plus readily available replenishments and resultant problems can be excruciating if sources dry up at inopportune moments. Two dissimilar cases are instructive in both regards: retaliatory resource warfare in East Asia and the Pacific between 1941 and 1945 destroyed Japan's abilities to project military power far beyond her borders well before atomic bombs hit Hiroshima and Nagasaki; anticipatory operations by a U.S.-led coalition in 1990-1991 relieved widespread anxieties that renegade Iraqi President Saddam Hussein might use ill-gotten Persian Gulf petroleum as an economic weapon against opponents whose livelihood depends on that resource.

RESOURCE WARFARE AGAINST JAPAN

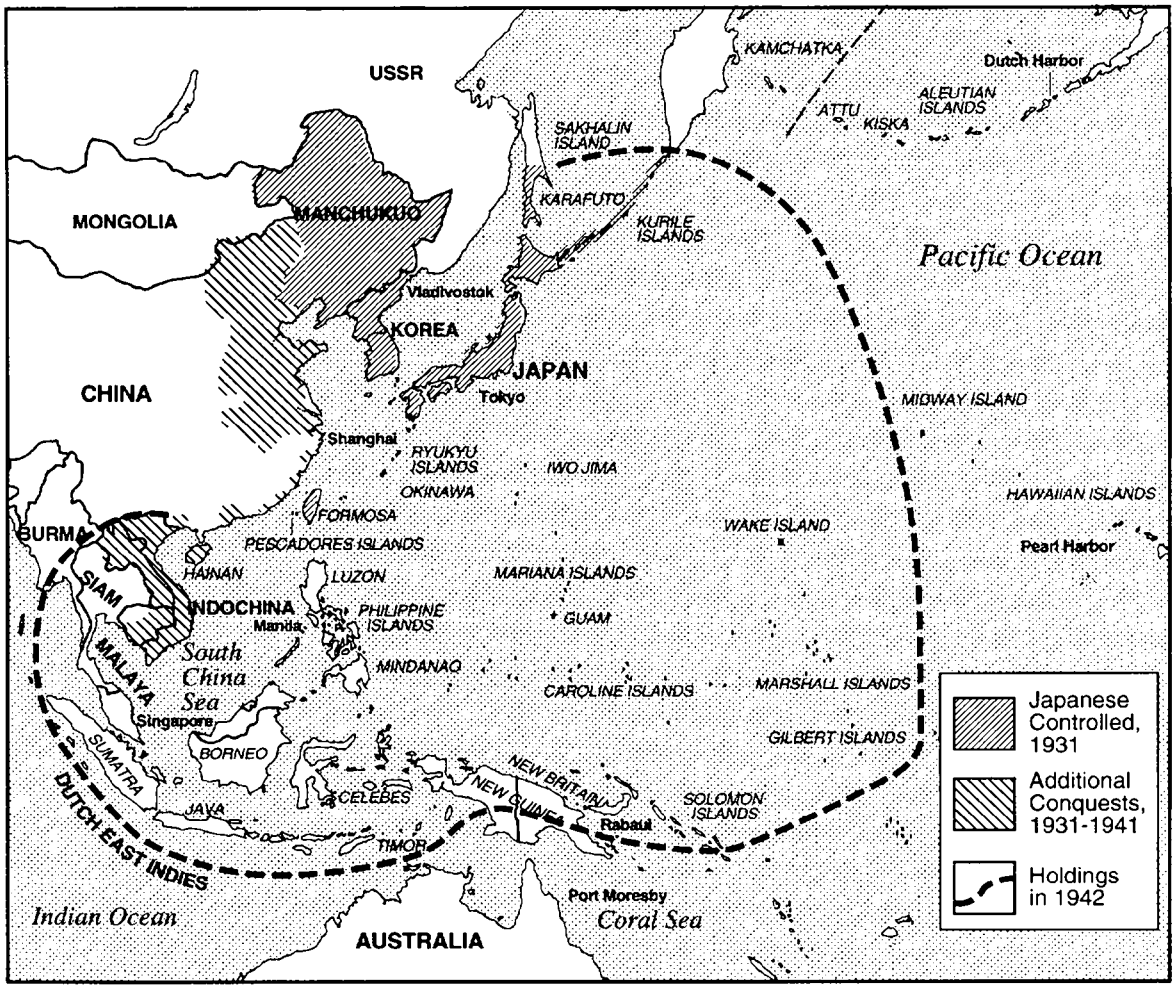
Japan in the early 1930s consisted of four mountainous islands, crowding more than 70 million people onto less arable land than the State of Iowa then contained, and the population was increasing at the rate of one million each year. Scarce natural resources made industrial progress expensive and restricted military capabilities, partly because foreigners supplied most minerals and all petroleum at higher prices than self-sufficient competitors paid, and partly because shipping costs were considerable.

Remedial Measures. Japan began to augment home-grown resources in 1910 when it acquired Korea, which opened access to hydroelectric power along with rich deposits of coal, iron ore, and other minerals. The Mariana, Caroline, and Marshall Islands, German possessions that the League of Nations mandated to Japan after World War I, brought phosphates and phosphorite. The 1931 march into Manchuria, followed shortly by suzerainty

over northern China and bits of the littoral from Shanghai as far south as Hainan Island, netted more iron ore, coking coal, some tin, and aluminous shale.[18]

Tokyo's quest for natural resources received its first serious setback in September 1940, when Japan signed a tripartite pact with Nazi Germany and Fascist Italy. President Roosevelt in response embargoed U.S. scrap metal and petroleum shipments to Japan, then froze all Japanese assets in the United States 10 months later after troops flying the Rising Sun flag swarmed over Indochina with Vichy French acquiescence. The British and Dutch Governments soon imposed similar sanctions.[19] Those body blows hurt, because some Japanese stockpiles, including oil, were sufficient for little more than a year, others for less. Resource deprivation hence dictated Japanese strategy to a high degree. The mission in December 1941 was to grab what they needed, throw a cordon around the gains, and tenaciously hang onto territory that map 25 depicts.[20]

Map 25. *Japanese Territorial Holdings in 1942*



Adapted from Arthur Zich, *The Rising Sun.*

Ruinous Results. Japan initially enjoyed great gains. Burma, Malaya, and Siam provided bauxite, cobalt, tungsten, and tin. Southeast Asian plantations were lucrative sources of rubber, New Caledonia contributed nickel, and the Philippines furnished chromium. Oil

from Tarakan in northeast Borneo, Banjermasin farther south, and Palembang in Sumatra lubricated Japanese machines after bloody but brief fights. Dutch Shell employees torched some facilities and British General Harold Alexander did likewise to 150 million gallons of Burmah Oil Company products outside Rangoon, but most installations remained intact, and Japanese technicians restored capacities so rapidly that output exceeded expectations within a few months.[21]

Japan nevertheless died the Death of a Thousand Cuts, beaten by a U.S. naval and air blockade that devastated its fragile economy. Submarines sank merchant transports faster than Japanese shipyards could build them. Cargoes increasingly substituted salt, soy beans, and cereals for the sinews of war. Aircraft industries, strapped for minerals, metals, and coal, turned out fewer airframes, engines, motor mounts, landing gears, and fittings of such poor quality that performance fell sharply while accident rates rose. Petroleum tanker losses, which exceeded 750,000 tons in 1944, outstripped construction. The octane ratings of aviation fuel dropped dramatically (some batches were alcohol blends), pilot training was cut to 30 hours in 1944 (less than half the previous allocation), and formations played follow-the-leader after navigation schools closed. *Kamikaze* flights became popular, partly because one-way missions cut gasoline consumption in half. Japanese fleets, which required prodigious amounts of petroleum, were in even worse shape. Several major surface combatants were confined to home ports, only one battleship had enough fuel to help defend Okinawa in March 1945, and U.S. aircraft sank or heavily damaged at dockside four "sitting duck" battleships, three aircraft carriers, and two heavy cruisers during final months of the war.[22] *The United States Strategic Bombing Survey* summarized overall results as follows: "The insufficiency of Japan's war economy was the underlying cause of her defeat. Before the air attacks against [Japanese] cities began, war production had been steadily declining because of the ever-increasing shortages of raw materials....This resulted in a growing margin of unused plant capacity. Thus, even substantial bomb damage to plant structures and equipment frequently had little, if any effect on actual production."[23] Resource warriors had already wreaked such havoc that direct assaults merely administered a *coup de grace*.

RESOURCE WARFARE BY IRAQ

Iraqi President Saddam Hussein in January 1991 unleashed an immense oil spill (100,000 barrels a day) at the head of the Persian Gulf, apparently to foul potential invasion beaches and forestall U.S. amphibious landings. Currents shortly carried slicks all the way to the Strait of Hormuz, with environmentally disastrous consequences.[24] His henchmen later set 650 Kuwaiti oil wells afire when Iraqi Armed Forces withdrew in February 1991, perhaps to ensure that Saddam's opponents could take less comfort from his defeat and reap fewer early financial benefits. Sixteen international fire fighting companies and 10,000 men worked round-the-clock for more than 8 months to extinguish those flames at a cost of about $1 billion (much faster than first predicted), while estimates placed reclamation and reconstruction costs at twenty times that figure.[25]

Saudi Arabian Petroleum Facilities. Possibilities for infinitely greater mischief were present in Saudi Arabia, which Saddam Hussein might have seized had that nation remained undefended by a formidable coalition. Petroleum-dependent nations everywhere would have been at his mercy as long as he controlled so much productive capacity and exploited it for his own purposes.

Outsized Saudi Arabian petroleum infrastructure would have been hard to replace if badly damaged or destroyed. The main complex sprawls over an area 350 by 250 miles—5,630 by 3,220 kilometers (map 26), and many wells lie under water along the Persian Gulf littoral. Extraction, collection, processing, and distribution systems illustrated schematically in figure 27 contain many one-of-a-kind components that would be hard to replace: 50 gigantic gas-oil separators; many huge pumping stations (2 million barrels each per day); the world's biggest water injection plants (400 million cubic feet daily for the Abqaiq field alone); the world's biggest storage tanks, 72 feet high, 352 feet in diameter, capacity 1.25 million barrels apiece; the biggest oil port; a monster desalinization plant. Drill pipes, casings, tubing, bits, blowout preventers, valves, pressure gauges, engines, and compressors plus indispensable starches, caustic sodas, alcohols, organic chemicals, and construction steels would be instantaneously insufficient if enemies sabotaged major elements. Shipping requirements would strain oceangoing transports.[26]

Sabotage Potential. Ballistic missile defense systems available to the allied coalition in 1991 might best be described as "porous," but Iraqi Scuds were too inaccurate to do much damage except by chance, and the Iraqi Air Force was too timid to cause serious concerns. Opportunities for sabotage on a grand scale, however, would have been wide open to Iraqi ground forces before they abandoned positions in Saudi Arabia, provided personnel in charge possessed sufficient expertise. Wells, pipelines, pumping stations, power plants, storage tanks, refineries, and loading facilities all were vulnerable in varying degrees.

It would be easy to punch holes in welded steel pipelines half an inch or so thick, although oil field workers could repair punctures with relative ease even if demolition experts tore great gaps. Heavy crude oil would be hard to ignite in giant storage tanks with walls 1.7 inches (4.3 centimeters) thick at the base, because shaped charges would sputter in the thick liquid. Flares would shoot from containers full of high-octane fuel, but distances between tanks would confine spreads even if saboteurs found ways to kindle full-fledged fires.

Demolition specialists who concentrate on separators, stabilizers, power packs, and pumping stations conversely could produce paralytic effects. Free-flowing Saudi wells, like those in Kuwait, are extremely flammable. Fires in offshore facilities would be especially fearsome. It took 136 days to smother flames at just one Shell Oil platform off Louisiana's coast after 11 wells blew in 1970. Sixteen private companies and three U.S. Government agencies committed 650 men to fight another offshore fire at Bay Marchand. Two barges sprayed sea water on the platform superstructure to keep it from melting. Five mobile drilling rigs, two "jack-up" rigs, and eleven mud barges working in concert sank new shafts, pumped water into the producing layer to prevent subterranean oil reservoirs from feeding fires, and then blocked burning wells with mud. A derrick barge with a 500-ton crane cleared 3,000 tons of debris before new well heads could be connected to new platforms. A special shore-based control center replete with communications, power sources, fuel supplies, a helipad, seaplane dock, and living quarters was constructed to accommodate supervisors.[27]

Additional difficulties would develop in Saudi Arabia if prevailing Persian Gulf winds swept burning oil slicks south from Berri to port facilities at Juaymah and Ras Tanura, where explosions could level installations ashore. Just one supertanker laden with gasoline or naphtha would have devastating effects (70 tons of liquefied natural gas destroyed 80 square blocks in Cleveland, Ohio, in 1945; the contents of a 100,000-gallon tanker would be catastrophic in comparison).[28]

Map 26. *Saudi Arabian Oil Fields and Facilities*

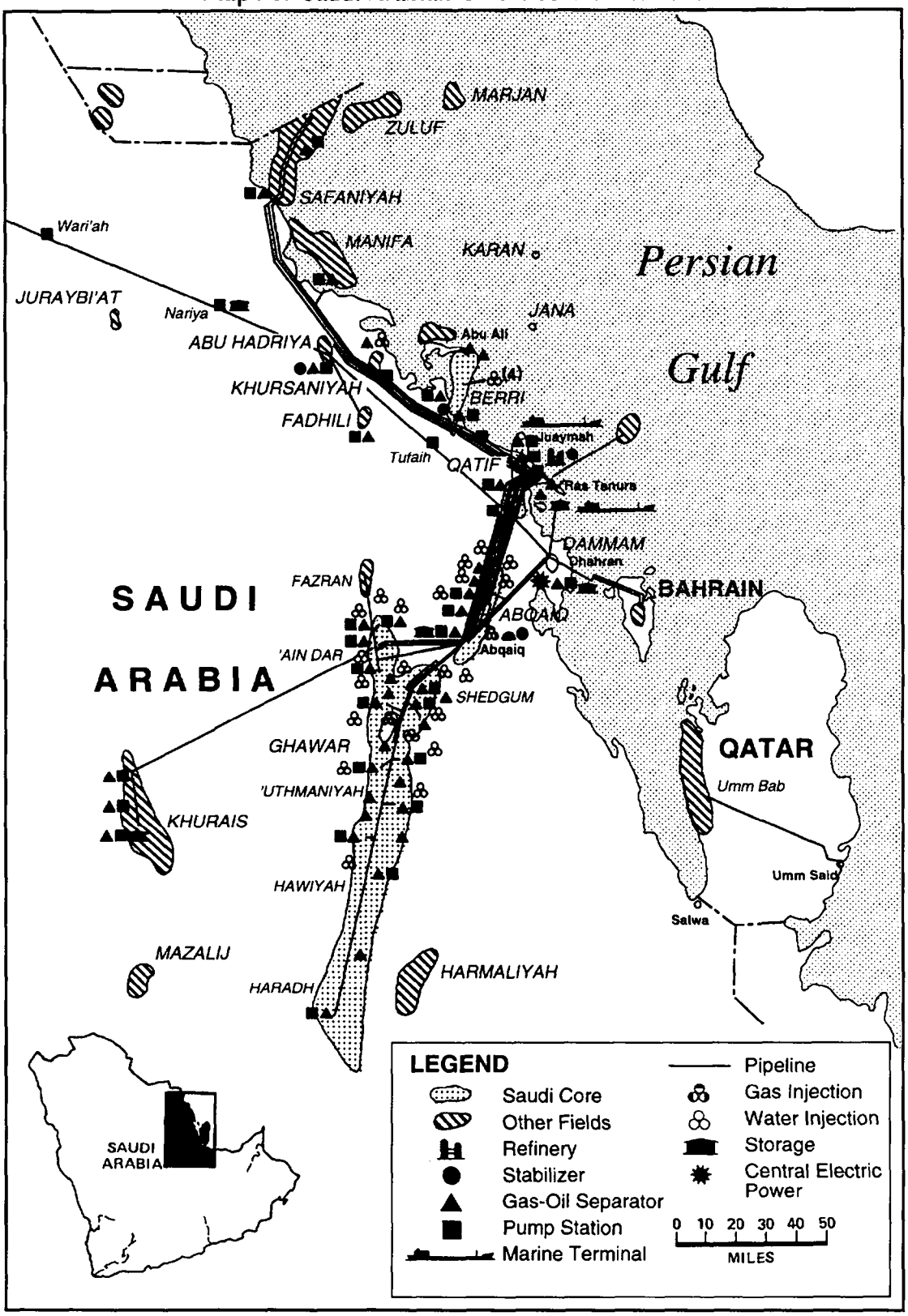
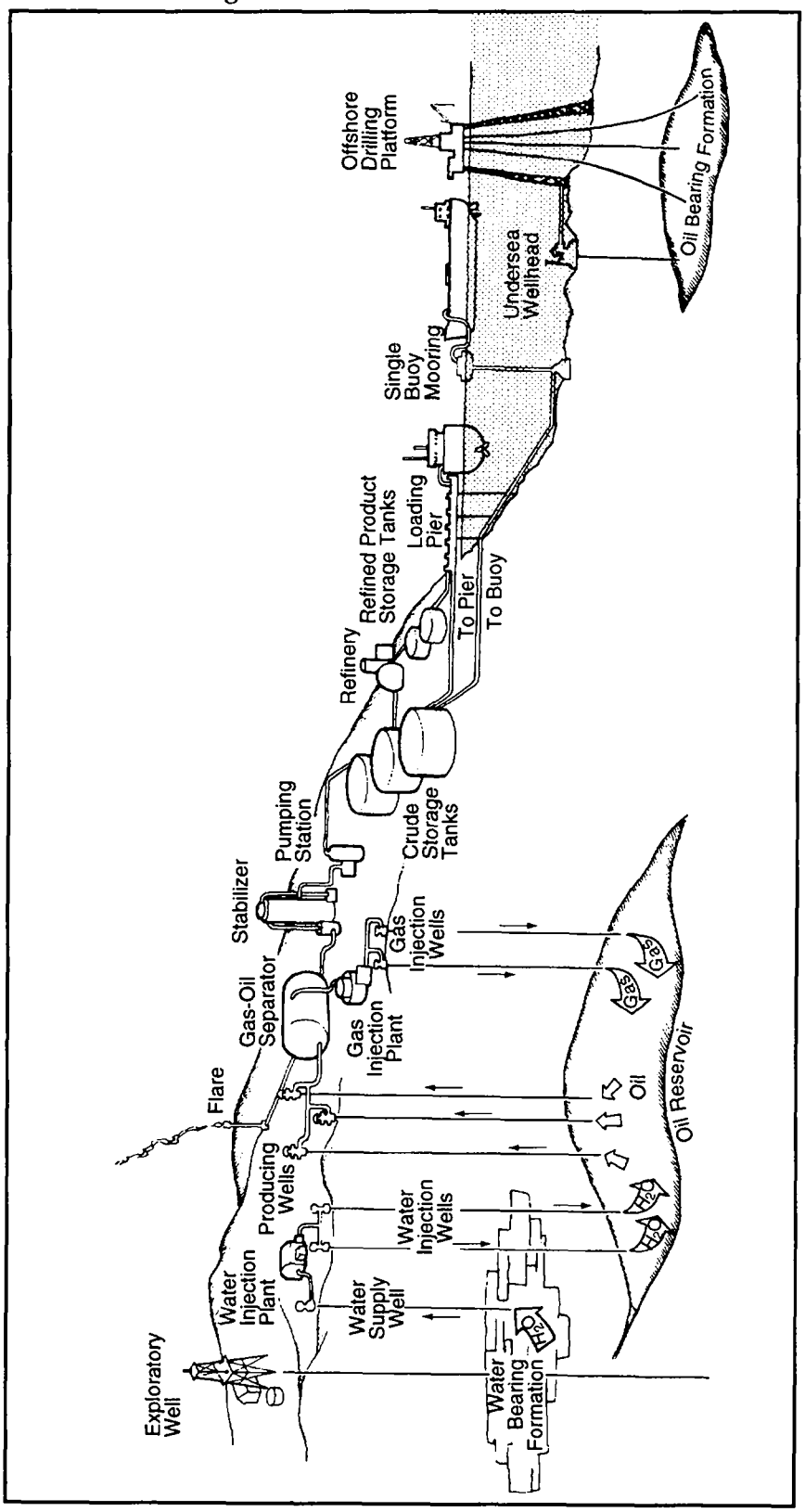


Figure 27. *Oil Fields and Facilities*



Niccolo Machiavelli explained the problem nicely in *The Prince* (1514 A.D.): "One must never allow disorder to continue so as to escape a war. One does not escape. The war is merely postponed to one's disadvantage." The Allied coalition that blocked Iraqi Armed Forces at the Kuwaiti border in August 1990, then drove them out the following February, performed an internationally valuable service when seen from that perspective. The price in lives lost and money expended was minuscule compared with penalties that might have been paid if Saddam Hussein had launched a ruthless resource war while withdrawing under pressure from Saudi Arabia.

KEY POINTS

- National interests in natural resources and raw materials shape international relationships, incur enmities, and underpin defense industries without which armed forces could not function.
- Competition for some commodities is intense, because few countries are entirely self-sufficient.
- Prudent national leaders therefore seek to establish strong ties with foreign suppliers, safeguard essential supply routes, and stockpile reserves for use in emergencies.
- How much of what each country needs depends on the technological sophistication of its armed forces, together with present and projected requirements.
- Sensible degrees of reliance on foreign providers depend on international relationships at any given moment, alternative sources, and the security of shipping lines.
- Stockpiles should emphasize resources and raw materials in order of importance. Steel production, for example, will demand manganese and coking coal until technologists identify substitutes or devise different methods.
- Poorly attended stockpiles deteriorate rapidly and soon become obsolescent unless supervisors recorrelate them with changing requirements at realistic intervals.
- Continued reliance on fossil fuels, for which no suitable substitutes now are available, leaves industrialized nations and their armed forces vulnerable to devastating resource deprivation.
- Synthetic materials are rapidly altering the value of many other natural resources.
- Resource warfare can threaten modern societies and damage military capabilities just as surely as nuclear weapons.

NOTES

1. Alfred R. Greenwood, *On Issues Relating to the National Defense Stockpile*, briefing before the Readiness Subcommittee of the House Armed Services Committee, March 8, 1994, Attachments 2-4.

2. Ewan W. Anderson, *Strategic Minerals: The Geopolitical Problems for the United States* (New York: Praeger, 1988); Marc D. Lax, *Selected Strategic Minerals:The Impending Crisis* (New York: University of America Press, 1992).

3. Ibid.

4. Congress, House, Joint Committee Print, *Nuclear Proliferation Factbook*, 99th Congress, 1st sess., August 1985, 299-499; *Proliferation of Weapons of Mass Destruction: Assessing the Risks* (Washington, DC: Government Printing Office, August 1993), 33, 35-36, and *Technologies*

Underlying Weapons of Mass Destruction (Washington, DC: Government Printing Office, December 1993), 131, 147-148.

5. Alfred R. Greenwood, *The Availability of Strategic and Critical Minerals for the United States Economy* (Washington, DC: Congressional Research Service, November 16, 1983). U.S. updates are contained in *Mineral Commodity Summaries, 1996* (Washington, DC: U.S. Department of the Interior, Geological Survey and Bureau of Mines). See also Kent Hughes Butts, *Strategic Minerals in the New World Order* (Carlisle Barracks, PA: Strategic Studies Institute, U.S. Army War College, November 30, 1993).

6. Michael Shafer, "Mineral Myths," *Foreign Policy,* no. 47 (Summer 1982): 154-171.

7. Greenwood, *The Availability of Strategic and Critical Minerals*, 6, 7.

8. Joseph P. Riva, *Petroleum Status of the Western Persian Gulf,* Report No. 90-378 SPR, November 13, 1990, and Bernard A. Gelb and Dario Scuka, *Oil Flows, World Reserves, and the Iraq-Kuwait Situation,* Report No. 90-374E, August 7, 1990 (Washington, DC: Congressional Research Service).

9. Yuan-li Wu, *Economic Warfare* (New York: Prentice-Hall, 1952), 277-280.

10. Greenwood, *The Availability of Strategic and Critical Minerals*, 14-18.

11. Ibid. U.S. updates are contained in *Inventory of Stockpile Material (LZ-1)*, Defense National Stockpile Center, September 30, 1996; Greenwood, *On Issues Relating to the National Defense Stockpile,* March 8, 1994.

12. "Exclusive Interview by *Business Week*, December 23, 1974," *Department of State Bulletin*, January 27, 1975, 101.

13. Robert Bamberger, *The Strategic Petroleum Reserve*, IB87050 (Washington, DC: Congressional Research Service, August 14, 1990).

14. Ronald H. Bailey, *The Home Front: USA* (New York: Time-Life Books, 1977), 84.

15. *Advanced Materials by Design* (Washington, DC: Government Printing Office, June 1988).

16. Howard G. Maahs, "Carbon-Carbon Composites," *World & I*, June 1989.

17. *Commercializing High-Temperature Superconductivity* (Washington, DC: Government Printing Office, June 1988).

18. *The United States Strategic Bombing Survey* (USSBS), with intro. by David MacIssac, vol. 8, *The Effects of Strategic Bombing on Japan's War Economy* (New York: Garland Publishing, 1976), chapter I; Arthur Zich, *The Rising Sun* (New York: Time-Life Books, 1977), 18-27.

19. Jerome B. Cohen, *Japan's Economy in War and Reconstruction* (Minneapolis, MS: University of Minnesota Press,1949), chapter 3.

20. Ibid; Zich, *The Rising Sun*, 119-129.

21. Cohen, *Japan's Economy in War and Reconstruction*, chapter 4.

22. *USSBS*, vol. 9, *The Effects of Air Attack on Japanese Urban Economy*, Summary, v-vi.

23. "Huge Oil Spill Fouls Persian Gulf," *Facts on File Yearbook 1991*, Indexed Record of World Events, vol. 51 (New York: Facts on File, January 31, 1991), 57-58, 92-93; M. Lynne Corn, *Persian Gulf Oil Spills and the Biology of the Persian Gulf,* Report No. 91-123 ENR (Washington, DC: Congressional Research Service, January 30, 1991).

24. Jennifer Parmalee, "Kuwaiti Emir Snuffs Out Last Iraqi-Lit Oil Fire," *Washington Post*, November 7, 1991, 1.

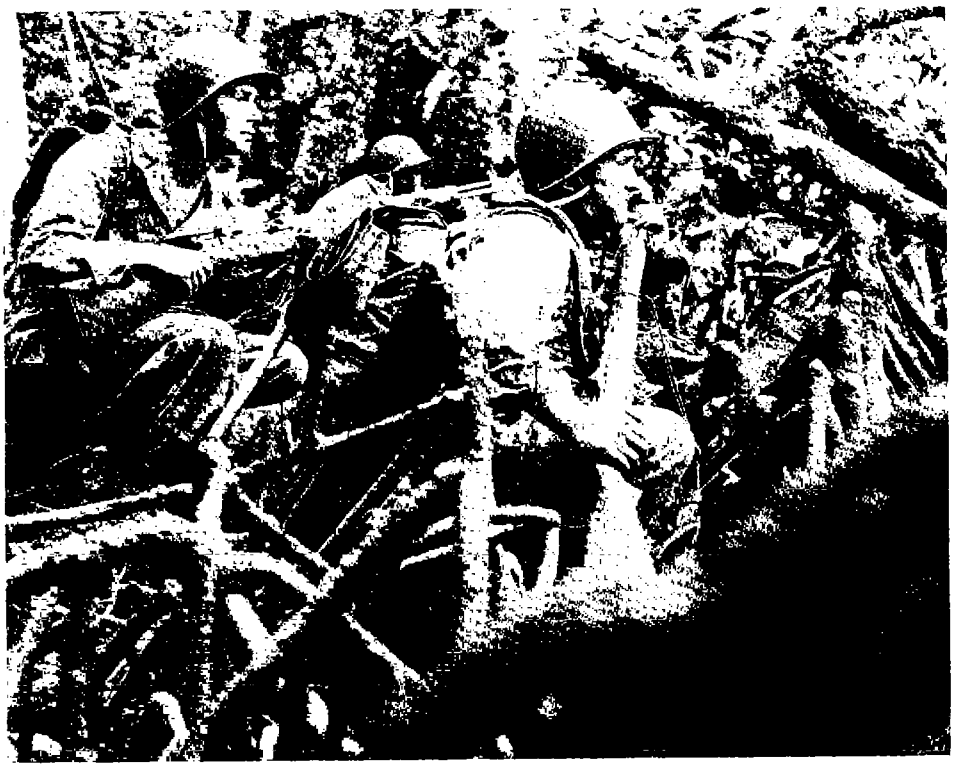
25. Congress, House, *Oil Fields As Military Objectives*, prepared for the Special Subcommittee on Investigations of the Committee on International Relations by the Congressional Research Service, 94th Congress, 1st sess., August 21, 1975, 17, 71; Ismail I. Nawwab et al., eds., *ARAMCO and Its World* (Dhahran, Saudi Arabia:1980), 214-217.

26. *Oil Fields As Military Objectives*, 45, 70.

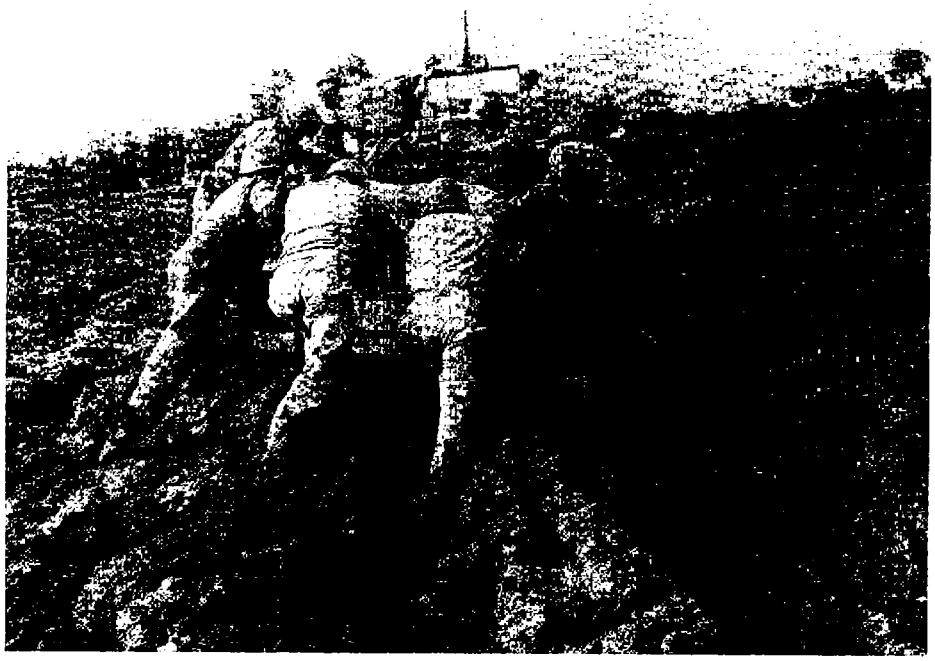
27. "How Shell Rejuvenated Fire-Damaged Bay Marchand Wells" *Ocean Industry* (October 1973): 47-50; R. F. Nelson, "The Bay Marchand Fire," *Journal of Petroleum Technology* (March 1972): 225-249.

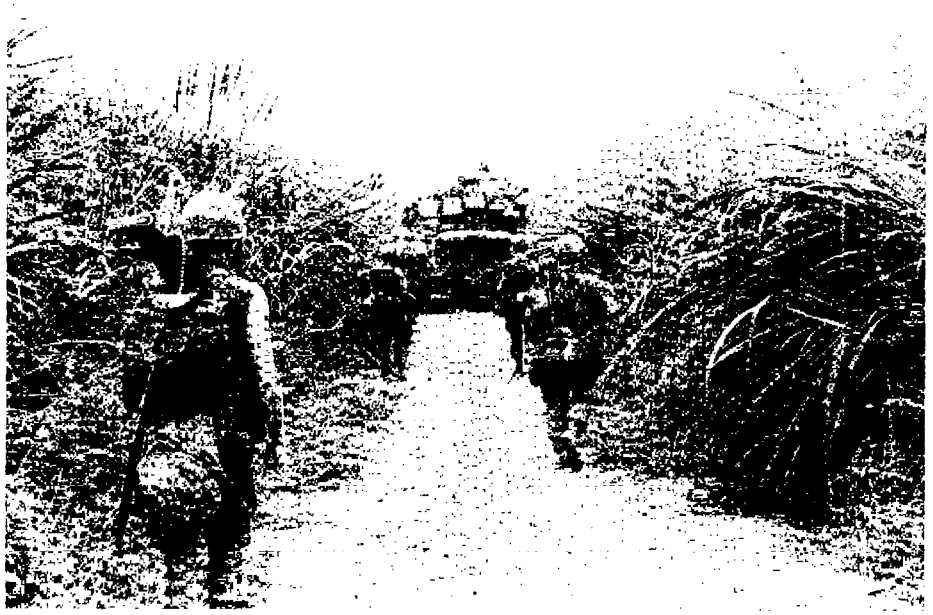
28. *Oil Fields As Military Objectives*, 17, 44-46, 69-71.



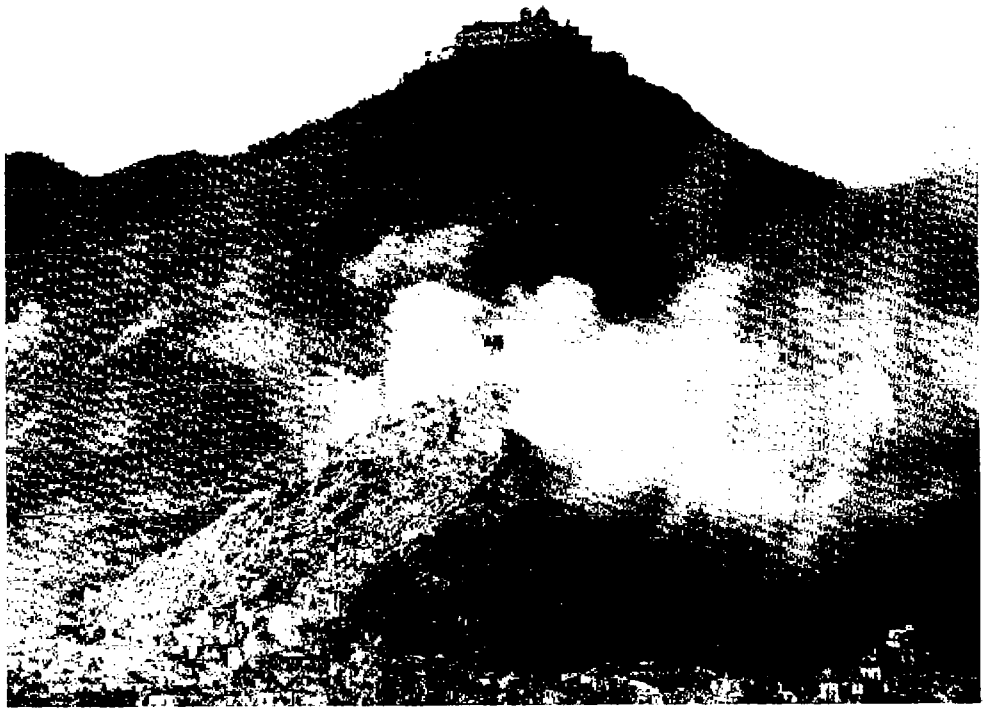


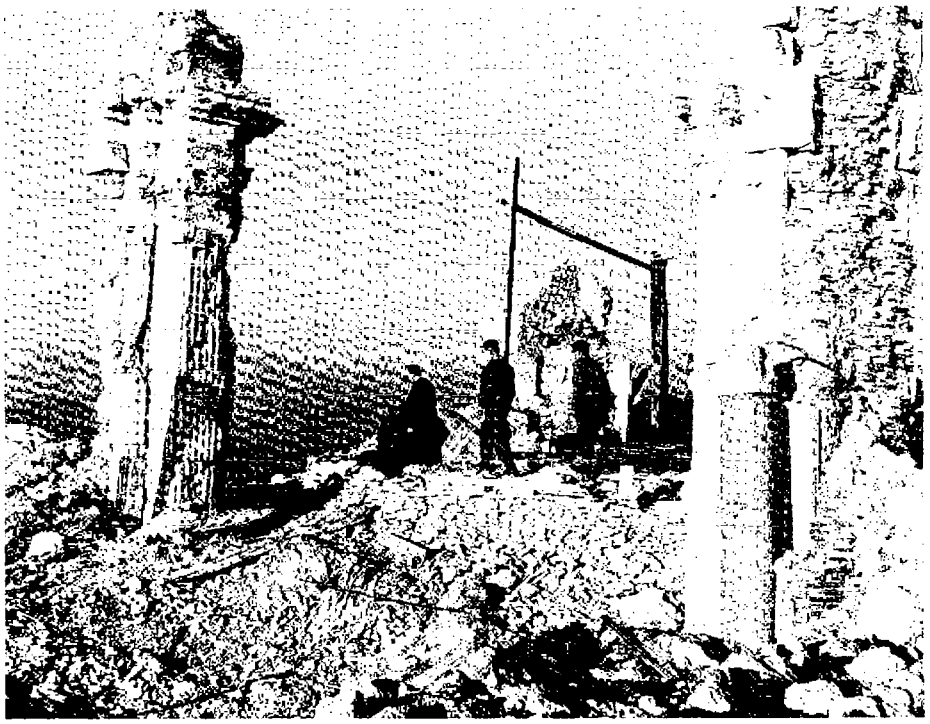
Top: Amphibious assault troops wade across a coral reef through hip deep water on their way to Yellow Beach Two on Makin Atoll in the Gilbert Islands. All eyes face right, where a Japanese machine gun has just opened fire. Smoke rises from oil storage tanks ignited by naval gunfire (U.S. Army photograh).
Bottom: Gnarled tree roots above ground and under fetid black water typify tidewater swamps, where observation and fields of fire extend a few feet at most in any direction. Close combat by foot troops is a nerve-wracking proposition under such conditions (U.S. Army photograph).





Top: Deep, sticky mud that acts like a suction cup turns unsurfaced roads into quagmires during rainy seasons and precludes cross-country movement by motor vehicles. Frozen mud can cement truck convoys in place like Greek friezes (U.S. Army photograph).
Bottom: Wary, well-dispersed troops look for enemy ambush sites as they advance along a tropical road that runs between thick stands of "elephant grass," which excludes the slightest breeze, is stifling hot, and restricts observation to less than one arm's length (U.S. Marine Corps photograph).





The small castle in the foreground and the 1,400-year-old Benedictine monastery on the skyline both offered fine observation posts and defensive positions during the battle for Cassino, Italy, early in 1945. German paratroopers, who avoided the abbey until Allied bombers blasted it flat, fought tenaciously in the debris below (U.S. Army photographs).



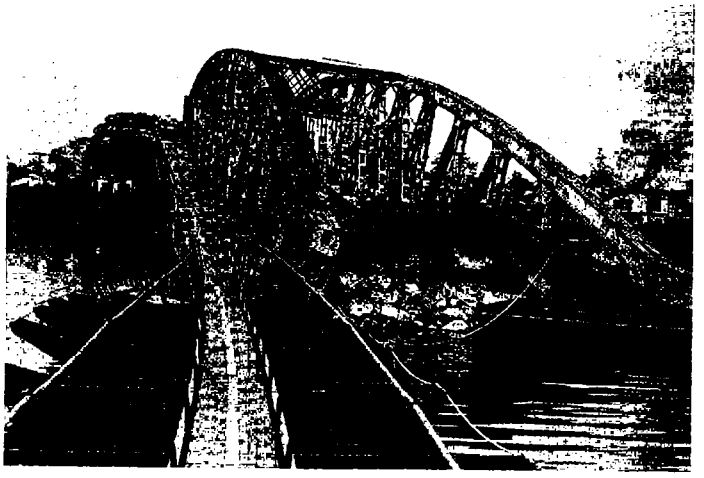
A truck convoy on the Burma Road above the Salween River gorge creeps around 21 switchback curves with slippery surfaces, precipitous slopes on both sides, and no guard rails. Men, mules, and motor vehicles sometimes slipped into the abyss (U.S. Army photograph).



Manpower and mules must replace motor vehicles wherever rude tracks and trails supplant roads, unless helicopters are available. Heavy mortar crews like the one depicted found the going difficult whether they moved up or down steep slopes in Italy's Apennine Mountains (U.S. Army photograph).



The bridge over the Rhine River at Remagen became the most important piece of property in Western Europe when German demolition teams failed to destroy it completely before U.S. troops raced across on March 7, 1945. The tenuous bridgehead that they seized initially expanded for 10 days before the weakened structure collapsed (U.S. Army photograph).



The pontoon bridge in the foreground supported foot traffic after Viet Cong sappers during the Tet offensive of February 1968 dropped the sturdy steel truss that spanned the Perfume River at Hué, but motor vehicles and trains could no longer cross (U.S. Marine Corps photograph).

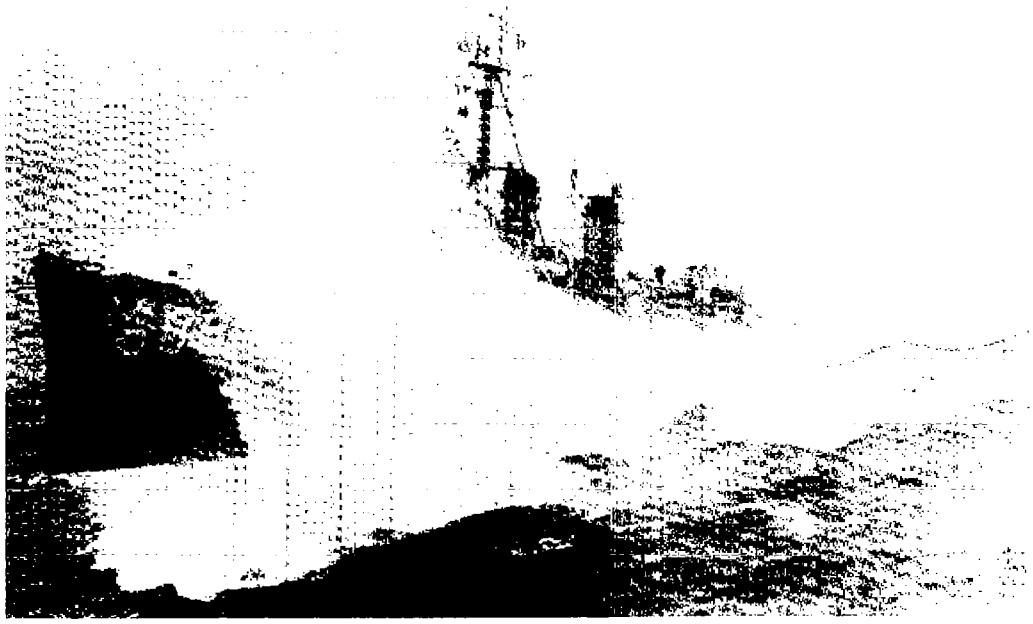


Subzero weather and wicked winds near North Korea's Changjin Reservoir made life miserable for U.S. Marines, the Army's 32d Infantry Regiment, and British Royal Marine Commandos in mortal combat with Chinese Communist "volunteers" who streamed south from Manchuria in November 1950 (U.S. Marine Corps photograph).

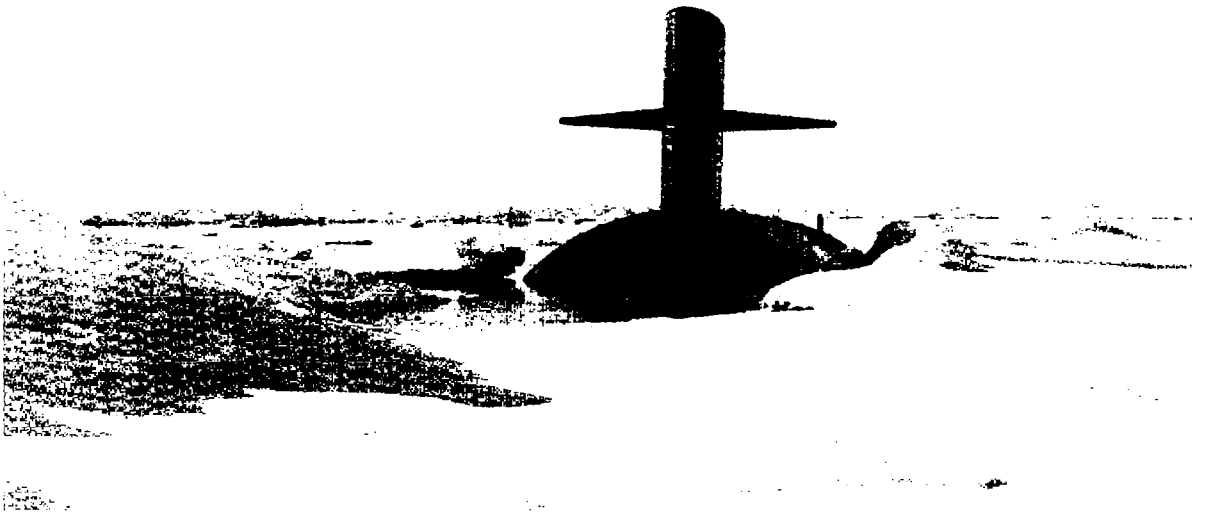


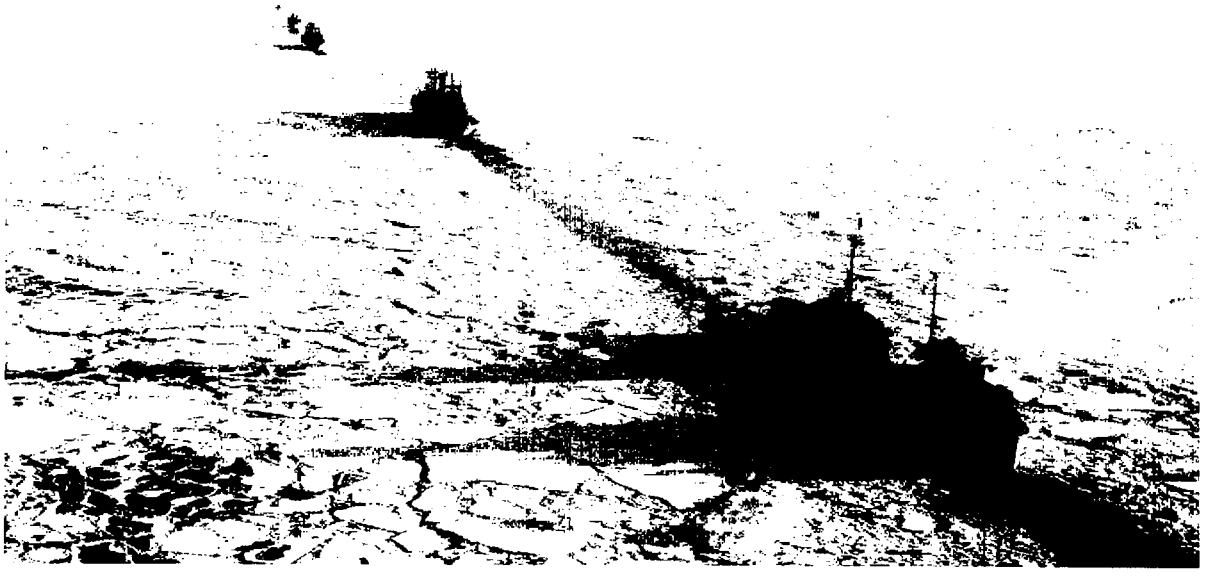
Front line medics find it much easier to treat stretcher cases while the weather is warm and dry than in winter, when freezing rain and wet snow soak casualties who lie in the open. Hypothermia, which is common under such conditions, can kill almost as fast and just as surely as lethal weapons (U.S. Army photograph).





Top: Close air support is a sporty proposition when valleys experience clear weather while heavy clouds shroud hilltops, a condition that commonly prevails between Vietnam and the Laotian panhandle near Khe Sanh. Route 9 runs diagonally from left to right along the valley floor in this photograph (U.S. Marine Corps photograph).
Bottom: Underway replenishment is a complex task even under placid conditions. Skilled destroyer skippers and crews are required to transfer supplies safely during stormy weather, when roiling water washes across rolling, pitching decks, slams against bulkheads, creates instability that magnifies every cargo-handling problem, and increases risks of collision (U.S. Navy photograph).





Top: Submarines under arctic ice packs that often are 10 feet (3+ meters) thick must surface before they can safely launch ballistic or cruise missiles. They also must be able to break through in emergency, because crews otherwise would suffocate if air supplies failed for any reason (U.S. Navy photograph).
Bottom: A string of ships play "follow the leader" through a narrow lead in Antarctic ice so that only one has to force its way. Opportunities to do so near either pole are limited to short summer seasons, because pack ice is frozen solid most of each year (U.S. Navy Photograph).





Top: Heavy coatings of thickly frozen salt water spray can block air intakes and add tons to ship bulkheads, superstructures, hatches, masts, rigging, exposed machinery, antennas, and weapon systems. Results reduce the operational capabilities and endanger the stability of ice breakers (shown) as well as surface combatants and transports in the absence of effective countermeasures (U.S. Navy photograph).
Bottom: Water always is the staff of life during military operations in deserts. U.S. troops that deployed to Egypt during Exercise *Bright Star* in 1985 reconfirmed that flexible hoses can transfer large quantities over long distances faster and more cost-effectively than fleets of tanker trucks (U.S. Army photograph).

PART TWO: CULTURAL GEOGRAPHY

9. POPULATIONS

There is the so-called theory of "weapons mean everything." . . . Weapons are an important factor in war, but not the decisive one; it is man and not material that counts. The contest of forces is not only a contest of military and economic power, but also one of the power and morale of humans.

Mao Zedong
On Protracted War

MAO'S REMARKS WERE NOT RESTRICTED TO UNIFORMED COMRADES WHO, IN 1935, COMPLETED THE LONG March from Jiangxi Province to the Shaanxi caves near Bao'an (map 3, page 19). He also meant the Chinese people, peasantry in particular, whose sturdy stock was his primary source of strength. Mao still planned to "drown [invaders] in a hostile human sea" even after the nuclear-armed Soviet Union turned against him a quarter-century later, steadfast in his belief that "modern long-range weapons, including atomic bombs," would be "helpless and ineffective" in any protracted war when opposed by industrially backward but ideologically indoctrinated masses who were not afraid to die for their homeland.[1]

Soviet leaders never put Mao's premise to the test, but most authorities generally agree that the human element in military affairs is huge. Strategists and tacticians who concoct plans and conduct operations in the absence of sound knowledge concerning the demographics, cultural characteristics, and social structures of coalition partners as well as opponents are on shaky ground. Sun Tzu, who was Mao's mentor many times removed (circa 500 B.C.), took that contention one step further: "Know the enemy and know yourself," he counseled, "in a hundred battles you will never be in peril. When you are ignorant of the enemy but know yourself, your chances of winning or losing are equal. If ignorant both of your enemy and yourself, you are certain in every battle to be in peril."[2] Population patterns, the racial-ethnic-tribal mix, languages, religions, customs, tempers, attitudes, and loyalties are everywhere important.

DEMOGRAPHY

Demography deals with the size, density, geographic distribution, composition, and other vital statistics of populations the world over. Military practitioners concentrate on demographic conditions that influence current plans, programs, and operations. Birth rates, life expectancies, the practice of polygamy, and percentages of married persons, for example, are less important than sex and age profiles that determine the number of individuals eligible for military service and the size of local labor pools. Relationships between minorities and majorities are more important than relative percentages of the population that each represents.

PERTINENT HEAD COUNTS

Approximately 5.8 billion people populated Planet Earth in 1997, of which four-fifths lived in the least developed countries (figure 28). China and India alone contributed two billion, while the Western Hemisphere, Africa, Europe, and Central Asian states that belonged to the former Soviet Union divided most of the remainder. Populations in the poorest regions will expand disproportionately before the year 2025, most of them in Asia and Africa, if projections prove correct, which is by no means a foregone conclusion considering the unpredictable impact of AIDS, widespread starvation, and wars.[3]

Militarily important statistics include total populations in any given country, the number of men and women of military age (generally ages 15 to 49), and percentages that are fit for active service. Israel (population 5.7 million, of which 15 percent are Palestinians[4]) cannot maintain large active forces in "peacetime," must mobilize reserves from the civilian work force to meet military emergencies, could ill afford extensive casualties, and would face economic collapse in a protracted war of attrition. Armed services fed by much larger societies are better able to replenish heavy losses before they become combat ineffective, as several major powers demonstrated during two World Wars in the 20th century. Even the winners, however, paid a higher price than table 13 reflects, because figures therein exclude civilian casualties, military personnel rendered permanently ill or disabled, horrendous Chinese losses from 1937 through 1941, and incalculable deprivation of latent talent.[5]

Table 13. ***Military Dead and Missing, World Wars I and II***

	WW I	*WW II*	*Total*
Russia/USSR	2,760,000	7,500,000	10,260,000
Germany	1,610,000	2,800,000	4,410,000
China	N/A	2,000,000	2,000,000
France	1,428,000	247,000	1,675,000
Japan	N/A	1,500,000	1,500,000
British Commonwealth	911,000	305,000	1,216,000
United States	107,000	407,000	514,000

DISTRIBUTION PATTERNS

A few favored nations ideally distribute many cities, towns, and villages over large land masses and keep a high percentage well removed from unfriendly frontiers. Countries cursed

Figure 28. *Present and Projected World Populations*

POPULATION MOMENTUM

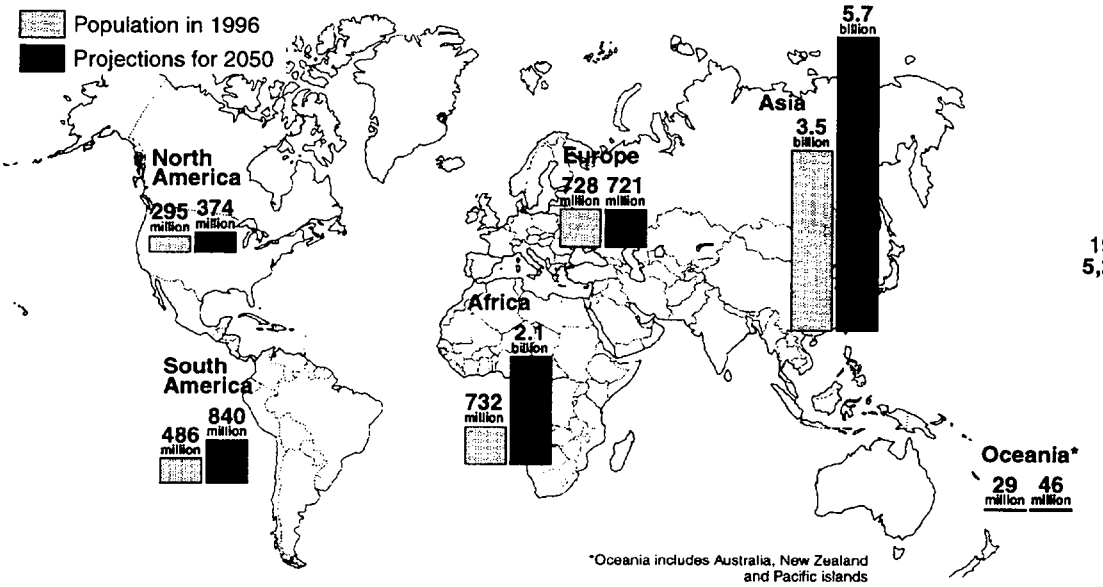
By 2050, 9.8 billion people will inhabit Earth, an increase of 73 percent from the current 5.7 billion. The population of developing countries is expected to grow by 80 million people each year, on average, doubling by about 2050. Africa alone will almost triple its current population by 2050. While the growth rate is declining almost everywhere, the population increase continues, reflecting high birth rates in past decades.

POPULATION CLOCK

Number of births per minute, 1996



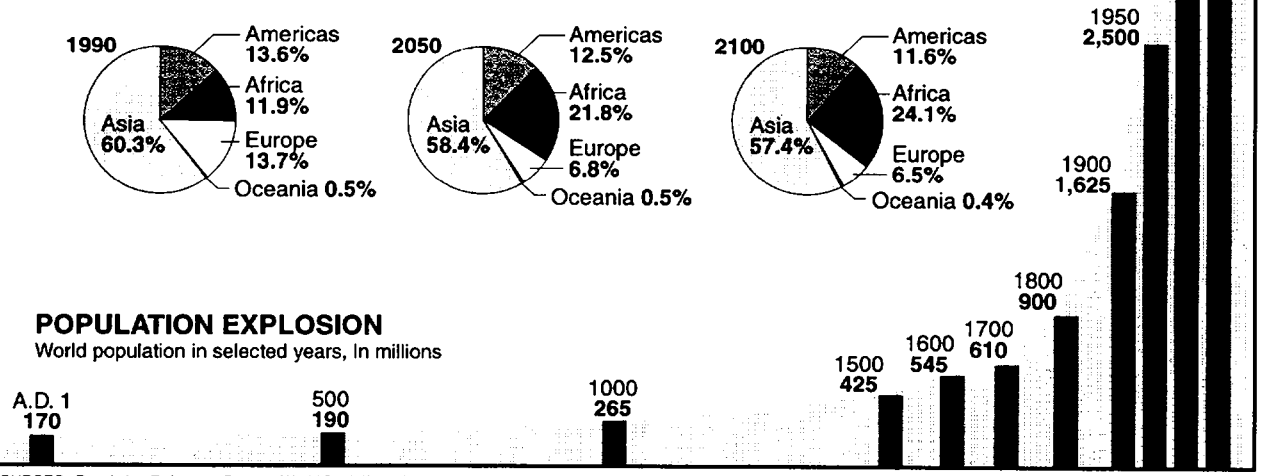
FUTURE POPULATION GROWTH



DISTRIBUTION OF WORLD POPULATION BY CONTINENT

POPULATION EXPLOSION

World population in selected years, In millions



SOURCES: Population Reference Bureau, World Bank "World Population Projections"

By Dita Smith and Laura Stanton–The Washington Post

with population patterns that afford fewer safeguards are more vulnerable to invasion unless blessed with benign neighbors (as Canada is) or topographic barriers (such as those that shelter Switzerland). Russia's territory, for example, is immense, but its people are predominantly located on flatlands west of the Ural Mountains in positions that have been overrun repeatedly. Syria, Israel, Jordan, Egypt, Saudi Arabia, Kuwait, Iraq, and Iran are even more vulnerable, because most residents occupy capital cities—Damascus, Tel Aviv, Amman, Cairo, Riyadh, Kuwait City, Baghdad, and Teheran—plus a sprinkling of other centers such as Hama, Jerusalem, Alexandria, Jiddah, Basra, Meshed, and Isphahan. Even one well-placed tactical nuclear weapon delivered by an aircraft, missile, motor vehicle, or other means might instantaneously put any of those countries politically, economically, and militarily out of commission. No amount of dispersion could provide any nation with complete protection against such attacks, but population patterns that require enemy marksmen to hit many targets instead of one or two increase the costs of aggression and reduce dangers that accompany excessive concentration.

POPULATION DENSITIES

Overpopulation can lead to armed conflict if pressures cause intolerable spillovers or internal combustion. Real or imagined inabilities to support preferred life styles often act as catalysts, as Adolph Hitler confirmed early in World War II when he seized Slavic lands partly to satisfy Germany's alleged need for *Lebensraum* (literally "living space"). Japan invaded Manchuria in 1937 and later established a Greater East Asia Co-Prosperity Sphere for much the same reason.[6] Spontaneous overflows may inadvertently instigate strife that no one intended, which happened in 1971 when nine million refugees from East Pakistan (now Bangladesh) flooded into already overcrowded India to escape massacres by West Pakistanis and thereby precipitated a brief three-way war. Population pressures also can cause or contribute to civil wars contained within national borders. Prominent observers of Burundi, for example, contend that wholesale slaughters in that country twice occurred because too little room exacerbated political and class rivalries between the Tutsi and Hutu tribes, first in 1972 and again in the 1990s.[7]

PHYSICAL ATTRIBUTES

National and regional populations consist of *individuals* who differ considerably with regard to strength, endurance, hardiness, and health. Military commanders and staffs function most effectively only if they fully understand the *collective* implications of such characteristics, which may be positive, negative, or neutral.

COMPARATIVE PHYSIQUES

Not many militarily significant physical attributes distinguish one people from another. Heavily built, lightly built, and moderately built men and women perform equally well under most circumstances, whether they are tall or short, dark or light skinned, blond, brunette, or red-headed, given proper equipment, equal training, and periods of acclimatization when shifted from familiar to unfamiliar geographic regions. Two exceptions seem to stand out.

Military personnel whose skin or hair color is different than those of opponents find it difficult to operate behind enemy lines if the civilian population is hostile and, if caught and

incarcerated, rarely elude recapture. Every U.S. prisoner of war (POW) who slipped out of a North Korean stockade between 1950 and 1953 was apprehended, as was every fugitive from a permanent camp in North Vietnam (1965-1972), partly because black and white faces were conspicuous in hostile territory. Only one made it home from Laos and very few escaped from Viet Cong cages in Communist-controlled territory within South Vietnam. [8]

Operations at very high altitudes comprise the second exception. Lowlanders seldom (some say never) seem to attain the same stamina in rarefied atmosphere as mountaineers born and raised above the tree line, no matter how long they remain.[9] Few battles, however, have been fought at extreme elevations since Francisco Pizarro defeated the Incan Emperor Atahualpa early in the 16th century and Peruvians ousted Spanish forces 300 years later. Chinese regulars and Tibetan resistance groups clashed sporadically in the 1950s before Beijing crushed a hopeless revolt.[10] Chinese, Indian, and Pakistani troops have periodically skirmished along Himalayan heights since then, most notably over control of Jammu and Kashmir, but never have conducted sustained campaigns despite repeated threats to do so.[11]

Troops that descend from lofty homelands to do battle near sea level experience no adverse effects, if the legendary Gurkha Rifles of Nepal are anywhere near typical. They have served the British Crown well since 1817 under every geographic condition from steaming jungles to the frigid Falkland Islands.[12]

PUBLIC HEALTH

Poor public health conditions and endemic diseases can undercut military capabilities just as surely as enemy actions. Potentially fatal maladies such as malaria, typhoid fever, typhus, cholera, plague, and influenza, together with nonlethal miseries that drastically reduce proficiency, have taken a terrible toll on armed forces throughout history. Serious problems remain despite intensive and extensive searches for solutions, as U.S. statistics from World War II, Korea, and Vietnam illustrate:[13]

Table 14. *Causes of U.S. Wartime Casualties*

	Combat Casualties	*Noncombat Casualties*	*Disease Casualties*
	%	%	%
World War II (1944)			
Europe	23	10	67
Southwest Pacific	5	12	83
China-Burma	2	8	90
Korea (1950)	8	17	75
Vietnam (1969)	19	14	67

U.S. medical intelligence specialists catalog diseases in 140 countries according to short (less than 15 days) and long incubation periods. Anthrax, AIDS, and ebola are relatively recent additions to an already long list that runs from African trypanosomiasis (sleeping sickness) to yaws and yellow fever. Acute respiratory diseases as well as penicillin-resistant strains of syphilis and gonorrhea are rampant worldwide. Mosquito-borne Rift Valley fever, tick-borne hemorrhagic fever, and leishmaniasis, a parasitic disease deposited by sand flies, are a few among many tropical afflictions.[14] Countermeasures emphasize immunizations and sanitation, with particular attention to purified water for drinking, cooking, shower facilities, even field laundries; vermin-free kitchens, chow lines, and living quarters; disinfected latrines; periodic "delousing" whenever appropriate; insect and rodent control; and proper waste disposal.

CULTURAL CHARACTERISTICS

Some large populations are nearly homogeneous, but most mingle majorities and minorities with assorted languages, religions, traditions, customs, mores, likes, dislikes, and life styles that create internal or international tensions. Former Yugoslavia, for example, is a crazy quilt of ethnic, religious, linguistic, and cultural animosities. Serbs, who are Orthodox Christians, and Roman Catholic Croats are the most prominent entities, followed by Slovenes, Slavic Muslims, Albanians, Macedonians, and perhaps 15 smaller groups. Serbo-Croatian is considered one language, although Serbs use the Cyrillic alphabet while Croats prefer Latin letters. Slovene and Macedonian are two other official tongues.[15]

MAJORITIES AND MINORITIES

Heterogeneous nations generally contain *genetically dissimilar* racial stocks and *culturally distinct* ethnic groups that sometimes subdivide into clans or tribes. Table 15 displays representative relationships that commonly are complex. Racial, ethnic, and tribal factions that enjoy a marked quantitative majority do not necessarily dominate, as relatively few European colonists long demonstrated in heavily populated Asian and African countries. Minorities may mesh well (witness the former U.S. "melting pot") or be anathematized (witness the former pogroms against Jews in Europe). Military strategists and tacticians should study racial, ethnic, and tribal connections in assigned areas of responsibility, because root causes of conflict, potentials for escalation, countermeasures, and probabilities of success are situationally specific from place to place and case to case.[16] Racial tensions, for instance, precipitated irreconcilable troubles in Black Africa as long as whites held the upper hand, while religious and cultural factors presently predominate in Bosnia, where all belligerents are essentially Slavic, and in the Middle East where Arabs as well as Israelis are Semitic.

Three waves of racial, ethnic, and tribal conflict have caused incalculable suffering in the 20th century. The first onslaught began shortly before, accompanied, and followed World War I, when Ottoman and Austro-Hungarian rulers lost control. Atrocities against "starving Armenians" were among the most terrible.[17] An anticolonial wave washed across southern Asia and almost all of Africa in the wake of World War II. The third wave hit the Third World wherever weak replacement governments seemed vulnerable or strong ones were repressive. The bloodletting in Biafra (southeastern Nigeria) that pitted powerful Fulani and Hausa tribes against the Ibo minority between 1967 and 1970 took more than a million lives and briefly made banner headlines,[18] as did genocidal operations that the Khmer Rouge

Table 15. *Representative Racial, Ethnic, and Tribal Relationships*

Caucasoid	*Mongoloid*	*Amerind*	*Negroid*	*Australoid*
Nordic Teutonic Gaelic Celtic Slavic Semitic Mediterranean	Chinese Japanese Korean Filipino Indonesian Malayan Inuit	Indians of North America Meso-America South America Aleuts	Bantu Nilotic Bushmen Hottentot	Melanesian Micronesian Polynesian Aborigine

Race	*Ethnic Groups*	*Tribes*
Caucasoid	Russian Belorussian Ukrainian Polish Czech Slovak Croat Serb Macedonian Bulgarian	N/A
Amerind	Arctic, Sub-Arctic Northwest Pacific West, Southwest Intermountain, Plateau Eastern Woodlands Southeast Plains	 Arapaho Blackfoot Comanche Shoshone Dakota Sioux

conducted against city dwellers in Cambodia (1975-1979).[19] Former Yugoslavia caught fire a few years after Tito's death, largely because successors were unable to keep the lid on ancient animosities. Other collisions traceable to racial, ethnic, or tribal rivalries have occurred since 1990 in hot spots such as Peru, Rwanda, Somalia, Sudan, and Liberia. Motivations include communal violence, various abuses, secessionist movements, irredentism, actions to retrieve lost territory, and hypersensitivity, often in combination.[20]

LANGUAGES

Linguistic cohesion tends to solidify societies whereas fragmentation pulls them apart. Small wonder, therefore, that inability to communicate effectively often leads to armed conflict. Nine language families currently exist: Indo-European (Slavic, Germanic, Romance, Iranic,

Indic); Hamito-Semetic; Altai; Niger-Congo; Malayo-Polynesian; Uraic; Sino-Tibetan; Austro-Asiatic; and a miscellaneous family that includes Aborigine, Amerind, Dravidian, Eskimoan, Khoisan, Nilo-Saharan, Paleosiberian, Papuan, and Tai. Perhaps 6,000 tongues were recognizable at the end of the 20th century, of which only a dozen boasted more than a hundred million speakers (table 16).[21]

Many lesser languages at that time numbered a few million to a few thousand adherents (a few hundred for some primitive tribes), sometimes clustered so tightly that they form "shatter zones" similar to the Caucasus, where 51 languages persist in an area roughly the size of Florida (table 17).[22] Russian troops deployed to keep that volatile region under control found it hard to communicate effectively with the local populace. Native Americans (mainly Navaho "Code Talkers") transmitted messages in their arcane languages during World War II, confusing enemy cryptologists, to whom Amerind variants were unfamiliar.[23]

Armed forces deployed in foreign countries must be able to participate in peacetime training with indigenous troops, interrogate prisoners of war, eavesdrop electronically on enemies, communicate with refugees, and interact with coalition partners. U.S. Special Forces reasonably fluent in Arabic accompanied more than 100 Middle Eastern formations during the Persian Gulf War of 1991 to facilitate coordination with English speaking units on their flanks, arrange U.S. artillery and air strikes, and reduce the likelihood of casualties from "friendly fire."[24] Textbook command of any language seldom is sufficient, because dialects, slang, local idioms, and argot abound, along with arcane military lingo. Figures of speech moreover are subject to frequent change—few in the United States still refer to marijuana as "grass" or police as "pigs," although "flower children" and "hippies" found both terms fashionable in the 1960s. Pidgin, which is popular in the South Pacific, rules out all but the most rudimentary conversations. Military "visitors" in foreign lands find reading and writing less important than spoken words wherever most people are illiterate or semiliterate.

U.S. citizens as a rule are reluctant linguists, partly because many officials, shop keepers, and hotel employees in foreign lands understand English, which additionally is the official language of NATO and air traffic controllers everywhere. Needs for expertise in Native American tongues are next to negligible throughout Latin America, where most people speak Spanish, except for Brazil where Portuguese takes precedence—although Quechua, which is common in Columbia, Peru, and Equador comes in handy for armed forces engaged in counternarcotics operations.

Proficiency in foreign languages nevertheless is useful in most places. U.S. Central Command currently covers 16 countries in northeast Africa and southwest Asia, plus Afghanistan and Pakistan, where Arabic, Farsi, Urdu, Pashtu, Dari, Amharic, Somali, and Swahili prevail. U.S. Pacific Command's area of responsibility, which embraces East Asia, most of the Indian subcontinent, Australia, and adjacent islands, contains 30 million people who speak 18 main languages and countless dialects. Strict priorities based on the best possible requirement forecasts are essential, because no command could possibly muster enough well-qualified linguists for every occasion (only 16 U.S. military linguists on active duty had studied Iraqi dialects before Saddam Hussein invaded Kuwait in 1990). Somali speakers were in such short supply when Operation *Restore Hope* erupted in December 1992 that warlord Mohammed Farah Aideed's son, a U.S. Marine corporal, served as a translator until his presence became impolitic. Foreign language specialists, produced at great expense in time and money, consequently should be considered prized possessions.[25]

Table 16. ***Ten Leading Languages (1990s)***

Family	*Language*	*Millions*	*Concentrations*
Sino-Tibetan	Mandarin Chinese	806	China, Taiwan, Singapore
Indo-European	English	426	United States, British Commonwealth, former British colonies
Indo-European	Hindi	313	Northern India
Indo-European	Spanish	308	Spain, most of Latin America, Southwest United States
Indo-European	Russian	210	Former Soviet Union
Hamito-Semitic	Arabic	182	Mid East, North Africa
Indo-European	Bengali	175	Bangladesh, Eastern India
Indo-European	Portuguese	166	Portugal, Brazil,
Malayo-Polynesian	Indonesian	132	Angola, Mozambique, Indonesia
Altaic	Japanese	123	Japan
Indo-European	German	118	Germany, Austria, Switzerland, Luxembourg, France, Northern Italy
Indo-European	French	115	France, Belgium, Switzerland, Québec, New Brunswick, former French and Belgian colonies

Source: L. Luca Cavalli-Sforza, ed., *The History and Geography of Human Genes* (Princeton, NJ: Princeton University Press, 1994), 162.

Table 17. ***Linguistic Clutter in the Caucasus***

Abaza	Bagvalai	Ginukh	Kubachi	Russian
Abkhaz	Balkar	Godoberi	Kumyk	Svan
Adygey	Batsbi	Greek	Kryz	Tabasaran
Agul	Bezhita	Hunzib	Kurdish	Talysh
Akhwakh	Botlikh	Ingush	Lak	Tat
Andi	Budukh	Karadray	Lezgi	Tindi
Archi	Chamalai	Karata	Mingrelian	Tsakhursez
Armenian	Chechen	Khaidaq	Nogay	Turkmen
Avar	Dargwa	Khinalug	Ossetian	Udi
Azerbaijan	Georgian	Khwarshi	Rutul	Ukranian

RELIGIONS

Judaism, Christianity, and Islam, which first appeared in that sequence, constitute "global religions" whose adherents spread far beyond their original regions. Buddhism, Taoism, Confucianism, and Shinto are confined largely to East Asia, Hindus and Sikhs concentrate in India, and various traditional religions (ancestor worship, animism, shamanism, and voodoo) are most prominent among Haitians and in Black Africa (table 18).[26]

Table 18. *Principal Religions and Selected Denominations*

Christianity (1.7 billion)	*Islam (1+ billion)*	*Judaism (13 million)*
Roman Catholic Orthodox Protestant	Sunni Shiite	Orthodox Reform Conservative

Mainly East Asian Religions	*Mainly Indian Religions*	*Traditional Religions*
Buddhism (300 million) Taoism Confucianism Shinto	Hinduism (700 million) Sikh (16 million)	Ancestor Worship Animism Shamanism Voodoo

Every religion tends to unify its followers, whereas "we against the world" syndromes tend to tear societies apart whenever they pit gentiles against Jews, Muslims against infidels, Christians against pagans, and "true believers" against agnostics.[27] Religious conflicts in fact can be incredibly cruel. Christian Crusaders between 1095 and 1270 were just as merciless toward nonconformists close to home as they were toward Muslims in the Holy Land. When Simon IV de Montfort asked the emissary of Pope Innocent III how he might identify heretics in the French city of Béziers the response was, "Kill them all. God will know his own."[28] The Thirty Years' War, which devastated Western Europe between 1618 and 1648, began as a Roman Catholic backlash against the Protestant Reformation in Germany.[29] Christian officers employed by the British East India Company in Bengal precipitated the Sepoy Mutiny of 1857 through failure to respect religious taboos—newly issued Enfield rifles furnished the catalyst, because indigenous troops had to bite paper cartridges that allegedly were greased with fat from cattle, which Hindus consider sacred, and fat from swine, which Muslims consider unclean.[30] British General Charles "Chinese" Gordon later crushed the theocratic Taiping Rebellion in China, but not before 20 million people perished between 1850 and 1864. Sudanese dervishes devoted to Muhammad Ahmad Ibn Assayyid, a self-proclaimed Mahdi (messiah) who sought to "purify" Islam, inflicted widespread casualties and slew Gordon two decades later before reinforcements reconquered Khartoum.[31]

One need not delve so deeply into the past to discover religious atrocities with profound military implications:[32]

- Peacekeepers must separate Christian Greeks from Islamic Turks on Cyprus, Jews from Muslims in the Sinai, and Muslims from Christians in Bosnia.
- Christian Armenians and Azerbaijani Muslims cannot seem to coexist in the Caucasus.
- Buddhist Sinhalese and Hindu Tamils in Sri Lanka profess little interest in peace.

- Interdenominational disputes spill blood by the barrel in Northern Ireland, where Catholics and Protestants are at each other's throats, and in Iraq where President Saddam Hussein prompts the Sunni majority to slaughter Shiite minorities.
- Religious warfare repeatedly desecrates hallowed grounds: hundreds have perished at the Sikh's Golden Temple in the Punjab; rioting at the temple where Rama reportedly was born left 2,000 Hindus and Muslims dead in 1992; and Jews battled Palestinians on Jerusalem's Temple Mount in 1996.

Military commanders and staffs who overlook religious traditions and temperaments risk wrong moves in at least two regards. First, they may inadvertently offend friends and neutrals who might mistakenly interpret their behavior as intentional disrespect (U.S. troops in Saudi Arabia abstain from alcoholic beverages because Islam forbids imbibement). Second, they may miss opportunities to exploit religious practices. Egyptian troops, for example, caught Israeli defenders flatfooted when they crossed the Suez Canal in 1973, because the attack not only coincided with Yom Kippur, a Jewish high holy day, but occurred during the month of Ramadan, which Muslims normally reserve for fasting and prayer.[33] North Vietnamese soldiers and their Viet Cong accomplices took similar advantage the following year when they triggered the Tet offensive while lunar New Year festivities with religious overtones were in full swing south of the demilitarized zone.[34]

CURRENT ATTITUDES

Moods of the masses play a pivotal role in political-military affairs, regardless of the size, distribution, density, and cultural characteristics of any population. Loyalties, morale, temperaments of the moment (aggressive, pacific, neutral, apathetic), discipline, laws, ethics, and values all are relevant.

LOYALTIES

Armed forces that hope to influence friendly, enemy, or neutral populations favorably in peacetime as well as war must understand where primary loyalties lie, because nations, regions, races, religious preferences, ethnic groups, tribes, political parties, social castes, and other affiliations may stake first claim when interests conflict and the chips are down. Communism currently dominates in North Korea, Canadians of French extraction cling to their ethnic heritage, and Somalis coalesce around clans. Predilections, moreover, may change over time. Stephen Decatur's stirring words, "Our country . . . may she always be right; but our country right or wrong" currently resonate less in the United States than they did when delivered in 1816. Allegiances, in short, strongly condition popular responses to external stimuli and strengthen tendencies to solidify or crack under pressure.

MORALE

General George C. Marshall, speaking at Trinity College in Hartford, Connecticut, on June 15, 1941, described public morale as

> a state of mind. It is steadfastness, courage and hope. It is confidence and zeal and loyalty. It is élan, esprit de corps, and determination. It is staying power, the spirit which endures

to the end—the will to win. With it, all things are possible, without it everything else, planning, preparation, production count for naught.

Leadership, discipline, community ties, and group self-respect commonly buttress morale. So can pain and privation coupled with steadfast belief in a worthy cause, provided they encourage civilians as well as uniformed personnel to produce more, consume less, and stand fast in desperate situations. That happened during the Battle of Britain in 1940, later in Leningrad, Stalingrad, and Berlin, and later still in heavily populated parts of Vietnam, where courage persisted despite a rain of bombs. Fascist Italy, in contrast, capitulated early in World War II because the urge to compete expired.[35]

Moods of the masses may be consistent or vacillate from liberal to conservative, hawkish to dovish, idealistic to realistic, rational to irrational. Shifting opinions sometimes create a pendulum effect similar to that experienced by the United States during the Vietnam War: indifference in the early 1960s; avid involvement in the mid-1960s; disillusionment in the late 1960s; and return to indifference after the last U.S. ground forces withdrew in 1972. Political-military leaders attuned to such trends are best able to exploit resultant enemy weaknesses and limit their own vulnerabilities.

MORAL AND LEGAL CONSTRAINTS

Legal, ethical, and moral codes of conduct designed to limit the way armed forces wage war were nearly nonexistent in olden times, when life belonged to the meat eaters. Every man, woman, and child, male or female, young or old, combatant or bystander who owed allegiance to or merely resided in rival territory was an enemy to be eradicated. Triumphant troops commonly slaughtered prisoners of war or sold them into slavery. Entire civilizations disappeared. Bloodthirsty Assyrians under Sennacherib obliterated Babylon in 689 B.C. Medes and Chaldeans shortly thereafter sacked Ninevah, the Assyrian capital, and sowed the site with salt.

Tighter ground rules apply today. Most nations, in principle if not in practice, approve controls contained in two Hague Conventions (1899, 1907), as well as the Geneva Conventions of 1864, 1906, 1929, and 1949, which, taken together, distinguish between uniformed combatants and bystanders, proscribe inhumane techniques, and prescribe humane treatment of POWs.[36] Dictators, firm in their conviction that might makes right, routinely match ends with military means as they see fit without much regard for legality, but leaders in free societies seldom can conduct sizable military operations for any purpose without the consent or passive acquiescence of people they represent. Fingers on the public pulse at home and abroad consequently can furnish useful clues concerning courses of action that either or both sides might adopt or discard.

NATIONAL PERSONALITIES

Political scientists eternally debate degrees to which (even whether) any nation possesses a collective "personality" that military planners and operators can safely include in their calculations. Disputants might well apply similar arguments to large racial and ethnic groups within any given society.

One school of thought insists that national personalities not only set peoples apart and condition the way they behave but strongly resist change. Patience, stoicism, and dogmatic devotion to the homeland, for example, remained dominant Russian attributes despite huge upheavals that wracked national institutions and values at every level of life after Communist dictators replaced tsars in 1917 and again after *glasnost* (openness) and *perestroika* (restructuring) programs started to transform that closed society in the late 1980s. Cambodians as a society consider themselves to be warriors, whereas Lowland Laotians, their next door neighbors, are gentle; many in mortal combat seek to scare off enemy spirits with near misses rather than shots aimed to kill. Disciples of this school, who contend that nearly every nation displays equally distinctive characteristics, see Germans as group-oriented, industrious, disciplined, and amenable to governmental authority while U.S. citizenry, in contrast, is individualistic, innovative, violent, generous, gullible, and protective of personal rights.[37]

A second school scoffs at these generalizations as stereotypes, challenges the permanence of national personality traits, and cites historical examples to support its contentions.[38] The German General Staff, headed by Prussian generals who prided themselves on "a genius for war" for 200 years, disappeared after World War II.[39] Japan, which long honored *Bushido* (the way of Samurai warriors), still subscribes to a 1946 Constitution that renounces war forever.[40] U.S. sentiments switched from isolationism in the 1930s to international involvement the following decade and have remained so ever since. Consistency, in short, is less characteristic than change, according to skeptics.

Spokespersons for school three see a middle ground. Different peoples, they assert, *do* "tend to be more like each other than they are like members of any other nation," members of a given culture *do* "tend to respond in similar ways," cultural pressures *will* "impose a more or less common direction on individual differences and mitigate them to some extent," and "large areas of near uniformity" *will* emerge.[41] Thoughtful statesmen and military commanders who seek to reconcile ambiguities tread carefully, because none of those three schools seems entirely correct or erroneous.

CROSS-CULTURAL SKILLS

Military personnel who work closely with counterparts in foreign countries must be familiar with local folkways and possess cross-cultural communication skills that include reasonable fluency in prevalent languages and dialects, plus reading and writing abilities wherever their contacts are literate.

FAMILIARITY WITH FOLKWAYS

Familiarity with folkways takes precedence over familiarity with foreign languages. Cogent considerations cover a broad spectrum that includes traditions, customs, values, motivations, hopes, fears, and taboos; religious beliefs; rites, rituals, and holidays; manners and mannerisms; behavior; social hierarchies; lines of authority; relationships between men and women; moral codes and sexual mores; work ethics, competition versus cooperation, and punctuality; views about bribes and official corruption; and dietary regimes.[42]

Dealings with unfamiliar cultures demand patience, self-control, abilities to cope with frustration, and tolerance for unfamiliar ways of life. An excerpt from instructions in *Saudi*

Arabia: A Soldier's Guide, which the United States Army issued to troops during Operation *Desert Storm*, illustrates items that, properly modified, might apply almost anywhere:

Greetings

DO—

- Shake hands when you meet and leave Arab men
- Rise to show respect when an esteemed person enters the room
- Feel free to return a hug or a kiss on the cheek initiated by an Arab man

Working with Arabs

DO—

- Train officers and enlisted men separately if possible
- Refer any serious problems to an Arab leader

DON'T—

- Criticize an Arab. Give corrective guidance privately and positively, if required
- Overpraise an Arab in front of others
- Lose your temper
- Expect Arabs to be punctual for administrative meetings

Conversation

DO—

- Open conversation with small talk (How are you? How is your family?)
- Talk to Arabs as equals; avoid arguments; maintain eye contact
- Look for subtle meanings, since Arabs often answer questions indirectly

DON'T—

- Initiate talk about politics, religion, or ask questions about female family members
- Patronize or talk down to an Arab
- Move away from an Arab who stands very close to you during conversation
- Point the soles of your feet at an Arab when you are sitting with him (it is insulting).[43]

FOREIGN AREA SPECIALISTS

Senior military staffs, attachés, foreign liaison cells, teams that train troops in foreign countries, psychological operations (PSYOP) forces, and civil affairs units all require foreign area specialists, because none can perform assigned missions most professionally without full appreciation for cultural contexts.

Military instructors, advisers, and mobile training teams, who need to know about foreign political peculiarities, pecking orders, and "eccentric" social practices, find that no amount of schooling and second-hand accounts can prepare them as well as onsite assignments. There is, in fact, no substitute for close association with people on the spot, where local leaders and the led possess assorted personalities, pursue personal or group agendas, and often as not live in separate worlds, segregated by rank, age, sex, color, education, and class barriers.

PSYOP specialists seek to influence the opinions, emotions, attitudes, and behavior of friends, neutrals, and enemies in ways that assist the accomplishment of national, international, or intranational objectives before, during, and after hostilities. They must master many political, economic, cultural, and topical subjects before they can tailor campaigns, themes, and messages that muster and maintain the attention of any given group and refute countermeasures, because each foreign audience has different interests,

predispositions, vulnerabilities, and susceptibilities to various persuasions. Otherwise, they could only guess what pictures and colors on PSYOP leaflets might appeal to particular audiences and which would repel or be received derisively.[44]

Civil Affairs (CA) forces also covet cross-cultural skills, without which they cannot most competently arrange the acquisition of indigenous labor, transportation, communications, supplies, other resources, and miscellaneous services for use by armed forces in foreign lands; minimize civilian interference with military operations (refugee control is one related concern); help military commanders fulfill legal/moral obligations to civilians within assigned areas of responsibility; and, as directed, exercise executive, legislative, and judicial authority in occupied territories. U.S. CA units, in collaboration with Arab counterparts, performed most of those missions when they directed the delivery of emergency food, water, and medical supplies to Kuwait City on liberation day in 1991, then helped the Government of Kuwait restore health, sanitation, transportation, and electrical facilities, repair utilities, reestablish police forces, and extinguish fires in neighboring oil fields.[45]

FAMILIARITY WITH FOREIGN LANGUAGES

Culturally attuned foreign area specialists need a reasonable command of the language(s) and dialect(s) prevalent where they perform. They sometimes can rely on a substitute tongue such as English, French, or pidgin, but abilities to communicate in the local vernacular gain much greater respect (a senior Japanese official once said to the author, "I expect to speak English when I'm in the United States, but I'm outraged when I must speak English to U.S. emissaries in my own country"). Conversational fluency moreover expands contacts immeasurably among citizens who are not bilingual. Face-to-face communications are most effective if presenters have a good feel for preferred tones of voice, emphases, inflections, and delivery speeds. Appropriate facial expressions and gestures also differ considerably from culture to culture. Americans who form a circle with thumb and forefinger, for example, signal "OK," whereas Greeks consider that gesture impolite and Brazilians believe it is obscene. The same sign signifies money in Japan and zero in France.[46]

Foreign area specialists who lack linguistic skills must employ interpreters, even though that practice is less than completely satisfactory under best case circumstances. Cockneys, Scots, Cajuns, and Connecticut Yankees all speak English, but unique accents, regional dialects, and colloquialisms make it hard for them to understand each other. Problems compound when messages filter through the minds, value systems, and lips of third parties who may have ulterior motives and hidden agendas. Interpreters cannot transmit *meanings* along with *words* unless their competence includes military jargon and technical terms as well as local patois. Those with impeccable linguistic credentials moreover must conform well with cultural prejudices and caste systems, lest audiences pay more attention to who he or she is rather than what is said. Women, for example, make poor choices in societies where their status is low. Enlisted interpreters offend military officers in many countries, while commissioned interpreters tend to intimidate enlisted trainees and thereby impede learning processes.[47]

Finally, it seems worth noting that foreign area specialists who can read and write as well as speak local languages learn much more about cultures and current events than those who cannot. Their capabilities and usefulness to assigned commands increase commensurately.

KEY POINTS

- "Know your enemy and know yourself" is a military imperative, not a military cliché. Sun Tzu might have added, "Know your friends and coalition partners" as well.
- Racial, ethnic, religious, and tribal animosities often cause wars and resist peacemaking efforts.
- Demographers predict population explosions in underdeveloped regions where overcrowding already creates dangerous unrest.
- Diseases can cause more casualties than combat actions unless armed forces are immunized appropriately and emphasize sanitation, especially in the tropics.
- Military plans and operations consequently benefit immensely from advice and assistance concerning population patterns, languages, religious preferences, cultures, customs, and social structures in present or projected areas of operation.
- Commanders and staffs in search of "force multipliers" should seek foreign area specialists who possess cross-cultural skills that are strategically and tactically valuable across the complete spectrum from peacetime to full-scale war.

NOTES

1. *Selected Works of Mao Tse-Tung* (London: Lawrence and Wishart, 1954-1956); Ralph L. Powell, "Maoist Military Doctrine," *Asian Survey* (April 1968): 240-243.
2. Sun Tzu, *The Art of War*, ed. and trans. Samuel B. Griffith (New York: Oxford University Press,1963), 84.
3. "What on Earth," *Washington Post*, July 20, 1996, A21.
4. *Population Statistics* (Tel Aviv, Israel: Central Bureau of Statistics, Israeli Foreign Ministry, September 11, 1996).
5. Willard Waller, ed., *War in the Twentieth Century* (New York: Random House, 1940), 92-93; *A Military History of World War II*, T. Dodson Stamps and Vincent J. Esposito, eds., *Operations in the European Theaters*, vol. 1 (West Point, New York: U.S. Military Academy, 1953), 669.
6. Edward Meade Earle, ed., *Makers of Modern Strategy: Military Thought from Machiavelli to Hitler* (Princeton, NJ: Princeton University Press, 1943), 388-400, 408, 506; John Tolland, *The Rising Sun: The Decline and Fall of the Japanese Empire* (New York: Random House, 1970), 3-53; Gordon Prange, *At Dawn We Slept* (New York: McGraw-Hill, 1981), 4-5,100-101, 169-170, 449.
7. Charles A. Webster, *Population Growth: Major Threat to the Next Generation of Peace*, (Washington, DC: Strategic Research Group, National War College, June 11, 1973), 1-7.
8. Eugene Kinkead, *In Every War But One* (New York: W. W. Norton, 1959), 15-16; official statistics, U.S. Defense Intelligence Agency, furnished telephonically, September 25, 1996.
9. Wayne O. Evans and James E. Hansen, "Troop Performance at High Altitudes," *Army* (February 1966): 55-58.
10. Melvyn C. Goldstein, *A History of Modern Tibet, 1913-1951: The Demise of the Lamaist State* (Berkeley, CA: University of California Press, 1989).
11. Richard F. Cronin and Barbara Ann LePoer, *The Kashmir Dispute: Historical Background to the Current Struggle*, Report No. 91-563F9 (Washington, DC: Congressional Research Service, July 1991).
12. P. Choudhuri, *9 Gurkha Rifles: A Regimental History, 1817-1947* (New Delhi, India: Vision Books, 1984); Bryon Farwell, *The Gurkhas* (New York: W. W. Norton, 1984).
13. *Disease Threats in the Middle East: Preventive Strategies for the 101st Airborne Division (Air Assault)* (Fort Campbell, KY: 101st Airborne Division Preventive Medicine Activity, 1982), 1; L.

Dudley Stamp, *The Geography of Life and Death* (Ithaca, New York: Cornell University Press, 1964), especially chapters I-V.

14. *Disease and Environmental Alert Reports* (Washington, DC: Armed Forces Medical Intelligence Center and Defense Intelligence Agency, March 1992); Kenneth F. Kiple, ed., *The Cambridge World History of Human Disease* (New York: Cambridge University Press, 1993); Robert Parsons, "Tracking Down Tropical Diseases," *Army Digest* (June 1970): 42-44; B. Denise Hawkins, "Plan OK'd to Give Troops Anthrax Shots," *Army Times*, October 21, 1996, 8.

15. Charles Sudetic, "The Society and Its Environment," in *Yugoslavia: A Country Study*, 3rd ed., ed. Glenn E. Curtis (Washington, DC: Federal Research Division, Library of Congress, 1992), 69-88.

16. Ted Robert Gurr, "Ethnic Warfare and the Changing Priorities of Global Security," *Mediterranean Quarterly* (Winter 1990): 82-98.

17. Gerard Chaliand and Yves Ternon, *The Armenians from Genocide to Resistance* (Totowa, NJ: Zed, 1984).

18. John J. Stremlau, *The International Politics of the Nigerian Civil War, 1967-1970* (Princeton, NJ: Princeton University Press, 1977).

19. Niyan Chanda, *Brother Enemy* (San Diego, CA: Harcourt Brace Jovanovich, 1986).

20. William A. Stofft and Gary L. Guertner, *Ethnic Conflicts: Implications for the Army of the Future* (Carlisle Barracks, PA: Army War College, March 14, 1994), 1-10.

21. L. Luca Cavalli-Sforza et al., eds., *The History and Geography of Human Genes* (Princeton, NJ: Princeton University Press, 1994), 160-164; Bernard Comrie, "Language," *Microsoft Encarta 97 Encyclopedia*.

22. Mike Edwards, "The Fractured Caucasus," *National Geographic* (February 1996): 130-131.

23. Margaret T. Bixler, *Winds of Freedom: The Story of the Navaho Code Talkers of World War II* (New York: Two Bytes Publishing Co., 1992).

24. *Conduct of the Persian Gulf War: Final Report to Congress* (Washington, DC: Dept. of Defense, 1992), 20-21; David Evans, "An Impressive—Yet Troubling—Marine on Duty in Somalia," *Chicago Tribune*, January 8, 1993, 23.

25. John M. Collins, *Special Operations Forces: An Assessment* (Washington, DC: National Defense University Press, 1994), 85, 88, 89, 129-130.

26. Edward Geoffrey Parrinder, *World Religions: From Ancient History to the Present* (New York: Facts on File, 1984); Niels Christian Nielsen, *Religions of the World* (New York: St. Martin's Press, 1983; updated by Alan Wilson Watts, "Religion," *Microsoft Encarta 96 Encyclopedia*.

27. Henry O. Thompson, *World Religions in Peace and War* (Jefferson, NC: McFarland and Co., 1988).

28. Terry Jones and Alan Ereira, *Crusades* (New York: Facts on File, 1995); Amin Maalouf, *The Crusades Through Arab Eyes*, trans. Jon Rothchild (New York: Schocken Books, 1984).

29. Geoffrey Parker, ed., *The Thirty Years' War* (New York: Military Heritage Press, 1987).

30. Christopher Hibbert, *The Great MutiNew York: India 1857* (London: Allan Lane, 1978).

31. Charles Chenevix Trench, *The Road to Khartoum: A Life of General Charles Gordon* (New York: W. W. Norton, 1979).

32. James A. Haught, *Holy Hatred: Religious Conflicts of the 1990s* (Amherst, New York: Prometheus Books, 1995); Robin Wright, *Sacred Rage: The Wrath of Militant Islam* (New York: Linden Press/Simon and Schuster, 1985); Barton Gellman, "Palestinians, Israeli Police Battle on Sacred Ground," *Washington Post*, September 28, 1996, 1, A22.

33. Saad Shazly, *The Crossing of Suez* (San Francisco, CA: American Mideast Research, 1980).

34. Don Oberdorfer, *Tet* (New York: Da Capo Press, 1984).

35. Hans J. Morgenthau, *Politics Among Nations*, 4th ed. (New York: Alfred A. Knopf, 1967), 129-131; A. F. K. Organski, *World Politics*, 2nd ed. (New York: Alfred A. Knopf, 1968), 184-189.

36. See especially *Hague Convention No. IV: International Convention Concerning the Laws and Customs of War on Land*, October 18, 1907; *Geneva Convention Relative to the Treatment of Prisoners of War*, August 12, 1949; *Geneva Convention Relative to the Protection of Civilian Persons in Time of War*, October 12, 1949.

37. Morgenthau, *Politics Among Nations*, 122-129.

38. Organski, *World Politics*, 87-91; Thomas L. Hartshorne, *The Distorted Image: Changing Conceptions of the American Character* (Westport, CT: Greenwood Press, 1968), 1-14.

39. Trevor N. Dupuy, *A Genius for War: The German Army and General Staff, 1807-1945* (Englewood Cliffs, NJ: Prentice-Hall,1977).

40. William Manchester, *American Caesar: Douglas MacArthur, 1880-1964* (Boston: Little, Brown, 1978), 498-501.

41. Hartshorne, *The Distorted Image*, 8.

42. *Interpretive Country Study: Student Outline 5342* (Fort Bragg, NC: U.S. Army John F. Kennedy Special Warfare Center and School Civil Affairs Dept., May 1987; *Cross Cultural Communications: Lesson Outline 3148* (Fort Bragg, NC: U.S. Army John F. Kennedy Special Warfare Center and School, March 1990).

43. *Saudi Arabia: A Soldier's Guide* (Washington, DC: Dept. of the Army, Public Affairs Office, undated) (September 1990), 12-29.

44. Joint Pub 3-53: *Doctrine for Joint Psychological Operations* (Washington, DC: Office of the Chairman, Joint Chiefs of Staff, July 31, 1993), 1-1, V-2, V-5; FM 33-1: *Psychological Operations* (Washington, DC: Dept. of the Army, February 18, 1993). The August 31, 1979, edition of FM 33-1 is more useful in some respects. See especially chapters 5, 9,and 13.

45. FM 41-10: *Civil Affairs Operations* (Washington, DC: Dept. of the Army, January 11, 1993). The October 20, 1969, edition is more useful in some respects. See especially chapter 2 and appendices E, J.

46. Sidney Shachnow, "Intercultural Communication: The Need for Conceptual Skills," *Special Warfare* (February 1993): 20-22; *Interpersonal Psychological Operations: Lesson Outline and Summary Sheet 3906* (Fort Bragg, NC: U.S. Army John F. Kennedy Special Warfare Center and School, March 1987), LO-2, LO-4, SS-1 through SS-3.

47. Field Circular 21-852: *Teaching Through Interpreters* (Fort Bragg, NC: U.S. Army John F. Kennedy Special Warfare Center and School, January 1984); *Utilization of Interpreters: Lesson Outline 5842* (Fort Bragg, NC: 3d Battalion, Civil Affairs Company, U.S. Army John F. Kennedy Special Warfare Center and School, January 1990).

10. URBANIZATION

No straw for him, no twigs or sticks,
this pig had built his house of BRICKS.
"You'll not get me!" the piggy cried.
"I'll blow you down!" the Wolf replied.
"You'll need," Pig said, "a lot of puff,
and I don't think you've got enough."
Wolf huffed and puffed and blew and blew,
the house stayed up as good as new.
"If I can't blow it down," Wolf said,
"I'll have to blow it up instead."

Roald Dahl
Revolting Rhymes

THE FOREGOING PARODY OF THE *THREE LITTLE PIGS*, WHO RESPECTIVELY BUILT THEIR HOUSES OF STRAW, sticks, and bricks, applies to urban combat on a grander scale. Some hamlets, villages, towns, and cities are more difficult to seize and secure than others if inhabitants strongly resist, but modern munitions can quickly reduce the best built settlements to rubble. Rational reasons to blow cities up or down, however, have been scarce for 2,500 years, since Sun Tzu proclaimed that, "The worst policy is to attack cities."[1] Aggressors who do so deprive themselves of valuable assets, defenders who do so destroy precious possessions, and well-meaning friends who do so wound their allies. The anonymous U.S. Army major who blurted, "It became necessary to destroy the town [of Ben Tre, South Vietnam] to save it" spouted nonsense.[2] Urban combat moreover disrupts unit cohesion, complicates control, blunts offensive momentum, and causes casualties to soar on both sides.

Most military doctrines the world over consequently advise land force commanders to isolate or bypass built-up areas, but the subjugation of political, industrial, commercial, transportation, and communication centers even so may sometimes decisively affect the outcome of battles, campaigns, even wars. Military commanders in such events face an endless variety of structures and facilities the seizure or control of which demands esoteric plans, programs, and procedures, since no two cities are quite alike. Urbanization moreover plays an imperative part in peacekeeping and humanitarian operations as well as deterrent strategies that hold cities hostage[3] and war fighting strategies that seek to break the will of stubborn enemies by bombing them back into the Stone Age.[4]

SITES AND STRUCTURES

Urbanization, for purposes of this appraisal, connotes plots of land where population densities equal or exceed 1,000 persons per square mile (about 3 square kilometers) and buildings average at least one on every 2 acres. That definition embraces small towns and suburbia as well as cities of assorted sizes and shapes, close together or widely separated, superimposed upon flat, rolling, or rough topography. The mixture of manmade and natural features generally is more complex than sparsely inhabited deserts, swamps, and jungles, which contain fewer distinctive terrain features.

TOWN AND CITY CONFIGURATIONS

Some towns and cities emphasize governmental affairs, physical security, industries, commerce, business, or services, while others accommodate two or more primary functions. Every agglomeration is uniquely configured with regard to horizontal and vertical dimensions, structures, building materials, street patterns, access routes, bypasses, parks, recreational facilities, rural enclaves in otherwise urban settings, and undeveloped lands (table 19). Original layouts occasionally remain intact over long periods of time but often expand willy-nilly in response to new needs. Urban centers in North America and Western Europe toward the end of the 20th century, for example, tend toward lower average population densities per square mile as municipalities expand, more freestanding construction as opposed to solid blocks, greater use of glass, fewer buildings with basements, and a dearth of subways in suburbia where private automobiles abound.[5]

Urban environments consequently differ drastically in several militarily relevant respects. Castles, cathedrals and solid medieval buildings flush with narrow, crooked streets mark the midst of many European cities, whereas downtown Washington, DC, features construction astride a wide, rectangular mall that runs for 3 miles (5 kilometers) from Capitol Hill to the Lincoln Memorial. Affluent suburbanites sometimes encircle metropoli loaded with slums, shantytowns elsewhere surround prosperous inner cities, and the rich mayhap mingle with poor. Building designs and materials reflect urban functions, available resources, climatic conditions, and cultural proclivities. Construction in heavily forested parts of frigid Siberia favors lumber, easily obtained adobe is popular in relatively warm, arid regions, and structures elsewhere variously emphasize reeds, sod, reinforced concrete, or stone. Assorted street patterns also are observable (figure 29). Main thoroughfares run the gamut from unpaved threadneedle alleys to broad, hard-surfaced avenues abutted by open spaces that not only permit two-way traffic several lanes abreast but allow off-the-road vehicular movement.[6]

UTILITIES, FACILITIES, AND SERVICES

Modern towns and cities could not perform major functions or sustain present standards of living without lights, power, electricity, food, and potable water, together with supply, storage, distribution, maintenance, and waste disposal systems. Community life would slow to a crawl or stop if denied public transportation, police, fire departments, hospitals, telephones, and news media (newspapers, radio, television).

Table 19. *Variable Town and City Components*

Functions	*Building Construction*	*Street Characteristics*	*Utilities, Facilities*	*Access Routes*
Governmental	Single Story	Wide	Electricity	Roads
Industrial	Multistory	Narrow	Gas	Railways
Commercial	High Rise	Straight	Food, Water	Airports
Transportation		Winding	Waste Disposal	Seaports
Educational	Brick			
Residential	Stone	Paved	Telephones	
	Wood	Unpaved	Newspapers	
	Metal		Radios	
	Adobe	Radial	Televisions	
	Glass	Radial Ring		
	Concrete	Checkerboard	Bulk Storage	
		Irregular	POL Storage	
	Dense		Maintenance	
	Random		Hospitals	
	Orderly			
	Dispersed		Hotels, Motels	
			Schools	
			Barracks	
			Open Spaces	
			Subways	
			Trolleys	
			Buses	
			Taxicabs	
			Ferries	

Engineers, logisticians, and civic action forces are intensely interested in the current condition of urban infrastructure, restoration requirements in wartime, total capacities, and percentages that could be diverted for military use without dangerously depriving civilian inhabitants. Typical considerations include:

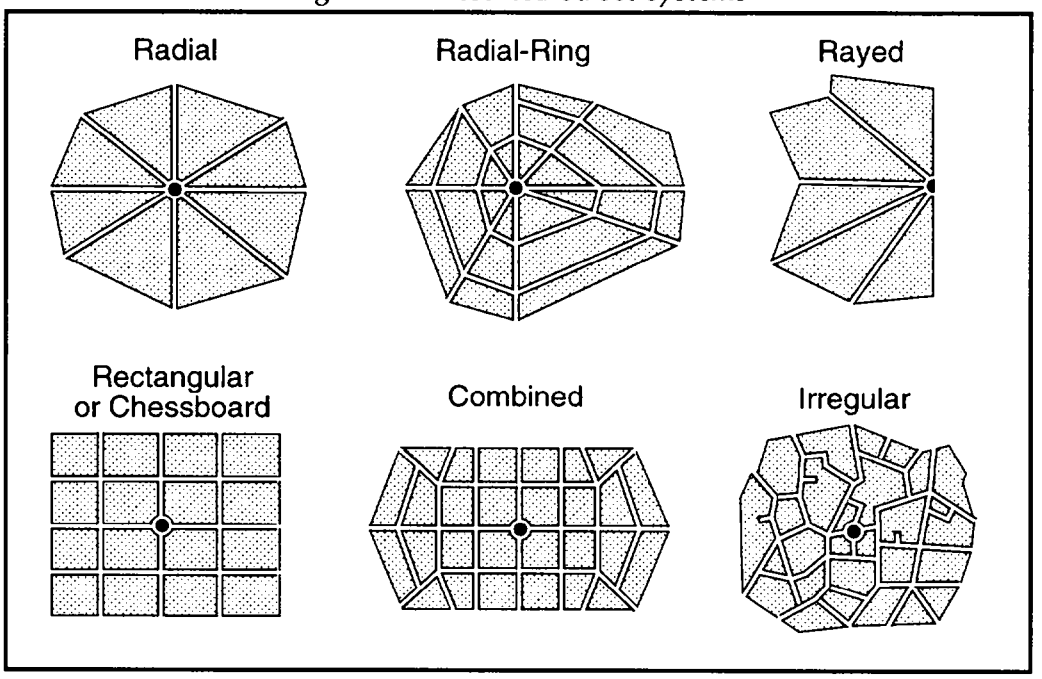
- The number, type, and capacities of water purification plants, reservoirs, and aqueducts
- Garbage, trash, sewage, and industrial waste collection, dumps, incinerators, and processing facilities
- Food processing plants and bakeries
- The number of hospitals by type, plus numbers of beds
- Electrical power, gas, and central heating plants, along with distribution lines
- Open, covered, and cold storage, POL tanks, arsenals, and ammunition dumps
- Public transportation facilities, including conveyances, parking lots, car barns, garages, and repair shops

- Potential military billets (hotels, motels, schools, churches, barracks, auditoriums, parks, and other open spaces)
- Historical and cultural landmarks to be preserved
- Recreational facilities, such as cinemas, gymnasiums, stadiums, and swimming pools.

URBAN SPRAWL

Half of all people on Planet Earth live in urban communities, but that number will reach two-thirds by 2025 if expectations prove correct. Forecasters predict that more than 40 cities then will exceed 10 million residents, of which Europe, the United States, and Canada will contribute only two—New York and Los Angeles (table 20). Each complex covers far more area than forerunners did during the Middle Ages, when most centers generally consisted of a castle surrounded by shacks on a few acres, whereas Los Angeles within its incorporated limits occupied almost 500 square miles (1,300 square kilometers) in 1997.[8]

Figure 29. ***Assorted Street Systems***



Mighty cities moreover are coalescing to form enormous urban walls in many places on all continents save Africa and Australia. Seoul, which has swollen from 1.1 to more than 11 million since war erupted in 1950, included most of the lower Han River valley as far west as Inchon in 1997 and was swallowing Suwon to the south. The Ruhr and Rhine-Main complexes stretch almost 200 miles (320 kilometers) from Bonn to the Hook of Holland and continue to spread while Frankfurt-am-Main, Darmstadt, Mainz, Mannheim, Karlsruhe, Hanau, and Stuttgart are starting to form one megalopolis. Loosely linked villages, towns, and small cities a mile or two apart are common.[9] The same could be said for the U.S. eastern seaboard from Boston, MA, through New York City, Newark, NJ, Philadelphia, PA, Washington, DC, and Norfolk, VA.

Table 20. *Present and Projected Megalopoli*
(more than 10 million inhabitants; boldface indicates more than 20 million)

1995		*2015*			
Tokyo	**26.8**	**Tokyo**	**28.7**	Manila	14.7
Sao Paulo	16.4	**Bombay**	**27.4**	Cairo	14.5
NewYork	16.3	**Lagos**	**24.4**	Los Angeles	14.3
Mexico City	15.6	**Shanghai**	**23.4**	Seoul	13.1
Bombay	15.1	**Jakarta**	**21.2**	Buenos Aires	12.4
Shanghai	15.1	**Sao Paulo**	**20.8**	Istanbul	12.3
Los Angeles	12.4	**Karachi**	**20.6**	Rio de Janeiro	11.6
Beijing	12.4	Beijing	19.4	Lahore	10.8
Calcutta	11.7	Dhaka	19.0	Hyderabad	10.7
Seoul	11.6	Mexico City	18.8	Osaka	10.6
Jakarta	11.5	New Delhi	17.5	Bangkok	10.6
Buenos Aires	10.9	New York	17.6	Lima	10.5
Tianjin	10.7	Calcutta	17.6	Teheran	10.2
Osaka	10.6	Tianjin	17.0		
Lagos	10.3				

Urban obstacles would seriously constrain 21st century adaptations of General Count Alfred von Schlieffen's grand plan to sweep across the North German Plain through Holland and Belgium into France.[10] Blitzkriegs would be difficult to sustain and secure supply lines hard to maintain under such conditions. Rapid movement through suburbs seems feasible at first glance, because population densities are low and structural impediments few compared with urban cores, but urban sprawl sooner rather than later probably will impose barriers and chop high-speed avenues into short segments.[11]

CONVENTIONAL URBAN COMBAT

Conventional urban combat began perhaps 6,000 years before Joshua assailed Jericho and "the walls forthwith fell down" between 1300 and 1200 B.C.[12] Three options are open to present day policymakers whenever armed forces cannot bypass cities because so doing seems geographically infeasible, politically improvident, or militarily imprudent: they can spare selected centers if attackers and defenders *both* agree; attackers can lay siege while defenders try to survive; or attackers can try to seize control from opponents in possession.

OPEN CITIES

Defeat in olden days was a life or death crapshoot for city dwellers who never could be certain whether fate would be kind or cruel if they capitulated quietly, because winners ordinarily took as many liberties as they liked. Benevolence was a rare exception to that rule. "Open city" declarations that deliberately preserve urban areas for political, economic, military, aesthetic, or humanitarian reasons remain few, and degrees of success differ considerably.

Hitler permitted Field Marshal Albert Kesselring to vacate Rome on June 3, 1944, largely because that ancient city was the capital of his Italian ally, Benito Mussolini; it housed the Vatican, which was revered by Bavarian Catholics; and historical treasures therein were irreplaceable. German forces streamed out, and Allied troops who streamed in the next day found that all key bridges over the Tiber River as well as other valuable structures were still standing. Triumphant generals assembled fearlessly for photo opportunities at Piazza de Campidoglio on Capitoline Hill.[13]

French Commander in Chief General Maxime Weygand officially declared Paris an open city on May 11, 1940, after sporadic fighting. Victorious Germans took possession peacefully three days later, but low-key opposition continually marred their 4-year occupation.[14] Hitler personally designated General Dietrich von Choltitz as fortress commander when Allied divisions neared Paris in August 1944, vested him with full powers of a *Befehlshaber* (commander in chief), and directed him to ruin that symbol of French resistance. His hand-picked destroyer, however, refused to comply and, in direct defiance of *der Führer's* orders, implicitly designated Paris an open city. Sharp clashes occurred, but that action by General von Choltitz saved the heart and soul of France.[15]

Manila fared less well the following year when General Douglas MacArthur made good on his promise to return. Japanese General Tomoyuki Yamashita informally declared the Philippine capital an open city and planned to evacuate all but a handful of stay-behind forces in January 1945, but diehards under Rear Admiral Sanji Iwabuchi refused to obey his orders. Fierce battles raged until March 3, by which time more than 17,000 military men on both sides and 100,000 civilians lay dead (nearly 15 percent of the population); thousands more had been seriously wounded, and Manila's ancient walled center along with everything in it had been torn to shreds.[16]

SIEGES

Sieges involve prolonged military blockades that isolate cities until supplies run out, attackers breach defenses, reinforcements break the ring, or morale cracks and occupants surrender. Partial encirclements, however lengthy, fail to satisfy that definition if the defenders never are isolated from essential sources of sustenance.

Siegecraft was popular well into the 19th century when most cities still were rather small, artillery was primitive by present standards, bombers had not yet been invented, and patience was a virtue.[17] Those circumstances, however, no longer pertain. Few modern military commanders currently seem anxious to instigate sieges, even if competing missions and time permit, and few of their civilian supervisors seem willing to pay the political and economic costs of "sedentary" confrontations with no end in sight.

Some dramatic exceptions nevertheless have occurred in relatively recent times. Most of them, typified by the siege of Singapore (1941-42), featured desperate efforts to fend off enemy armed forces.[18] German General of the Airborne Forces Bernhart-Hermann Ramcke won Hitler's highest decoration, the Knights Cross with Oak Leaves, Swords, and Diamonds, for his brilliant defense of port facilities at Brest, France, which U.S. VIII Corps isolated and battered from August 12, 1944, until the one-division garrison capitulated on September 20.[19] The most horrific siege in history took place at Leningrad, where more than a million civilians (one-third of the population) became battle casualties, froze, starved to death, or died of disease between September 1941 and January 1944. Survival instinct provided the strongest

possible incentive to persist because, as local Communist Party chief Andrei Zhdanov bluntly explained, "The working class of Leningrad [would] be turned into slaves, and the best of them exterminated" if Nazi representatives of the "Master Race" overran their city.[20]

Besiegers with time to burn may invest urban centers without expending bullets or bombs to see how well-armed opponents might respond to pressure. Stalin did so in 1948-49, when he ordered Soviet and satellite forces to block all roads and rail lines into politically combustible Berlin, which lay deep in East Germany, 120 miles (195 kilometers) from the nearest friendly frontier. The United States, which then possessed the world's only nuclear weapons, might have threatened to use them but elected instead to mount a massive airlift that supplied Berlin with food, fuel, and other essentials for 11 months until the disgruntled Generalissimo backed down rather than risk a ruinous war.[21]

STREET FIGHTING

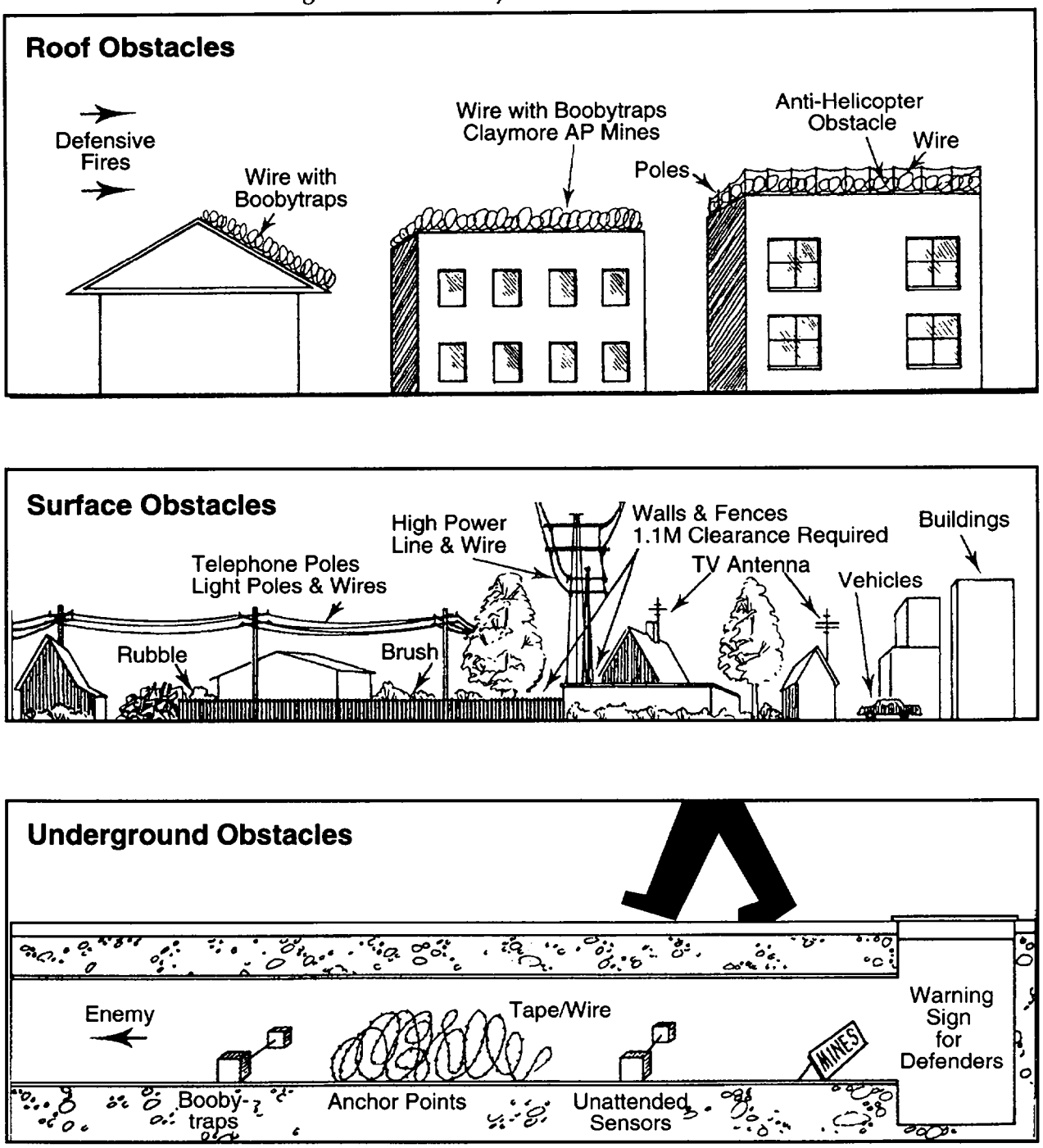
Street fighting ensues whenever armed forces try to wrest urbanized terrain from stubborn defenders. It can be brutal but brief in villages and a lengthy, agonizing struggle between small, isolated units in cities where concrete canyons and culs-de-sac degrade technological advantages, severely limit vehicular mobility, render tactical communications unreliable, complicate intelligence collection, and swallow troops wholesale. Restrictive rules of engagement designed to reduce collateral damage and casualties may further decease benefits obtainable from aerial firepower as well as artillery and magnify dependence on foot soldiers.[22]

Urban Avenues and Obstacles. Street fighting problems are similar regardless of locale, as battles for Stalingrad (1942-43),[23] Seoul (which changed hands four times between June 1950 and March 1951),[24] and Hué (1968)[25] bear witness. Motorized troops must stick to streets and open spaces, whereas infantrymen fight three-dimensional wars at ground level, on rooftops, and in subterranean structures such as subways, sewers, and cellars, creeping over, under, or around each structure, blasting "mouseholes" through walls, ceilings, and floors when more convenient avenues are unavailable. Mines, booby traps, barbed wire, road blocks, rubble, and other obstacles abound (figure 30).

Every inner city building becomes a potential strong point, particularly those that overlook key intersections or open spaces.[26] Clear fields of fire for flat-trajectory weapons seldom exceed 200 yards (185 meters) even in suburbs, where ornamental shrubbery and sweeping curves often limit lines-of-sight. One lucky French gunner at the Arc de Triomphe may have established a world's record during urban combat in August 1944 when, with a first-round hit, he defanged a German Panther tank 1,800 meters (more than a mile) away at the opposite end of the Champs-Elysées.[27]

Armored Firepower. Tanks and other armored vehicles inch through inner cities at a snail's pace, find little room to maneuver on narrow or rubble-clogged streets, cannot turn sharp corners, and are vulnerable beneath enemy-occupied buildings unless they "button up," which limits visibility and invites ambush. Many lucrative targets remain beyond reach, because most range-finders produce fuzzy images close up, tank turrets cannot swivel freely in cramped quarters, and main guns on level ground can neither elevate nor depress enough to blast upper stories or basements nearby. Tank-killer teams armed with short-range weapons commonly seek sanctuaries in resultant "dead spaces," from which they can attack soft spots such as gas tanks and treads with relative impunity. Conventional urban combat

Figure 30. *Three Layers of Urban Obstacles*



consequently calls for few rather than many tanks, mainly to furnish close support for front-line infantry.[28] Exceptions to that rule normally involve opponents in disarray or other special circumstances, as demonstrated on August 25, 1944, when French General Jacques-Philippe Leclerc's 2d Armored Division led Allied liberators into Paris.[29]

Artillery. Urban jungles, like their leafy analogs, discourage artillery. Chemical warfare (CW) munitions in one sense are well suited, since they can seep into crannies, retain required concentrations longer than CW strikes in the open, and neutralize opponents without damaging structures, but inimical consequences could ensue if lethal chemicals caused mass casualties among friendly civilians. The effects of high explosives are easier to control, although detonations are hard to adjust in densely populated areas and buildings reduced to rubble provide better protection for enemy troops than those left standing. High-angle artillery fire in urban areas thus is often used mainly to clear rooftops and target troops in the open while mortars, which are more maneuverable and less destructive, handle most close support missions. Medium and heavy artillery projectiles, however, perform superbly at low angles and pointblank range, as the senior German general in Aachen discovered on October 21, 1944. He waved a white flag as soon as the first U.S.155mm shell hit his command center, with the wry comment, "It's time to quit when artillerymen turn into snipers."[30]

Recoilless and Wire-Guided Weapons. Urban combat inhibits lighter crew-served arms as well. Backblast makes it dangerous to emplace recoilless weapons in small, unvented rooms or other cramped spaces where loose objects, glass, and combustible materials must be covered or removed. Enclosures so amplify explosive sounds that personnel without earplugs become deaf after a few experiences. Minimum feasible ranges and limited abilities to elevate or depress launchers severely restrict the utility of wire-guided missile systems in towns and cities, where such obstructions and entanglements as buildings, rubble, walls, fences, trees, brush, telephone poles, power lines, and television antennas are abundant (see center diagram of figure 30). Firing positions on roofs or in lofty rooms allow clearer fields of fire than sites at street level, but long-range shots even so are scarce.[31]

COMBAT SERVICE SUPPORT

Logistical requirements in cities differ significantly from those in open terrain. The dearth of vehicular traffic reduces petroleum consumption, except for engineer and power generating equipment. Reliance on artillery munitions declines as well, although troops in compensation expend prodigious amounts of small arms ammunition, machine gun bullets, hand grenades, mortar shells, and plastic explosives. They also wear out weapons, equipment, and uniforms at abnormally rapid rates. Route clearance is a high priority task that requires bulldozers wherever offensive forces find rubble in the way, whereas defenders demand materials with which to build barriers. Both sides use sandbags to shore up positions in and around buildings.[32]

Commanders in densely populated centers often must divert military supplies, other resources, and manpower to sustain life among noncombatants, who need food, water, and some sort of shelter along with medical assistance for the sick and wounded. Early control over endemic diseases and septic threats becomes doubly important if civilian health and sanitation systems break down. Stringent security measures, such as identification cards, curfews, restricted areas, restraining lines, checkpoints, and road blocks, may be required to

prevent pilferage, looting, and actions that interfere with military operations. Refugee control can assume immense proportions if panic-stricken civilians, young and old, many of them infirm, pour out of cities by the thousands on foot and aboard automobiles, bicycles, horse-drawn wagons, ox carts, or baby carriages, together with all possessions they can possibly carry (General "Lightning Joe" Collins never forgot one elderly Korean man who, during the first exodus from Seoul in 1950, carried on his back an A-frame laden with rice bags "atop which sat his wizened old mother").[33]

RESEARCH AND DEVELOPMENT

Military trappings intended primarily for use in wide open spaces are liabilities in cities, where short-range weapons are more valuable than those with long reaches and inexpensive, durable, or disposable items are preferable to costly accouterments. Ready markets consequently await innovators, as the following samples suggest.

Tank guns and artillery would be more useful if higher and lower angles of fire were feasible. All armored vehicles engaged in urban warfare would benefit from sprint capabilities, greater all-round visibility, and better protection for soft spots that are particularly vulnerable during close combat. Richer defensive suites, increased agility, and stealthiness would help helicopters survive at window level between high-rise buildings. Sensors able to "see" around corners and in pitch black sewers would be infinitely more advantageous than those that rely on ambient light. Engineers need the wherewithal to raze multistory structures on short notice without undesirable collateral damage.[34]

Several categories of nonlethal weapons, exemplified by adhesives ("stickums"), anti-traction substances ("slickums"), thermal barriers, foams, calmatives, and odiferous agents, perhaps could reduce fatalities among belligerents as well as noncombatants and limit unplanned damage to urban property.[35] Street fighters also would welcome wheeled, tracked, and walking robots, remotely controlled or with artificially intelligent computers for brains that could operate for long periods without sustenance or sleep and remain emotionless under fire. Assorted automatons, each with specialized skills, could reconnoiter, spearhead attacks, clear obstacles, breach minefields, and perform other hot, heavy, hazardous, humdrum, or repetitious (H^4R) missions.[36]

UNCONVENTIONAL URBAN COMBAT

Ingenious insurgents, resistance movements, and transnational terrorists thrive in labyrinthine cityscapes that amplify their capabilities and frustrate technologically superior adversaries who find it difficult to acquire timely, accurate intelligence and quickly discover that conventional military tactics are marginally useful in urban games of "cat and mouse."

REVOLUTIONARY UPRISINGS

"People's wars," as expounded by Mao Zedong, Ché Guevara, and Vo Nguyen Giap, are mass insurrections that open primarily in rural areas and work their way toward cities. Urban insurgencies, which take a different tack, start in cities where most people reside and, if successful, pay off faster.

Recipes for Urban Revolutions. French General P.-G. Cluséret penned the original recipe for urban revolutions in his *Memoires* of 1887, which Lenin adapted in 1905 and published in the Bolshevik newspaper *Vperid*. Hit or hold real estate, he advised, because

ruling classes "will sell any government you like, in order to protect their property." Paralyze police stations at the onset, seize buildings that command key intersections, blow up or burn down whatever cannot be captured, block subterranean approaches, build barricades, cut telephone lines, disable utilities, and strike before dawn while most cities sleep.[37]

Carlos Marighella, an aging Brazilian firebrand who authored the *Minimanual of the Urban Guerrilla*, emphasized how easy it is for revolutionaries familiar with streets, alleys, byways, impasses, straits, shortcuts, parks, underground passageways, and other peculiarities of their own city to move surreptitiously, appear by surprise, strike with impunity, then fade away like specters. "It is an insoluble problem for the police," he asserted, "to get someone they can't see, to repress someone they can't catch, to close in on someone they can't find."[38]

Rhetoric Versus Results. Correlations between the foregoing rhetoric and real-life results are tenuous. The Russian Revolution of 1917, which involved brief, spontaneous uprisings in Petrograd (now Saint Petersburg), developed overtly without recourse to serious violence, ousted Tsar Nicholas II, and terminated 300 years of Romanov rule. Geographic factors scarcely influenced that cataclysmic upheaval, which would have achieved all objectives if neither General Cluséret nor Lenin had ever written a word.[39] The 7-year Algerian struggle for independence from France (November 1954 to March 1962), which was well-planned and protracted, proceeded in a very different vein. Climactic actions took place in crooked corridors of the Casbah, where 80,000 wretched souls were cheek to jowl on 75 isolated acres. The revolutionary Front de Libération Nationale (FLN), which hit public buildings, police posts, communication centers, cafes, and shops, made all the right moves according to Cluséret and Marighella. French troops savagely suppressed passive supporters along with active participants, but ultimately lost the war because President Charles de Gaulle saw no way to keep a tight lid on the cauldron indefinitely.[40] The influence of geography on urban uprisings, in short, varies radically from time to time and place to place.

RESISTANCE MOVEMENTS

Resistance movements, as contrasted with revolutionary uprisings, aim to evict occupying powers, "puppet" regimes, or well-meaning domestic meddlers whose intrusion they resent. Those who make best use of urban terrain invariably fare better than those who do not, even if they lose.

The handful of heroes in Berlin who attacked Soviet tanks with Molotov cocktails and stones (1953)[41] and Hungarian freedom fighters who battled in Budapest 3 years later[42] were quickly outclassed, whereas unconventional urban brawlers armed with antiquated weapons were formidable in Somalia, despite unfavorable odds. Wily warlord Aideed's lightly armed militia ambushed unwelcome Pakistani peacemakers under a U.N. banner in Mogadishu on June 5, 1993, killed 25, wounded 53, and escaped unscathed. U.S. Special Operations Forces captured several of his lieutenants on October 3, but the ensuing fire-fight caused 91 serious casualities on the U.S. side (18 dead) and mangled maybe 1,500 Somalis. The resultant U.N. military "victory" became a major psychological defeat. President Clinton, in response to adverse public opinion at home and abroad, soon withdrew all U.S. Armed Forces from Somalia. Aideed thereafter was free to run his own show without foreign interference.[43]

Sabotage, a more subtle, less risky form of resistance, can pay off handsomely provided personnel involved are well informed about the locations, characteristics, overall values, and vulnerabilities of potential targets. Teams armed with timely, accurate information can

prioritize intelligently, strike targets that promise the most lucrative payoffs, and avoid those that would put sympathizers out of work, deprive them of public utilities, or otherwise impair popular support. Ignorant saboteurs, on the other hand, may do more harm than good, as one feckless French team discovered in a Paris sewer during World War II: its members leveled and flooded more than a city block and left many friends dead or wounded when they detonated a charge to sever telephone service with Berlin, unaware that the lines lay next to gas and water mains.[44]

TRANSNATIONAL TERRORISM

Urban centers are the main milieu of transnational terrorists, whose operations in foreign cities aim to spread panic and cause such turmoil that authorities comply with their sociopolitical demands to avoid further suffering. Atrocities against innocent bystanders make warped sense when seen in that light.

U.S. experience indicates great potential for the escalation of transnational terrorism since one small bomb killed 12 persons at La Guardia Airport in 1975.[45] Suicidal assailants buried 220 U.S. Marines, 18 Navy bluejackets, and 3 U.S. Army soldiers in their barracks on the outskirts of Beirut in 1983.[46] Greater property damage and repercussions followed an enormous explosion that shook New York City's 110-story World Trade Center on February 26, 1993. Perhaps 55,000 employees and thousands of visitors were trapped for hours in pitch black, smoke-filled stairwells; a monstrous traffic jam in lower Manhattan impeded police cars, fire trucks, and ambulances en route to rescue them; many banks, businesses, brokerage houses, law firms, and other tenants were displaced for a month and lost about $1 billion as a direct result; and city police investigated 364 bomb threats during the first 5 days after the blast (5 or 6 per day previously was average).[47] Other potentially lucrative urban targets for consideration by transnational terrorists include air traffic control centers, information storage and transfer sites (computerized banks, commercial houses, and stock exchanges), transportation nodes (airports, bridges, tunnels, switching centers), nuclear reactors, and petrochemical plants. Calamities could ensue if commuter service ceased, ventilating systems failed, and perishable products spoiled.

The President and Secretary of Defense in 1996 consequently issued unusually urgent security directives designed to protect urban infrastructure and occupants against terrorist acts.[48] Those steps came as no surprise, because counterterrorism specialists have not yet devised countermeasures that credibly cover worst case contingencies. They could convert critical installations into fortresses across the country, and U.S. allies could do likewise, but budgets would balloon, mission effectiveness would suffer, and free societies would become less free. Creative solutions consequently are required.

CONVENTIONAL URBAN BOMBARDMENT

Aerial bombardment specialists, who have very different perspectives about urban combat than conventional street fighters and special operations forces, promote two basic options or some combination thereof. Option A emphasizes precision strikes against carefully selected targets, the destruction of which would degrade rival military *capabilities*; Option B stresses conventional carpet bombing designed primarily to break the enemy's *will*.

OPTION A: PRECISION BOMBING

"Smart" weapons first saw combat in 1943, when Luftwaffe dive bombers sank the defecting Italian battleship *Roma* in the Mediterranean Sea, but full appreciation for precision-guided munitions (PGMs) was deferred for three decades until large U.S. laser-guided bombs dropped North Vietnam's Paul Doumer and Thanh Hoa bridges in April 1972, both of which had survived repeated attacks with "dumb" munitions.[49]

Fixed-wing aircraft and helicopters armed with air-to-surface PGMs currently can see and strike point targets with far greater accuracy and far less collateral damage than ever before. Heavier payloads, greater explosive power, and abilities to penetrate far into reinforced steel and concrete structures before detonating further enhance the utility of PGMs wherever enemies mingle civilian populations with militarily valuable assets typified by command/control centers, urban strong points, air defense sites, supply depots, defense industries, power plants, railroad yards, and port facilities. Not every "brilliant" aerial bomb or missile performed as well as advertised against targets in downtown Baghdad during Operation *Desert Storm* (1991),[50] but results were nonetheless impressive, major improvements are under development, and further advances are technologically feasible.

OPTION B: CARPET BOMBING

Italian Brigadier General Guilio Douhet voiced urban carpet bombing concepts in 1911, 8 years after the first powered aircraft flew, and published his contentious views in *Command of the Air* a decade later. He stated unequivocally that the basic objective of war "has always been, still is, and always will be . . . to compel the enemy to bow to one's will," then concluded that "to bend the enemy's will, one must put him in intolerable circumstances; and the best way to do that is to attack directly the defenseless population of his cities and great industrial centers" using chemical warfare (CW) as well as conventional munitions.[51]

Past Practices. Air power proponents exposed Douhet's principles to their most stringent test during World War II. The German Air Force, which took first turn, razed a good deal of Rotterdam on May 14, 1940, under the guiding hand of Reich Marshal Hermann Göring, then began to bomb Liverpool, Bristol, Plymouth, Southhampton, Manchester, Birmingham, and other British cities in September. The prolonged Blitz of London killed 10,000 civilians, left 17,000 badly wounded, and damaged or demolished historic buildings that included parts of Parliament, St. Paul's Cathedral, Old Bailey, and Buckingham Palace between September 1940 and May 1941. V-1 "buzz bombs" and V-2 ballistic missiles subsequently mounted terrorist attacks.[52] Göring's Luftwaffe visited Coventry 17 times before a horrific raid on November 14, 1940, left that charming city in ruins.[53]

The Allies then took their turn. Britain's Bomber Command by night and U.S. Eighth Air Force by day shellacked most major German cities for 2 consecutive years, beginning in 1943. Together they hit Hamburg six times between July 24 and August 3, 1943, with results that recipients called *die Katastrophe*.[54] Berlin looked like a lunar landscape by VE-Day: 50,000 buildings had been destroyed, many more were little more than shells, and resultant rubble conservatively totaled 100 million cubic yards (75 million cubic meters).[55] Beautiful Dresden, famed for baroque and rococo architecture as well as exquisite porcelain figurines, practically disappeared on the night of February 13, 1945, when 135,000 residents, refugees, foreign laborers, and prisoners of war died—more than the combined toll at Hiroshima and Nagasaki after both were atomized.[56]

Low-level U.S. raids against Japan, all at night, slighted high explosives in favor of incendiaries, mainly magnesium, white phosphorus, and jellied gasoline (one bizarre scheme, eventually discarded, proposed dropping millions of bats "armed" with miniature delayed-action flammables [57]). Successes destroyed 40 percent of 66 cities, left almost one-third of Japan's population homeless, and inflicted far more casualties than Japanese Armed Forces suffered during all of World War II. The cataclysmic Tokyo raid of March 9 and 10, 1945, killed 83,000 when high winds among flimsy wooden and rice paper structures whipped up uncontrollable fire storms that one eye witness said looked like paintings of Purgatory. Kobe, Osaka, and Nagoya experienced similar fates that terrible night. Japanese noncombatants felt shock effects many times greater than those that accompanied urban bombing campaigns against Germany, because attacks were concentrated in a much shorter period.[58]

Past Repercussions. Conventional bombing campaigns nevertheless were less rewarding than Douhet and his disciples predicted. Urban bombardment indeed devastated the Third Reich, but "did not so reduce German war production as to have a decisive effect on the outcome of the war," according to the *United States Strategic Bombing Survey*. Resilience was greater than expected, partly because damage to machine tools (as opposed to structures) was slight. Depression, defeatism, and fear were rampant, but apathy made most people amenable to discipline and receptive to Reichminister Joseph Goebbel's propaganda ("Enjoy the war; the peace will be terrible" became a cynical slogan when defeat loomed). Deeply ingrained work ethics coupled with needs for enough deutsche marks to put ersatz food on the table kept most bread winners on the job until the bitter end.[59] Conditions were worse in Japan, where shortages of raw materials crippled war efforts well before U.S. bombers began to batter the home islands. Cottage industries, which were logistical mainstays, closed down completely after workers en masse fled fire storms. National traditions of obedience, conformity, stoicism, and willingness to make sacrifices, however, prevented collapse despite widespread desperation—most men, women, and children who heard Emperor Hirohito's recorded radio broadcast on August 14, 1945, expressed stunned disbelief when he announced that Japan had surrendered.[60]

Future Applicability. Currently available guided missiles and modern bombers that carry huge loads of technologically advanced conventional explosives could ravage cities faster, more efficiently, and with worse effects on enemy morale than World War II weapon systems, which were much more numerous. Lethal chemicals and biological warfare attacks could wipe out poorly defended populations. Carpet bombardment therefore remains a credible course of action for any country that possesses armed forces able to penetrate enemy defenses in sufficient strength. The key question to be resolved thus involves policy decisions concerning conscionability rather than military capabilities.

URBAN CENTERS AND NUCLEAR STRATEGY

The ability of urban centers to resist nuclear bombardment varies considerably with size, configuration, and predominant construction materials, but well-placed weapons in the megaton range could obliterate the biggest, most solidly built with instantaneous shock effects many magnitudes greater than any previously experienced in wartime. Deterrence and defense accordingly have attracted intense attention since August 1945, when the 15-kiloton

Little Boy bomb flattened much of Hiroshima and the 23-kiloton *Fat Man* of different design ravaged Nagasaki 3 days later. [61]

U.S. Policies and Postures. U.S. deterrent strategists emphasized a "balance of terror" after Soviet adversaries acquired nuclear weapons in the early 1960s. Concepts focused on urban targets picked to "ensure the destruction, singly or in combination, of the Soviet Union, Communist China, and the communist satellites." Secretary of Defense Robert S. McNamara assumed that abilities to eradicate "say, one-fifth to one-fourth of [the Soviet] population and one-half of [Soviet] industrial capacity would represent intolerable punishment," and therefore be credibly dissuasive. Efforts to protect U.S. cities received slight attention at that stage, because McNamara believed that power to pulverize aggressors provided the prime deterrent, not "the ability partially to limit damage to ourselves."[62] Homeland defense aspirations resurfaced two decades later with President Reagan's so-called "Star Wars" speech in March 1983,[63] but U.S. and allied cities at the turn of the 21st century nevertheless remain at risk, because adequate ballistic missile defense systems have not yet been fully developed, much less deployed.

Soviet Policies and Postures. Russian leaders assigned a high priority to homeland defense long before Soviet successors sanctified Lenin's saying that "the primary producer of all mankind is the laboring man, the worker. If he survives, we save everything . . . if he dies, so does the State."[64] Soviet ballistic missile defenses, like those of the United States, were limited largely to warning networks, but their air defense apparatus was impressive and stout civil defenses emphasized fallout shelters, hardened facilities, stockpiles, and thorough indoctrination in their use. Elaborate plans to evacuate Soviet cities during intense crises, however, aroused widespread skepticism among Western strategists, who questioned whether logistical capabilities then available could adequately feed, clothe, shelter, and otherwise minister to millions of displaced persons whose homes and places of employment might be leveled during their absence in summertime, much less in subzero winter.[65]

Prospects for City Defense. It is helpful at this point to put past pluses and minuses in perspective. Few cities currently are as well prepared to withstand a nuclear assault as Soviet counterparts were before the Cold War wound down. Ballistic missile defense (BMD) specialists have made immense technological stride since the mid-1980s, but even small nuclear-capable nations will be able to hold urban centers hostage until much better BMD systems have been perfected, purchased, and deployed in adequate quantities.

OVERALL URBAN VULNERABILITIES

Modern metropolises depend on outside sources for food, water, fuel, electricity, and other essential facilities. They also must dispose of garbage, rubbish, and toxic waste materials beyond their borders. Areas of vulnerability consequently include sources of supply and distribution systems far beyond city limits.

KEY POINTS

- Military operations should be tailored to suit particular urban configurations, which differ widely with regard to sizes, shapes, structures, materials, street patterns, and population densities.
- Urban sprawl increasingly creates barriers that restrict military freedom of action in many places on every continent save Africa and Australia.
- Street fighting, a brutal form of warfare, becomes necessary when policymakers designate cities as military objectives or armed forces cannot conveniently bypass.
- Most armed forces that are organized, equipped, and trained for operations in open terrain often are poorly prepared for street fighting, which features small unit infantry actions and severely limits the value of heavy weapons as well as motor vehicles.
- Most armed forces that are organized, equipped, and trained for conventional combat in cities are poorly prepared to cope with elusive urban guerrillas who hit and run.
- The condition of urban utilities and facilities, total capacities, percentages available for military use, and restoration requirements are important logistical matters.
- Military commanders in metropolises commonly must divert precious military resources and manpower to control refugees and sustain noncombatants.
- Aircraft armed with precision-guided munitions generally can see and strike urban targets with far greater accuracy and far less collateral damage than high-angle artillery fire.
- Policymakers should match ends and means appropriately before they approve aerial bombardment of enemy cities using conventional or nuclear weapons.
- Cities cannot survive if enemies sever outside sources of sustenance.

NOTES

1. Sun Tzu, *The Art of War*, ed. and trans. Samuel B. Griffith (New York: Oxford University Press, 1963, 78).
2. Associated Press dispatch, *New York Times*, February 8, 1968, 14.
3. Albert Wohlstetter, "The Delicate Balance of Terror," in *Problems of National Strategy*, ed. Henry A. Kissinger (New York: Praeger, 1965, 34-58).
4. Curtis E. LeMay, *Mission With LeMay: My Story* (Garden City, New York: Doubleday, 1965), 565.
5. FM 5-33: *Terrain Analysis* (Washington, DC: Dept. of the Army, July 1990), 2-1 through 2-3; B. Bruce-Briggs, "Suburban Warfare," *Military Review* 54, no. 6 (June 1974): 8-9.
6. FM 90-10: *Military Operations on Urbanized Terrain* (Washington, DC: Dept. of the Army, August 15, 1979), 1-4 and 1-5; FM 30-10: *Terrain Analysis*, March 27, 1972, 112-113, 116-117 (superseded by FM 5-33, same title, July 1990, but contains better information about urbanization); Patrick O'Sullivan, *Terrain and Tactics* (New York: Greenwood Press, 1991), 147.
7. FM 30-10: *Terrain Analysis*, March 27, 1972, 115-117. For detailed outlines, see *National Intelligence Survey*, section 25, Urban Areas and Supplement IV, Urban Areas, available in the Defense Intelligence Agency classified library.
8. "Mega Cities," *Washington Post*, June 8, 1996, A17; Lewis Mumford, *The City in History: Its Origins, Transformations, and Its Prospects* (New York: Harcourt-Brace, 1968).
9. B. Bruce-Briggs, "Suburban Warfare," 4-5; FM 90-10: *Military Operations on Urbanized Terrain*, 1-2 and 1-3.

10. Trevor N. Dupuy, *A Genius for War: The German Army and General Staff, 1807-1945* (Englewood Cliffs, NJ: Prentice-Hall, 1977), 130-145.

11. Paul Bracken, "Urban Sprawl and NATO Defense," *Survival* (November/December 1976): 254-260; John W. Burbery, "Perspectives and Patterns," *Military Review* 58, no. 3 (March 1978): 3-10. For rebuttals to FM 90-10: *Military Operations on Urbanized Terrain*, 1-6 through 1-10, and B. Bruce-Briggs, "Suburban Warfare," 9-10. Also see Patrick O'Sullivan, "Military Analysis of Urban Terrain," *The Professional Geographer* (August 1986): 286-290.

12. *The Holy Bible*, Book of Joshua, Chapter VI; Yigal Yadin, *The Art of Warfare in Biblical Lands*, vol. 1 (Norwich, England: Jarrold and Sons, 1963), 16-24, 32-35.

13. Martin Blumenson, *Mark Clark* (New York: Congdon and Weed, 1984), 213-216.

14. Alistair Horne, *To Lose a Battle: France, 1940* (Boston: Little, Brown, 1969), 94, 381-394, 561-564, 573. Open city declared, 562.

15. Larry Collins and Dominique Lapierre, *Is Paris Burning?* (New York: Pocket Books, 1965), 25-29, 79-80, 195-197, 275-280, 301-303, 316-320.

16. Rafael Steinberg, *Return to the Philippines* (New York: Time-Life Books, 1979), 107, 114-121, 134-149.

17. Christopher Duffy, *Siege Warfare: The Fortress in the Early Modern World, 1494-1660* (London, Routledge and Kegan Paul, 1979), and *Fire and Stone: The Science of Fortress Warfare, 1660-1860* (London, David and Charles, 1975).

18. J. Bowyer Bell, *Besieged: Seven Cities Under Siege* (New York: Chilton Books, 1966).

19. Rudolf Böhmler and Werner Haupt, *The German Paratroops, 1939-1945*, rev. ed. (New Malden, Surrey, United Kingdom: Altmark Publishing, 1971), 218-220, 224-225.

20. Leon Gouré, *The Siege of Leningrad* (Stanford, CA: Stanford University Press, 1962). For Zhadnov's quotation, see Alexander Werth, *Russia At War, 1941-1945* (New York: E. P. Dutton and Co. 1964), 305.

21. Ann and John Tusa, *The Berlin Airlift* (New York: Athenium, 1988); Avi Shalaim, *The United States and the Berlin Blockade, 1948-1949: A Study in Crisis Decision-Making* (Berkeley, CA: University of California Press, 1983).

22. John W. Hendrix, "A Perspective on Military Operations on Urban Terrain," *Infantry* (November-December 1995): 1-2; T. R. Milton, Jr., "Urban Operations: Future War," *Military Review* 74, no. 2 (February 1994): 37-46.

23. V. E. Tarrant, *Stalingrad: The Anatomy of an Agony* (New York: Hippocene Books, 1992).

24. Roy E. Appleman, *South to the Naktong, North to the Yalu (June 1950-November 1950)* (Washington, DC: Dept. of the Army, Office of the Chief of Military History, 1961), 30-36, 515-541; Billy C. Mossman, *Ebb and Flow, November 1950-July 1951* (Washington, DC: Dept. of the Army, Center of Military History), 192-208, 328-330.

25. Keith William Nolan, *Battle for Hué: Tet, 1968* (Novato, CA: Presidio Press, 1983).

26. FM 90-10: *Military Operations on Urbanized Terrain*, appendices A, C-E; C. N. Donnelly, "Soviet Techniques for Combat in Built-up Areas," *Military Review* (November 1977): 37-48; Patrick O'Sullivan and Jesse W. Miller, Jr., *The Geography of Warfare* (New York: St. Martin's Press, 1983), 131-135; Bruce-Briggs, "Suburban Warfare," 8-10.

27. O'Sullivan, *Terrain and Tactics*, 141-146; Collins and Lapierre, *Is Paris Burning?*, 309-310.

28. Adolf Carlson, "Tanks in Urban Combat," *Armor* (March-April 1981): 30-31, 33-35; FM 90-10: *Military Operations on Urbanized Terrain*, F-1.

29. Collins and Lapierre, *Is Paris Burning?*, 281-368.

30. Carlson, "Tanks in Urban Combat," 31-32, 35-36; FM 90-10, 4-1 through 4-3, 4-7 and 4-8, B-10, C-1

31. FM 90-10, B-6 through B-10.

32. Ibid., 5-2 through 5-5.

33. Ibid., 1-10, 5-1, 5-5 through 5-8; J. Lawton Collins, *War in Peacetime: The History and Lessons of Korea* (New York: Houghton Mifflin, 1969), 109.

34. Ralph Peters, "Our Soldiers, Their Cities," *Parameters* 26, no. 1 (Spring 1996): 43-50; Hendrix, "A Perspective on Military Operations in Urban Terrain," 2.

35. John L. Barry, et al., *Nonlethal Military Means: New Leverage for a New Era* (Cambridge, MA: Harvard University, John F. Kennedy School of Government, 1994); *Nonlethal Technologies: Military Options and Implications* (New York: Council on Foreign Relations, 1995).

36. Carl Paul Drev Dahl, "Mobile Robotics Will Serve Many Roles in Future Land Warfare," *Defense Systems Review* (November 1983): 13-17; Charles J. Garvey and James J. Richardson, "Robotics Find Application in Ground Warfare," *Military Electronics/Countermeasures* (March 1983): 85-91.

37. T. P. Featherstone, "A Communist Primer on Street Fighting," with "Street Fighting," by P.-G. Cluséret, *Journal of the Royal United Services Institute* 117, no. 1 (March 1972): 57-60.

38. Carlos Marighella, *Minimanual of the Urban Guerrilla* (Vancouver, Canada: Pulp Press, 1974).

39. Richard Pipes, *The Russian Revolution* (New York: Alfred A. Knopf, 1990).

40. Alistair Horne, *A Savage Peace: Algeria 1954-1962* (New York: Viking, 1978); Franz Fanon, *The Wretched of the Earth* (New York: Grove Press, 1965).

41. Wolfgang H. Kraus, "East Germany (June 1953)," in *Challenge and Response in Internal Conflict*, vol. 2, The Experience in Europe and The Middle East, eds. D. M. Condit, Bert H. Cooper, Jr., et al. (Washington, DC: Center for Research in Social Systems, American University, March 1967), 457-496.

42. Richard Lettis and William E. Morris, *The Hungarian Revolt, October 23-November 4, 1956* (New York: Scribner, 1961).

43. Senator Warner and Senator Levin, memo to Senator Thurmond and Senator Nunn, Review of Circumstances Surrounding the Ranger Raid on October 3-4, 1993 in Mogadishu, Somalia, September 29, 1995. Mark Bowden, "Blackhawk Down," *Philadelphia Inquirer*, 29 chapters serialized between November 16 and December 14, 1997.

44. Andrew R. Molnar, et al., DA Pamphlet 550-104: *Human Factors Considerations of Undergrounds in Insurgencies* (Washington, DC: SORO, American University, Dept. of the Army, September 1966), 220-221; William Powell, *The Anarchist Cookbook* (New York: Stuart Press, 1971).

45. *Facts on File Yearbook, 1975* (New York: Facts on File, 1976), 1028.

46. *Report of the DoD Commission on Beirut International Airport Terrorist Act, October 23, 1983*, The Long Report (Washington, DC: Dept. of Defense, December 20, 1983); Clyde R. Mark, *Marine Security in Beirut; A Comparison of the House Armed Services Committee and Long Commission Reports* (Washington, DC: Congressional Research Service, January 9, 1984).

47. Robert D. McFadden, "Blast Hits Trade Center, Bomb Suspected; 5 Killed, Thousands Flee Smoke in Towers," *New York Times*, February 27, 1993, 1, 22 (related reports on 1, 22-24); Alison Mitchell, "Businesses Try to Carry on After Trade Center Blast," *New York Times*, March 1, 1993, 1, B6 (related articles on 1, B4-B6); Peter Marks, "Hope Turning Dim on Fast Reopening for Trade Center," *New York Times*, March 3, 1993, 1, B6 (related articles on B6-B7).

48. Executive Order 13010: *Critical Infrastructure Protection*, July 15, 1996, in *Federal Register*, part 3, The President, July 17, 1996, 37347-37350, followed by *Critical Foundations: Protecting America's Infrastructures*, Report of the President's Commission on Critical Infrastructure Protection, Washington, DC, October 1997; Secretary of Defense William Perry, *Force Protection*, Report to the President and Congress on the Protection of U.S. Forces Deployed Abroad, September 16, 1996. Annex A is the *Force Protection Assessment of USCENTCOM AOR and Khobar Towers* (Report of the Downing Assessment Task Force), August 30, 1996.

49. David R. Mets, *The Quest for a Surgical Strike* (Eglin AFB, FL: Air Force Systems Command Monograph, Armament Division, 1987).

50. *Operation* Desert Storm*: Evaluation of the Air War,* GAO/PEMD-96-10, Report to Congressional Requesters (Senator Pryor, Representative Dingell) (Washington, DC: U.S. General Accounting Office, July 1996); Eliot Cohen, "A Bad Rap on High Tech: The GAO's Misguided Missile Against Gulf War Weaponry," *Washington Post,* July 19, 1996, 15.

51. Guilio Douhet, *Command of the Air,* trans. Dino Ferrari for the Office of Air Force History (Washington, DC: Government Printing Office, 1983); quotations are on 277, 282.

52. Philip Ziegler, *London at War, 1939-1945* (New York: Alfred Knopf, 1995).

53. Allan W. Kurki, *Operation Moonlight Sonata: The German Raid on Coventry* (Westport, CT: Praeger, 1995).

54. Martin Middlebrook, *The Battle of Hamburg* (New York: Charles Scribner's Sons, 1981).

55. "Berlin," *Encarta 96 Encyclopedia.*

56. David Irving, *The Destruction of Dresden* (New York: Holt, Rinehart and Winston,1963). Kurt Vonnegut, who was present as a POW, subsequently penned an antiwar novel, *Slaughterhouse Five* (New York: Delacorte Press, 1969).

57. Jack Couffer, *Bat Bomb: World War II's Other Secret Weapon* (Austin, TX: University of Texas Press, 1992).

58. *The United States Strategic Bombing Survey* (USSBS), vols. 7 and 10, part 3 (New York: Garland Publishing, 1976), 15-20.

59. USSBS, vol. 2 and vol. 4; Bernard Brodie, *Strategy in the Missile Age* (Princeton, NJ: Princeton University Press, 1959), 120-124, 131-138.

60. USSBS, vol. 7 and vol. 9

61. USSBS, vol. 7; *Little Boy* and *Fat Man* bomb data are contained in Chuck Hansen, *U.S. Nuclear Weapons: The Secret History* (New York: Orion Books, 1988), 11, 14, 21.

62. Robert S. McNamara, *Statement on the Fiscal Year 1969-1973 Defense Program and the 1969 Defense Budget,* January 22, 1968, 41-76, with quotes on 47, 50. Also, his *Statement on the 1968-1972 Defense Program and 1968 Defense Budget,* January 23, 1967, 38-39.

63. "President's Speech on Military Spending and a New Defense," *New York Times,* March 24, 1983, 20. For related compilations, see Dept. of Defense *Current News,* Special Edition, part 1, May 4, 1983, part 2, May 5, 1983, and a *Current News* series, "Strategic Defense Initiative," August 14 and 23, September 26, October 25, November 29, 1984, and January 3, February 7, 1985.

64. V. I. Lenin, *Complete Collected Works,* vol. 38, 5th ed. (Moscow: Political Literature Publishing House, 1958), 359.

65. P. T. Yegorov et al., *Civil Defense: A Soviet View* (undated), and N. M. Titov et al., eds. and trans., *Civil Defense,* July 1975, Oak Ridge National Laboratory; Leon Gouré, *War Survival in Soviet Strategy* (Miami, FL: Center for Advanced International Studies, University of Miami, 1976). For skepticism, see Fred M.. Kaplan, "The Soviet Civil Defense Myth," *Bulletin of the Atomic Scientists,* part 1 (March 1978): 14-20, and part 2 (April 1978): 41-66.

11. LINES OF COMMUNICATION

The Moving Finger writes:
and having writ,
Moves on; nor all Piety
nor Wit
Shall lure it back to cancel
half a line,
Nor all thy Tears wash out
a Word of it.

Rubáiyát of Omar Khayyam
Edward Fitzgerald's Translation

OMAR THE TENTMAKER EMPHASIZED THE IMPORTANCE OF IRRETRIEVABLE TIME THROUGHOUT HIS *RUBÁIYÁT*. So do seasoned military commanders, who know full well that a few minutes often spell the difference between military success and failure, victory and defeat. They therefore strive to make best use of land, sea, air, and space lines of communication (LOCs) that link nations with essential resources, connect military theaters of operation, facilitate support for deployed armed forces, simplify their movement from present positions at Point A to points of decision at B, C, and D, then enable formations to maneuver most effectively after arrival.[1] Assured access to essential LOCs is crucially important, because large modern armed forces, unlike their predecessors, cannot live off the land. Commanders and staffs at every level consequently need intimate knowledge about the current status of roads, railways, seaports, airfields, inland waterways, and pipelines that facilitate fluid military operations and simplify logistical support. The capabilities, limitations, and vulnerabilities of primary routes attract constant attention, with particular concern for bottlenecks, bypasses, maintenance requirements, and possibilities for new construction.

ROADS

Militarily useful roads probably predate the first chariots, which Egyptian Pharaohs imported from Caanan early in the 15th century B.C. Twenty-nine turnpikes that totaled about 50,000 miles (80,000 kilometers) later radiated from ancient Rome to every conquered province. Adolph Hitler built multilane *Autobahns* in the 1930s to shift armed forces rapidly from one front to another, and the value of overland routes since then has in no way diminished.

ROUTE RECONNAISSANCE

Lieutenant General George S. Patton, Jr., read *The Norman Conquest* before his Third Army entered France in 1944, "paying particular attention to the roads William the Conqueror used in his operations in Normandy and Brittany." Lessons learned informed him of medieval thoroughfares that had to be on solid ground and therefore promised easy bypassing if the German *Wehrmacht* demolished high-speed routes.[2] Elements of Israeli Colonel Yigael Allon's Negev Brigade outflanked Egyptian forces in the northern Sinai desert on Christmas Day 1948 after aerial photograph interpreters identified the remains of a long-idle Roman road that defenders overlooked.[3]

On-site reconnaissance and route classifications, however, commonly are required, because historical records, maps, and photo surveys seldom disclose enough information in sufficient detail about the following factors:

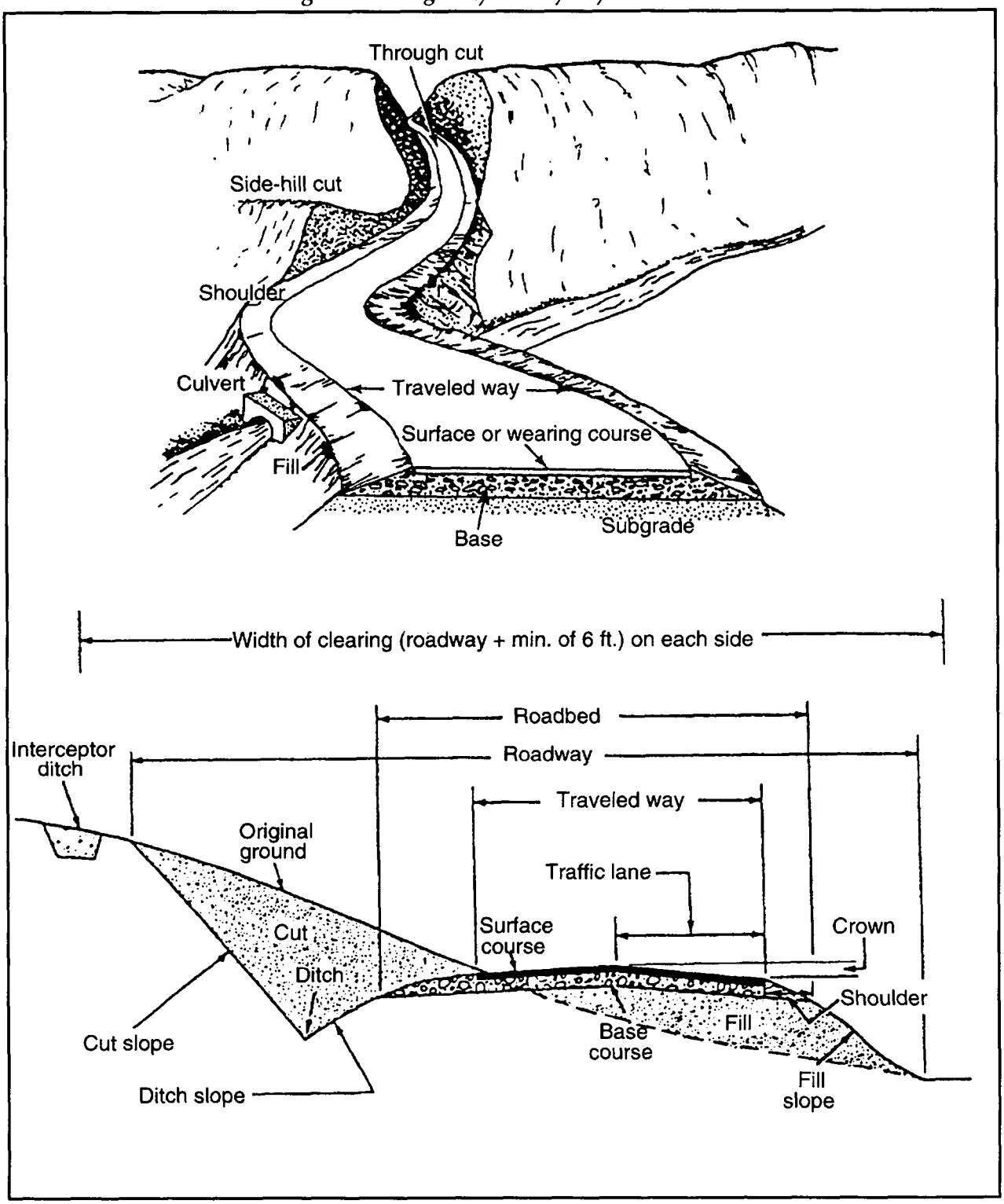
- Underlying and adjacent terrain (elevations, irregularities, slopes, drainage, soils, and defiles)
- Road foundations and surface materials (by section if construction is not uniform)
- The widths and status of roadbeds and shoulders
- Maximum grades and curvatures
- The stability of cuts and fills
- Bridges, tunnels, and underpasses (technical characteristics, clearances, weight-bearing capacities)
- The suitability of fords and ferries
- Obstacles (abatis, snow banks, rock slides, washouts)
- Current conditions (repair, maintenance, restoration)
- Passing lanes and areas suitable for rest stops
- Characteristics of alternative routes, detours, and local bypasses
- Construction requirements.

ROUTE CLASSIFICATIONS

Every well-constructed road consists of a surface; a base course of gravel or crushed rock that distributes stresses from heavy traffic; a foundation (subgrade) of natural materials; and a drainage system of crowns, cambers, culverts, ditches, and drains which disposes of ground water as well as runoff that could cause rapid deteriorization (figure 31). The width of each traveled way determines the number of lanes, which must average 11 to 12 feet (3.5 meters) for large trucks and 13 feet or so (4 meters) for most armored vehicles—single-lane roads make it impossible to pass or reverse course. Cracked pavements, unsealed roadbeds, pot holes, bumps, ruts, soft shoulders, grades greater than seven percent, sharp curves with a radius less than 100 feet (30 meters), and clogged drainage systems reduce the value of otherwise suitable roads until improvements are complete.[4]

All-weather roads have solid subgrades and base courses, traveled ways paved with concrete or bituminous mixtures, adequate drainage, enough width to accommodate two-way vehicular traffic, and throughput capacities that never are appreciably less than their

Figure 31. *Highway and Byway Attributes*



maximum, regardless of seasonal conditions, given reasonable maintenance. Similar routes topped with brick, stones, or gravel are somewhat less serviceable, while limited all-weather roads remain open at reduced capacity after heavy precipitation only by dint of greater effort.[5]

Fair-weather roads that meet less stringent standards often must suffice in combat zones, but LOCs that link front-line forces with sources of supply rate rapid upgrading. So do routes that interconnect senior command posts, communication centers, ports, airfields, and theater-level support installations in the rear. Stringent controls may also be necessary. Logisticians sustained U.S. Armed Forces over tenuous routes from the Normandy beachhead to the German border in late summer 1944 only because Supreme Headquarters Allied Expeditionary Force (SHAEF) designated Red Ball Highways, banned unessential traffic, operated every available truck 20 hours a day with brief stops to load, unload, and refuel, scraped the bottom of the barrel for relief drivers, and ran engineers ragged around-the-clock to keep those battered roads serviceable.[6]

WEAK LINKS AND BOTTLENECKS

Bridges, fords, ferries, tunnels, and underpasses are weak links and potentially troublesome bottlenecks along land lines of communication during military operations in peacetime or in war. Reconnaissance and classification crews consequently pay close attention to their characteristics.

Bridges. Thomas Macaulay immortalized one-eyed Captain of the Gate Gaius Horatius, the 6th century B.C. savior of Rome who, with two other warriors, held off 90,000 Etruscans while troops on the far side of the swollen Tiber River chopped underpinnings beneath Pons Sublicus, the only available bridge.[7] Warfare has repeatedly focused on key bridges ever since. The last span left standing over the Rhine on March 7, 1945, became the most important piece of property on the Western Front when German demolition teams at Remagen tried but failed to destroy it before engineers of the U.S. 9th Armored Division raced across to secure the east bank. That badly damaged bridge served well for the next 10 days, despite enemy artillery and air attacks, until weakened structures finally collapsed.[8]

Both offensive and defensive forces designate bridges as key terrain whenever seizure, retention, destruction, or control would afford marked advantage. Load-bearing capacities are crucially important—flimsy construction, for example, excludes tanks with heavy "footprints." Detailed data additionally are in demand concerning precise map coordinates, approaches and adjacent topography, designs, construction materials, critical dimensions (heights above gaps, lengths of spans, widths of traveled ways, overhead obstacles), and special features, such as those inherent in draw, swinging, and vertical lift bridges that let ships pass.[9]

A few civilian-style floating bridges, such as the mile-long model across Lake Washington near Seattle, rest on pontoons, but most permanent bridges feature solid construction. Designs depicted in figure 32 range from short, simple slabs that seldom exceed 30 feet (9 meters) to cantilevers and complex suspension bridges, several of which possess spans that extend more than 4,000 feet (1,200 meters). All bridges, regardless of type, share most militarily significant characteristics that figure 33 displays.

Figure 32. *Bridge Types Depicted*

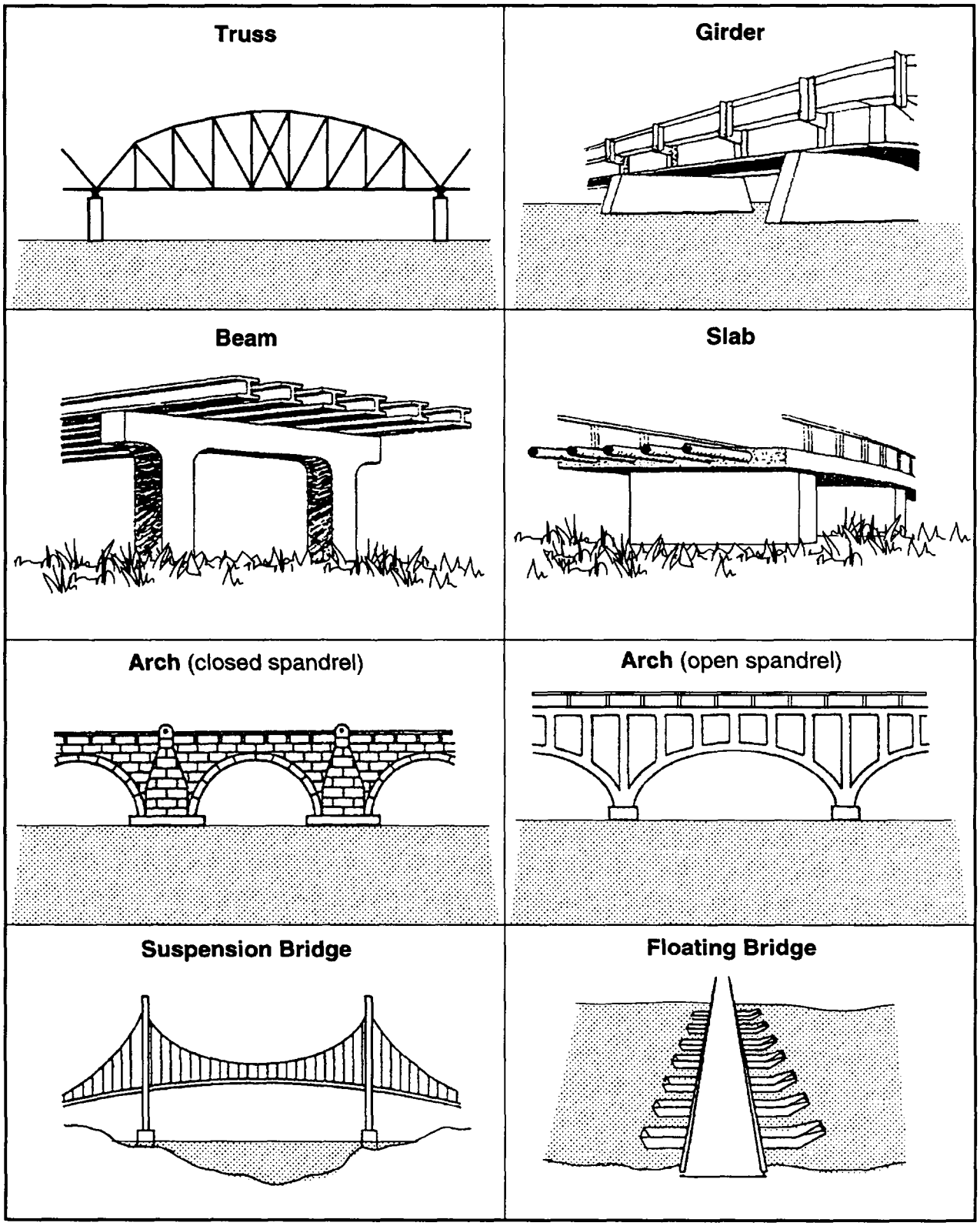
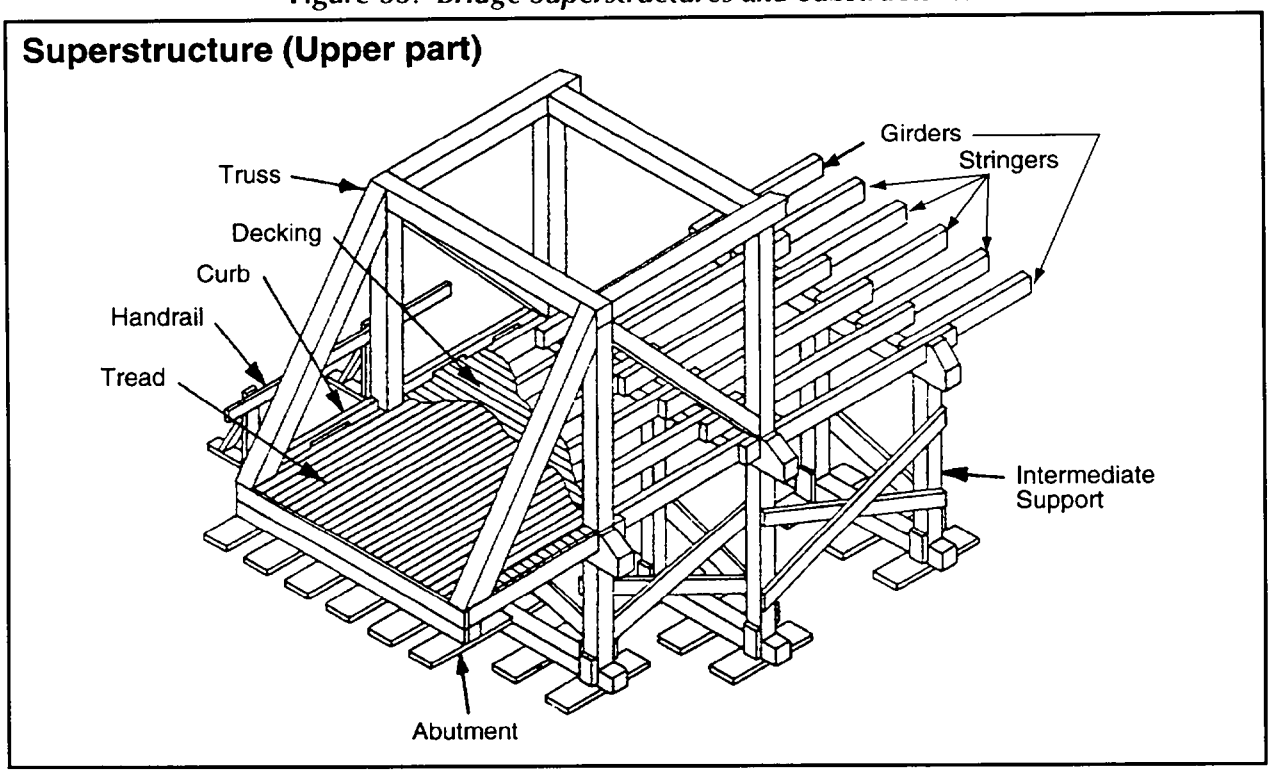


Figure 33. *Bridge Superstructures and Substructures*



Substructures consist essentially of abutments that rest on natural footings ashore, retaining walls that support banks at both ends to keep connecting roads from sinking and, if required, underpinning piers interspersed in stream at carefully calculated intervals. Superstructure assemblies vary according to site characteristics, construction materials, the length of each span, and intended capacities: arch, slab, beam, girder, and pontoon bridges sport decks, treads, and generally guardrails; truss bridges add load-bearing beams that form horizontal and vertical triangles; suspension bridges hang roadways from two thick cables anchored at both ends and draped between towers.[10]

Fords and Ferries. Armed forces ford unbridged water barriers where depths are shallow enough, currents are slow enough, and approaches as well as bottoms are solid enough for wheeled and tracked vehicles to proceed at reduced rates of speed under their own power or assisted by winches (refer to figure 5 on page 33 and accompanying text). Waterproofing kits and underwater roadways built of unprocessed timber, wooden planks, gravel, metal mats, even concrete can increase throughput capabilities considerably. Tanks equipped with snorkels sometimes cross completely submerged. Ferries propelled by drift, oars, poles, pulleys, gasoline, diesel, or steam see service where fords are infeasible, given a sufficiently slow current, enough depth to float from shore to shore, an absence of serious obstacles in stream, above freezing temperatures, and approach ramps that allow landings whether water levels are high or low. Rubber rafts, amphibious vehicles, assault landing craft, and motor boats typify possible conveyances.[11]

Tunnels and Underpasses. Tunnels, underpasses, and snow sheds that penetrate mountains or burrow beneath Earth's surface constitute formidable obstacles along land lines of communication, because they never would have been blasted, bored, or cut, covered, and excavated at great expense if attractive alternatives existed. Portal-to-portal lengths are less important than configurations, which may be semicircular, elliptical, square, or horseshoe-shaped and follow straight, curved, or irregular paths between walls that are natural or lined with brick, masonry, or concrete. Interior dimensions, together with ceiling shapes, wires, and other fixtures that influence overhead clearance, determine which vehicles and outsize loads can pass and which must detour.[12]

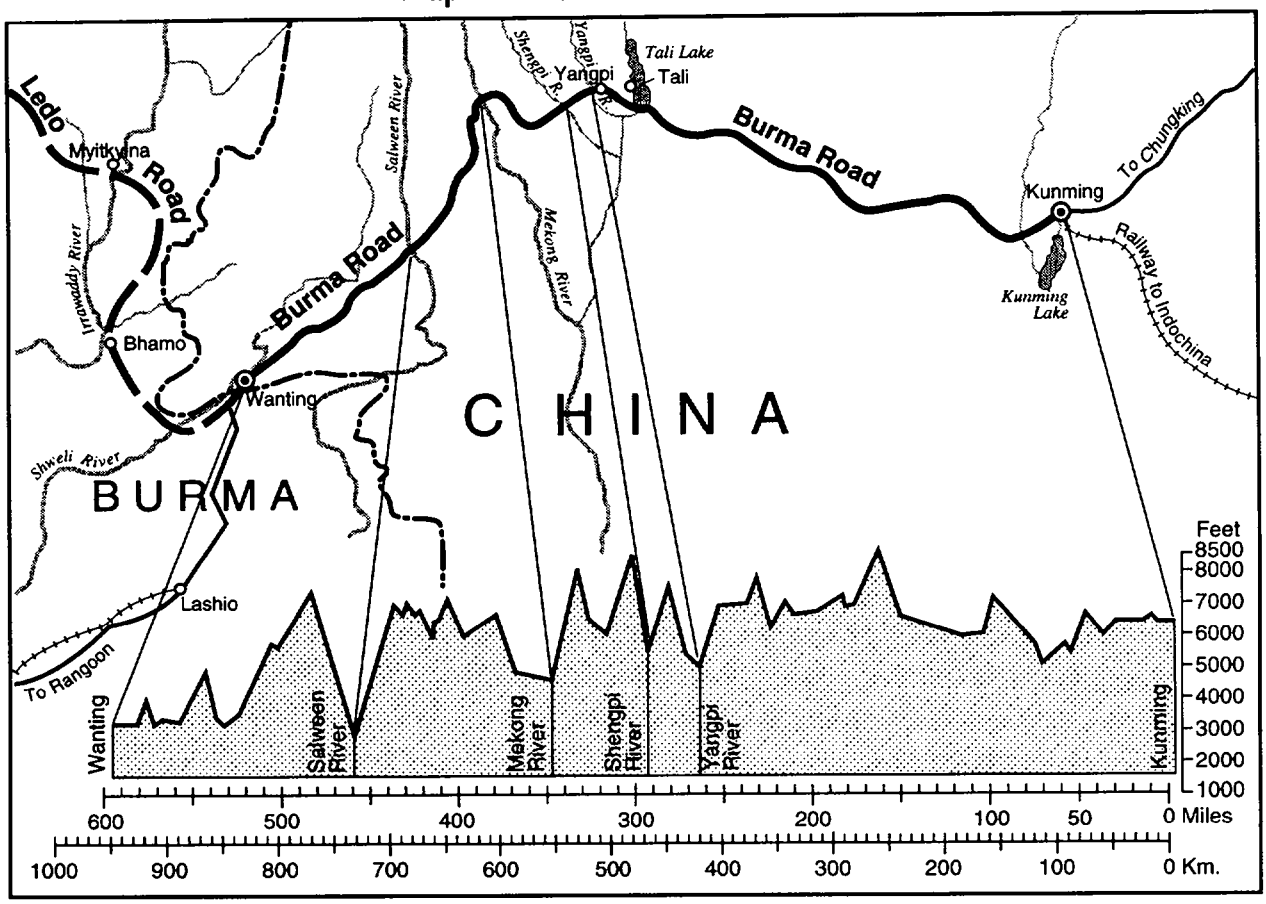
CONSTRUCTION PROBLEMS

Armed forces expend money, manpower, and materiel to construct new roads only when existing networks are poorly aligned or capacities are inadequate., but many monumental endeavors nevertheless come to mind. The 1,506-mile long (2,424 kilometers) Alaska Highway built by U.S. Army Corps of Engineers and private contractors between Dawson Creek, British Columbia, and Fairbanks as a main military supply route during World War II is among them.[13] So are interlacing land lines that U.S. and Soviet engineers laid across Afghanistan in the 1960s as part of competing programs to aid that impoverished but strategically well-placed nation.[14]

No project, however, overshadowed the "poor man's turnpike" that countless coolies built between Ledo, Assam, and Kunming, China, during World War II (map 17, on page 107, and map 27). The cost in human lives was high, but the benefits were incalculable.

Burma Road Obstacles. The eastern half of that prodigious endeavor, known as the Burma Road, led over three towering fingers from the Tibetan Plateau plus raging upper reaches of the Salween, Mekong, and Yangpi Rivers. Every stone for a strip 23 feet wide (6.7

Map 27. *Profile of the Burma Road*



Adapted from Flyleaf, Tan Pei-Ying, *The Building of the Burma Road.*

meters) and 7 to 10 inches deep was set in place one at a time by local peasants who planted them like seedlings in rice paddies. The first 85 miles (135 kilometers) from Burma's eastern border to Lungling contained "every torment that nature could devise," according to Tan Pei-Ying, the project manager: "Rain unending for months at a time; stifling heat and humidity; mountains of the slipperiest mud; and worst of all malaria." More than half of those bitten by mosquitoes died before partly effective antidotes belatedly became available. Men, women, and children who lacked modern equipment and used a poor grade of gunpowder as a substitute for dynamite chiseled through 250 linear miles (400 kilometers) of bedrock to a depth of 50 to 100 feet (15 to 30 meters), 3,860,000 cubic yards all told, while clinging to precipice faces like flies. "The most trying of all [such jobs]," Pei-Ying recalled, "was in the gorges running back from the Salween, where we had to cut one hairpin turn after another out of the sheerest cliffs, taking the Road up from 2,000 feet above sea level to 6,800 feet [610 to 2,075 meters] within a distance of 18 miles [29 kilometers]."[15]

Burma Road Bridges. It was hard enough to build 460 bridges of different types across relatively small streams, but the three biggest rivers posed prodigious challenges. Mr Hsu Yi-fang, without benefit of blueprints, designed three single-span suspension bridges to solve related problems—the longest was 410 feet (125 meters). Factorymen in Rangoon thereafter cut huge beams, steel rods, wire ropes, cables and other parts to his specifications and

delivered them to Lashio by rail, whereupon hundreds of men and mules bore heavy burdens for 300 more miles over awesome terrain. Some construction methods were centuries old, enemy actions caused recurrent nightmares, several thousand died before the last bridge was complete, trucks crossed one at a time because the maximum bearable load on the best of them was 10 tons, and jerry-rigged ferries had to take up some slack, but results in the end even so were satisfying. Some in fact say without tongue in cheek that building the Burma Road was comparable in scope to erecting ancient Egyptian pyramids.[16]

DESTRUCTION TECHNIQUES

Fictional Robert Jordan rigged a Nationalist bridge for demolition during the Spanish Civil War in Ernest Hemingway's classic novel *For Whom the Bell Tolls.* Movie actor William Holden portrayed a U.S. Navy pilot who dive-bombed *The Bridges of Toko-Ri* in North Korea. Real world warriors at different times and places have long employed those and additional techniques to interdict overland lines of communication using aircraft, missiles, artillery, mines, and explosive charges. Gravity bombs as well as air-to-surface and surface-to-surface missiles armed with precision-guided munitions currently can strike bridges, tunnel mouths, fords, and ferries with far greater effectiveness than in the recent past, and technologists promise to couple pinpoint accuracy with unprecedented nonnuclear destructive power in the future.[17] There are times, however, when total destruction is undesirable, because friendly armed forces and civilians might find repairable facilities useful at later dates.

Covert operations that conceal the identity of, or permit plausible denial by, perpetrators moreover may be politically prudent, especially in "peacetime." Demolition specialists able to infiltrate clandestinely, position charges precisely, then slip away sometimes prove invaluable under combat conditions, because they impose disproportionately heavy security burdens on defenders. First, they calculate how much of what type charge (TNT, tetrytol, plastic, or sheet explosives) to place where, taking into account the size, shape, and strength of targets to be attacked, required degrees of destruction, and collateral damage limitations, if any. Multiple charges may be more effective than one big blast against oddly shaped, large, or very hard objects, such as concrete bridge abutments and tunnels. Brittle cast iron breaks easily, but acetylene torches or thermite may be needed to slice nickel-molybdenum steel, which strongly resists conventional explosives. Proper placement is at least as important as destructive power. Large trees dropped to form an abatis across defiles fall in the wrong direction if cut improperly. Professionals whose mission is to stop road and river traffic temporarily cut supports at one end of truss bridges so affected spans fall in the water; they cut trusses at midspan to make bridges buckle if long-lasting destruction is the intent. Massive towers and thick cables on major suspension bridges resist powerful explosive charges, but slender suspenders that hang therefrom do not—roadway sections collapse if they are cut.[18] Tunnels in solid rock are tough targets to destroy unless saboteurs detonate truckloads of conventional explosives or man-portable nuclear weapons deep inside.

RAILROADS

Far-sighted German economist Friedrich List in 1833 was the first to visualize the military importance of railroads and General Helmut Karl von Moltke the Elder, as Chief of the Prussian General Staff, put principles into practice during the Austro-Prussian War in 1866.[19]

The first grand test, however, took place during the U.S. Civil War, when Union and Confederate forces both used rail lines to redeploy large formations over great distances and support them for long periods [20] (the first Medals of Honor ever awarded went to members of James J. Andrews' raiding party, who hijacked a rebel train at Marietta, Georgia, on April 11, 1862.[21]). Railroads subsequently played crucial roles in most major armed conflicts the world over.[22]

RAILROADS RELATED TO TROUBLE SPOTS

The United States, Canada, most of Europe, Japan, and a few other highly industrialized nations have modernized their railway systems since the 1950s. High-speed trains and computerized controls are common; lightweight rails are passé; steel and plastic replace wooden and concrete ties; flatcars carry more trailers and containers than any other cargo; steam locomotives, reefers, water towers, and hump yards have virtually disappeared.[23] Discussions that follow nevertheless concentrate on traditional railroads in underdeveloped countries, many of which are present or projected trouble spots, because U.S. and allied military transportation specialists could be called to cope with unanticipated problems.

RAILWAYS COMPARED WITH ROADS

Railways and roads are complementary lines of communication, each with strengths that compensate for the other's weaknesses. Trains rather than trucks carry the heaviest overland loads, just as ships rather than aircraft carry most bulky cargo between homelands and theaters of operation overseas. U.S. Army divisions at the height of the Cuban Missile Crisis, for example, depended on rail transportation to move them from widely separated bases in Colorado, Texas, Kentucky, and North Carolina to ports of embarkation scattered along the seaboard from Baltimore, Maryland, to Beaumont, Texas. That task was humongous, because it then took 4,200 flat cars and 820 pullmans (the equivalent of 100 trains end-to-end on 45 miles of track) to handle just one armored division with accompanying supplies. U.S. railroads also served extensively throughout World War II, the Korean War (1950-53), the Vietnam War (1965-72), and during altercations with Iraq (1991-92).[23]

Rail lines nevertheless are inflexible for most tactical purposes, because cross-country bypasses are infeasible for trains confined to tracks. That fact is especially significant wherever washouts, rock falls, snow slides, and manmade bottlenecks abound, as is the case with the Trans-Iranian Railroad, which encounters 224 tunnels and more than 4,100 bridges on its 895-mile (1,340-kilometer) trek from the Caspian Sea to the Persian Gulf. Trains on the Trans-Siberian Railroad once passed through 51 tunnels in rapid succession along a 52-mile stretch of track (84 kilometers) that skirted the southern banks of Lake Baikal before work crews built a better route. Construction costs, always higher than for roads, increase when many cuts and fills are required to reduce grades and smooth out sharp turns.

Railway reconnaissance teams, like colleagues who classify roads, catalog distances between selected points, the nature of nearby terrain, foundation materials, maximum grades, minimum curve radii, cuts, fills, obstacles, bridges, tunnels, ferries, and current conditions. They also look for characteristics peculiar to railroads, which are listed below:[24]

- Tracks (number, together with locations and lengths of sidings)
- Rails (condition, type, length, weight)
- Ties (condition, type, spacing, size)
- Ballast (width, depth, type, source of stones, drainage)
- Gauges, including changes at transshipment points
- Electrification (wires, cycles, voltage, support structures, substations)
- Operational limitations (speeds, number of cars per train, number of trains per day, allowable axle loads)
- Control facilities (dispatching, signaling, switching)
- Stations, yards, and terminals (locations, types, capacities, facilities)
- Servicing facilities (water, fuel, and ice replenishment; repair and maintenance shops; roundtables and cranes)
- Locomotives and rolling stock (numbers, types, sizes, weights, couplings)
- Mobile maintenance and repair equipment
- Management and work force.

RAILWAY INFRASTRUCTURES

Railroad infrastructures encompass all routes, real estate, rolling stock, and facilities required to operate and maintain trains. Military users are concerned primarily with the improvement and preservation of throughput capabilities, whereas enemy targeteers diligently study soft spots that, if interdicted, would deprive possessors of essential support at crucial times and places.

Roadbeds and Rails. All trains run on tracks, but not all tracks are the same. Some mainline roadbeds are merely compacted earth or thinly spread cinders, while sturdier bases that ensure proper drainage and distribute loads evenly consist of slag chips or crushed stone in layers up to 24 to 30 inches thick (61 to 76 centimeters). Crossties embedded in that ballast to support and align rails not only range from untreated timber to concrete but vary considerably in size and spacing. Steel rails may weigh less than 40 or more than 150 pounds per yard (20 to 68 kilograms per meter), tie plates and anchors called "anticreepers" may or may not hold rails in place, builders may or may not use 50- to 60-foot-long rails (15 to 18 meters) to reduce the number of joints, and they may or may not butt-weld or bolt rails together to strengthen construction. Firm ballast, solid crossties, heavy steel rails, welded joints, banked curves of no more than 1.5 degrees, and grades of 1.0 percent or less facilitate fast passenger and freight service.

Standard gauge tracks (4 feet 8.5 inches/1.435 meters) predominate in North America, Mexico, Great Britain, and most of continental Europe. Broader gauges (5 feet/1.524 meters or more) are the rule in former Soviet Socialist Republics, Finland, Ireland, Iberia, India, and Argentina, although trains waste valuable time while cars exchange undercarriages or transfer cargoes to other trains wherever dissimilar lines connect. Various gauges cover much of Latin America, Asia, Africa, and Australia, but many nations there as elsewhere still maintain narrow gauge railroads on level as well as mountainous terrain because construction, maintenance, locomotives, and rolling stock all are relatively inexpensive.[25]

Rolling Stock and Locomotives. Logisticians who hope to use allied and captured enemy railway infrastructure most effectively must consider many factors, because imported locomotives and rolling stock must be compatible with local rail gauges and couplings.

Steam, electric, diesel, and diesel-electric mainline locomotives are much longer and heavier than switch engines, which are geared to tow many cars at slow speeds. The military importance of sleeping and dining cars has declined dramatically since World War II, primarily because most personnel now move administratively by air, but boxcars, flatcars, gondolas, hoppers, tank cars, and refrigerators retain great utility.

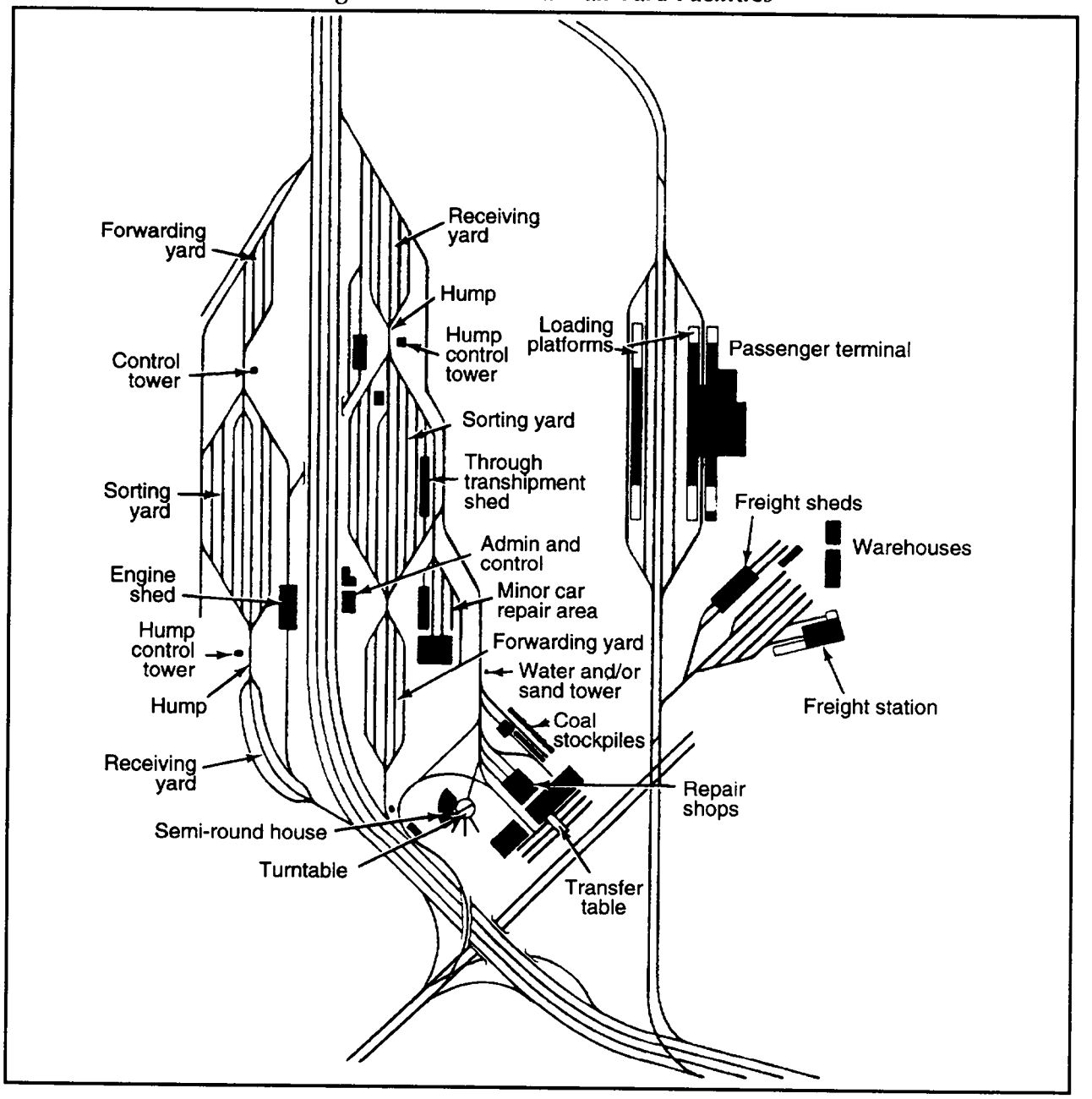
Terminals Yards, Railheads, and Stations. An elaborate array of installations is required to assemble trains, point them in proper directions, and make them run on time. Traditional rail yards at major terminals receive, unload, separate, classify, and sort incoming locomotives and rolling stock, couple predetermined numbers and types together, then shunt strings to other yards where they are serviced, reloaded, stored, or prepared for departure (figure 34). Locomotives proceed to roundhouses where turntables and cranes assist inspections, repairs, and maintenance. Switch engines tug cars from one traditional yard to another unless gravity pulls them from the top of humps to lower levels. Each complex contains parallel tracks, switches, sidings, platforms, sheds, shops, warehouses, water towers, storage tanks, and command/control facilities. Stations along each route and railheads where transshipments to other modes of transportation take place complete the list of railway real estate inventories.[26]

RELATIVE UTILITY AND VULNERABILITY

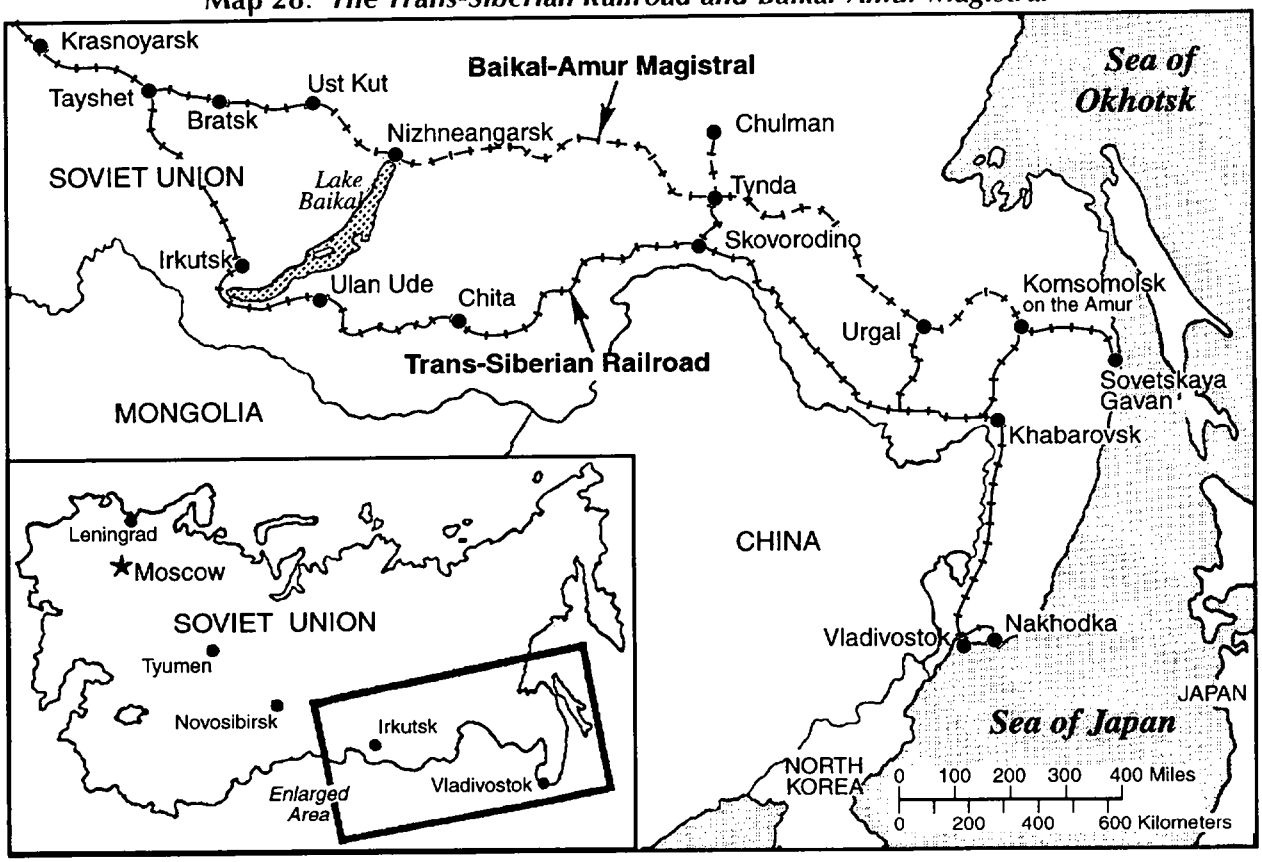
Some regions rely extensively on rail transportation, others very little. Those with many alternative routes and installations well removed from present or potential enemies are most flexible, although choke points along lonesome stretches far removed from maintenance units are vulnerable and wreckage is hard to repair. Marshaling yards concentrate lucrative targets, as evidenced during World War II, when repeated air attacks seriously disrupted the redeployment of German troops and the distribution of ammunition, fuel, food, and other supplies to forces in the field. Duty in large rail yards throughout occupied France as well as in the Third Reich was almost as dangerous as front line service.[27] Retreating Germans not only destroyed every right or left hand switch in classification yards, but uprooted rights of way by splitting ties down the middle and splaying rails with locomotive-mounted plows.

No major power during the Cold War had greater need for reliable rail service than the Soviet Union, but deficiencies were numerous.[28] Connections with European satellite states were cumbersome because the change from broad- to standard-gauge undercarriages at each border consumed about 2 hours per 20-car train and 2 more on return trips. Worse yet, the rudimentary road network that served European Russia diminished rapidly east of the Ural Mountains and virtually disappeared for 4,000 miles (6,400 kilometers) between Omsk and Vladivostok. The ribbon-like Trans-Siberian Railroad, single-tracked for 2,000 miles along the Chinese frontier, therefore bore most burdens. Stalin consequently suffered such heartburn that he began to construct the Baikal-Amur Magistral (BAM) rail line somewhat farther north using slave labor (map 28). Progress ceased after his death in 1953, but Leonid Brezhnev later revived that stupendous project, which crosses five mountain ranges, seventeen wide rivers, and seismically active plains that turn swampy in summer; passes through Severo-Muisky Tunnel, which is nearly 10 miles long (16 kilometers), and several others of lesser length; and boasts 3,000 bridges. Underlying permafrost created countless construction problems before the first train made its maiden trip in 1989.[29]

Figure 34. *Traditional Rail Yard Facilities*



Map 28. *The Trans-Siberian Railroad and Baikal-Amur Magistral*



MILITARY AIRPORTS

Military airports must accommodate fixed- and rotary-wing combat, utility, and cargo aircraft that, when directed, fly missions around-the-clock under adverse weather conditions. One size field, however, by no means fits all. Ramstein Air Base, situated in a narrow valley near Kaiserslautern, Germany, for example, served a U.S. fighter wing well during the Cold War, but tight terrain, a relatively short runway, slender taxiways, cramped parking areas, and limited cargo-handling facilities restrict C-141 and C-5A transports, its present tenants.[30]

SITE SELECTION AND CONSTRUCTION CRITERIA

Military requirements determine the number, characteristics, essential service life, and acceptable construction time of airfields in any area of operations. Topography, climatic conditions, vegetation, hydrology, soils, and logistical convenience strongly influence locations. Preferable sites feature the flattest terrain, the clearest weather, the most favorable winds, the fewest obstructions, the freest drainage, and easiest access to prominent land lines of communication but, if that ideal is unattainable for political, military, geographic, or cultural reasons, decisionmakers must compromise.

Primary runways generally parallel the direction of prevailing winds, taking high-velocity cross-currents into account. Runway lengths required by any given type aircraft would be standard everywhere if Planet Earth were a perfectly flat plain at sea level, all thermometers consistently registered any given temperature, the surface never was slick with rain, sleet, or

snow, and all pilots were equally competent. Military airfield designers in the real world, however, must extend runways to compensate for increases in altitude and do likewise where temperatures of the warmest month average more than 59 °F (15 °C), because those factors singly or in combination create rarefied air that degrades engine performance and affords less lift. Takeoffs up inclines and landings downhill also require longer runways. U.S. calculations in anticipation of foul weather and imperfect air crew performance add 25 percent more in combat zones, 50 percent more in rear areas, then tack a small "fudge factor" onto the adjusted total, as table 21 indicates.[31]

Table 21. *U.S. Military Aircraft Runway Length Calculations*

Basic Calculations	Takeoff Ground Run (TGR) at mean sea level; temperature 59 °F (15 °C)
Correction for Altitude	Add 10% to basic runway length for every 1,000-foot (305-meter) increase above 1,000 feet
Correction for Temperature	Add 4% to basic runway length for every 10 °F (6 °C) that temperatures of the warmest month average above 59 °F if the TGR is less than 5,000 feet (1,525 meters)
	Add 7% to basic runway length for every 10 °F that temperatures of the warmest month average above 59 °F if the TGR is 5,000 feet or more
	Never shorten basic runway lengths if temperatures of the warmest month average below 59 °F
Correction for Gradient	Add 8% to basic runway length for every 1% increase over a 2% gradient anywhere along the strip
Safety Factors	Add 25% for combat zone airfields; Add 50% for rear area airfields; Add 100 feet (30 meters) to the adjusted total

Minimum runway widths, consistent with degrees of lateral stability during final approaches and landings, increase with aircraft weights and sizes. Bombers and large transport aircraft need more elbow room than fighters, which are relatively maneuverable. Taxiways, parking aprons, and hangar floors, like runways, must have load-bearing capacities consistent with the heaviest aircraft for which the field is configured.[32] Approach zones and overruns at each end of every runway are graded to minimize damage if pilots accidentally land short, overshoot, or experience engine failure on takeoff. Engineers clear obstructions to points well below glide paths or mark them prominently if that proves infeasible and alternative sites are less satisfactory.[33]

EXPEDITIONARY BASES AND UPGRADES

Featherweight combat aircraft were able to operate from sod fields as late as the Battle of Britain in 1940, but runways soon became essential for all but the lightest planes. U.S. expeditionary air bases established in foreign lands, often on the spur of the moment, occupy three categories:

- Category One contains relatively austere strips that occupants abandon as soon as they outlive their usefulness.
- Category Two contains Category One airfields that occupants progressively upgrade and retain.
- Category Three contains permanent or semipermanent bases that are well constructed from scratch, occupied, then upgraded in stages.

Expeditionary airfield builders employ bulldozers, scrapers, back hoes, front loaders, dump trucks, and other earth-moving machinery deliverable by heavy lift helicopters ("flying cranes") and parachutes if necessary. Bare base kits, tailored for particular missions, include flight-line support, supply, maintenance, and housekeeping items of which the following are merely representative: durable runway membranes or matting; lights; navigation aids; approach apparatus; arresting gear; dust palliatives; prepackaged control facilities; portable shelters; power generators; field kitchens; and collapsible fuel storage containers.[34]

Drag chutes, thrust reversers, and jet/rocket-assisted take-off (JATO/RATO) propulsion systems benefit some aircraft that arrive while work on runways and approaches is still in progress. The Soviet Union, which lacked first-class bases in Siberia and found few in underdeveloped client states, put a premium on sturdy, short-takeoff-and-landing (STOL) designs that as early as the 1970s vested cargo aircraft with high power-to-weight ratios, special flaps, strong, multi-wheeled undercarriages, adjustable tire pressures, self-starting engines, gravity refueling, built-in test sets, and on-board cargo-handling equipment.[35]

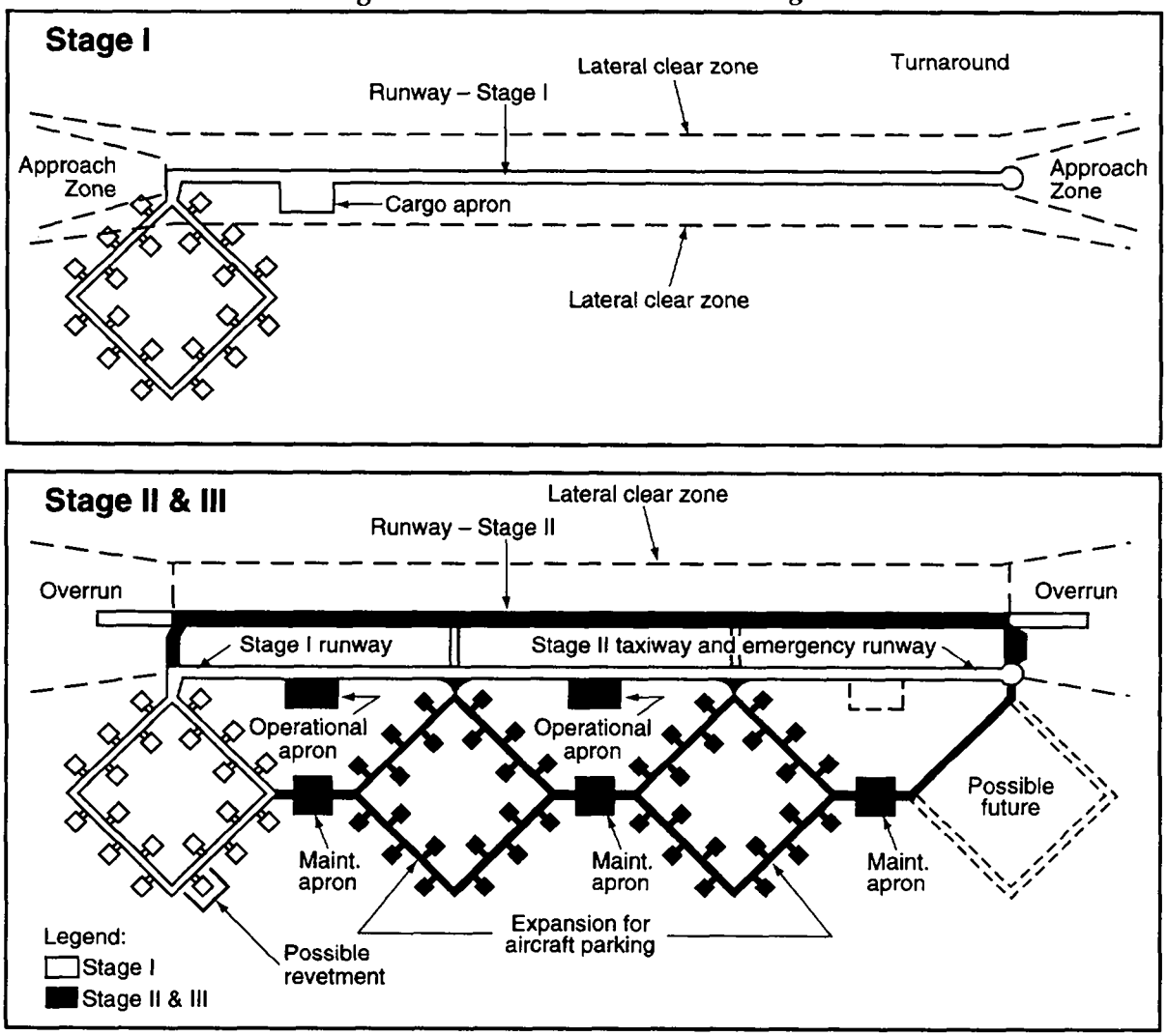
Phased upgrading of expeditionary air bases and captured enemy fields continues apace until they are fully able to support planned missions (figure 35). Stage I construction provides a loop that allows aircraft to land, taxi, park, unload, reload, and depart on expedient surfaces of minimum dimensions. Stage II increases capacities, safety, and operational efficiency, perhaps creates a second runway, and converts the original to a taxi strip that runs the length of the field. Stage III further expands facilities and paves surfaces if users plan long-term occupancy.[36]

AIR BASE DEFENSE

Military air terminals are even harder to protect than they are to construct, because no installations as yet possess credible ballistic missile defenses and all are vulnerable to attacks by such unsophisticated weapons as mortars, rocket-propelled grenades, and portable air-defense missiles. Unshielded ammunition dumps, aviation fuel supplies, and aircraft taking flight, on final approaches, or in unrevetted parking lots are especially vulnerable.

Audacious hit-and-run raiders can wreak havoc. British Major David Stirling's nascent Special Air Service (SAS) repeatedly roared out of the Sahara Desert during World War II to hit German Field Marshal Erwin Rommel's North African air bases. Eighteen jeeps with blazing machine guns ran straight down the runway at Sidi Haneish, Libya, on July 8,

Figure 35. *Airfield Construction Stages*



1942, and within a few minutes ruined more than two dozen aircraft parked on both sides, including Junker 52s which had been scarce since the *Luftwaffe* lost nearly 200 transports during the battle for Crete the previous year.[37] U.S. Army Major Robert C. Kingston, in his capacity as Commanding Officer, Company C, 3d Battalion, British 16th Parachute Brigade, led six five-man teams whose mission during pre-dawn darkness was to test security procedures at U.S. Air Base Lakenheath near Aldershot, England, in April 1962. Civilian constabulary in the adjacent town and roving patrols assisted by scout dogs, trip wires, and flares were on red alert beforehand, but stealthy infiltrators even so were able to "assassinate" the base commander, plant simulated demolitions on parked aircraft, neutralize the combat operations center, "explode" a liquid oxygen plant, place charges that could have cratered the main runway, and accomplish other missions without unacceptable losses.[38]

Better safeguards typified by space surveillance satellites, extremely sensitive land-based sensors, night vision devices, better aircraft dispersion, and formidable physical barriers limit

options open to present day counterparts of Majors Stirling and Kingston, but special operations forces even so still imperil the best protected air bases.

SEAPORTS AND HARBORS

Sea lines of communication terminate in harbors and ports that come in all sizes, shapes, and descriptions. Each harbor suitable for deep-draft ships features distinctive approaches, entrances, dredged channels, depths, protected anchorages, turning basins, and navigation aids. Each up-to-date seaport additionally displays a wide array of berthing, cargo-handling, storage, maintenance, and clearance facilities (figure 36).[39]

HARBOR ATTRIBUTES

Even fine natural harbors such as those that serve New York City, San Francisco, Rio de Janeiro, and Tokyo benefit from human improvements. Massive stone or masonry breakwaters, jetties (breakwaters that connect with the shore), and moles (jetties with a road on top) commonly depress swells and deflect stormy seas, dredges clear channels that are subject to silt, and sea walls reduce erosion along shore. Shapes, horizontal dimensions, depths, obstacles in stream, and ship characteristics (drafts, lengths, beams, mast heights, and hull forms) determine how many ships of what types any harbor can accommodate at one time.

Navigational aids in well-developed harbors normally include a lighthouse and channel-marking buoys. Huge buoys enable ships to moor in stream whenever suitable berths alongside moles, wharves, and piers are unavailable or soft bottoms make free anchorage unsafe. Deeply driven pilings called dolphins do likewise. Some basins rely on regulating gates, caissons, locks, and pumps to maintain requisite levels. Efficient harbor operations also employ various tugboats, ferries, salvage craft, fire-fighting vessels, launches, lighters, pile-drivers, dredges, rock breakers, barges and, in cold climes, icebreakers.

PORT FACILITIES

Harbors become seaports only when installations facilitate the transfer of personnel and cargo from ships to shore (figure 37). Most wharves (sometimes called quays) built for that purpose parallel and abut the harbor's perimeter or nearby islands (such as Ford Island inside Pearl Harbor), whereas piers project into the water at various angles and thereby provide berthage not only on both sides but at the head as well, given sufficient space. Petroleum tankers usually discharge products through submerged pipelines while tethered to deep-water terminal buoys.

The daily capacity of every port depends on ship types, percentages worked at wharfside compared with cargoes lightered from transports in stream, ratios of bulk to general cargoes, the efficiency of the labor force, and facilities ashore. Wheeled and tracked vehicles embark and debark from roll-on roll-off (RO/RO) ships under their own power while self-sustaining merchantmen use on-board booms or cranes to transfer freight, but containerships rely almost entirely on heavy hoists ashore. The largest gantry, jib, and cantilever cranes, which move on rails along wharves and piers, handle loads that range from 100 to 250 tons or more. Forklifts, jitneys, portable conveyers, and other mechanical devices serve stevedores. Transit sheds, warehouses, refrigerators, storage tanks, bunkers, and open stacking spaces stash consignments until they clear port by road, rail, inland waterways, or pipelines.

Figure 36. *Typical Naval Port Facilities*

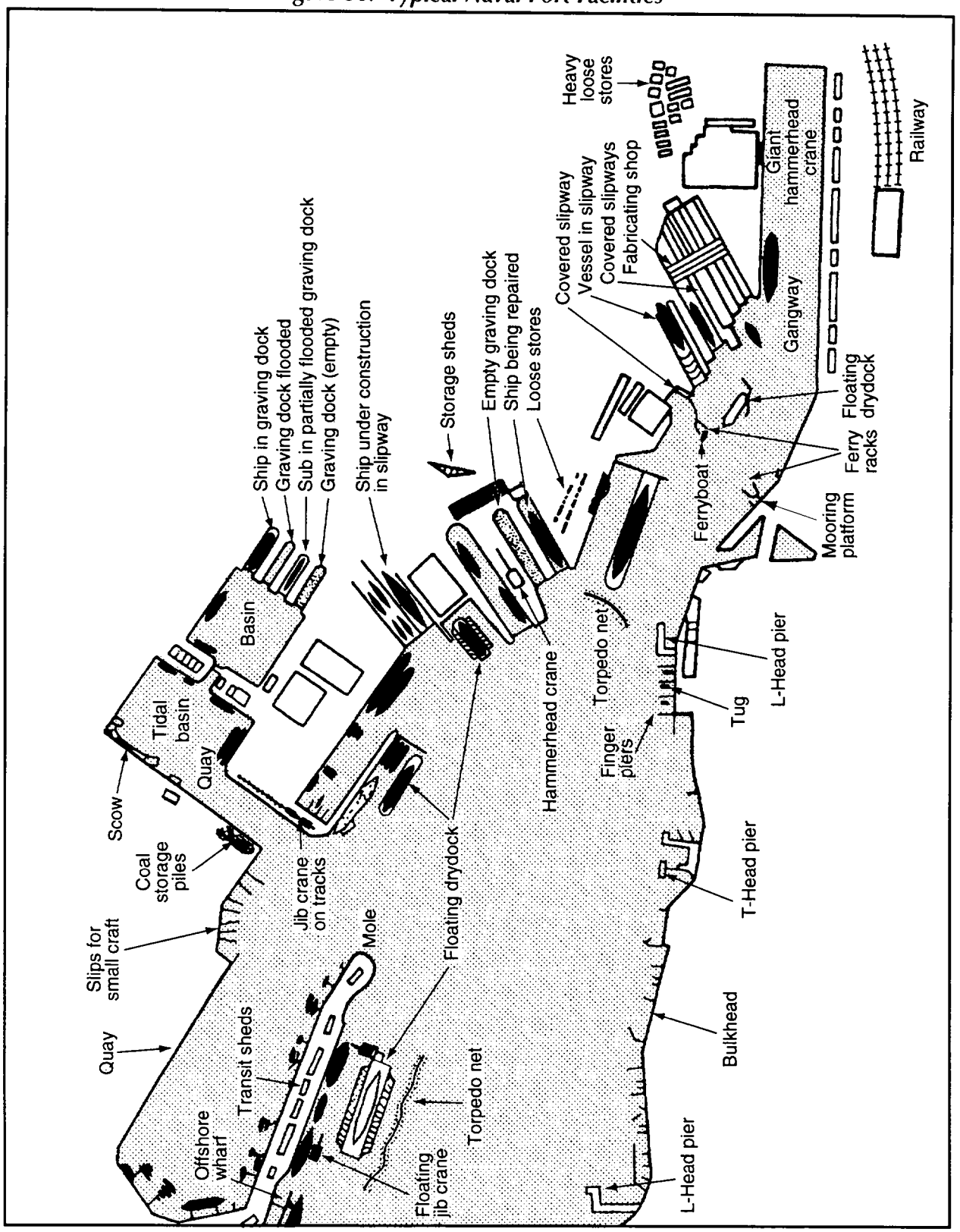
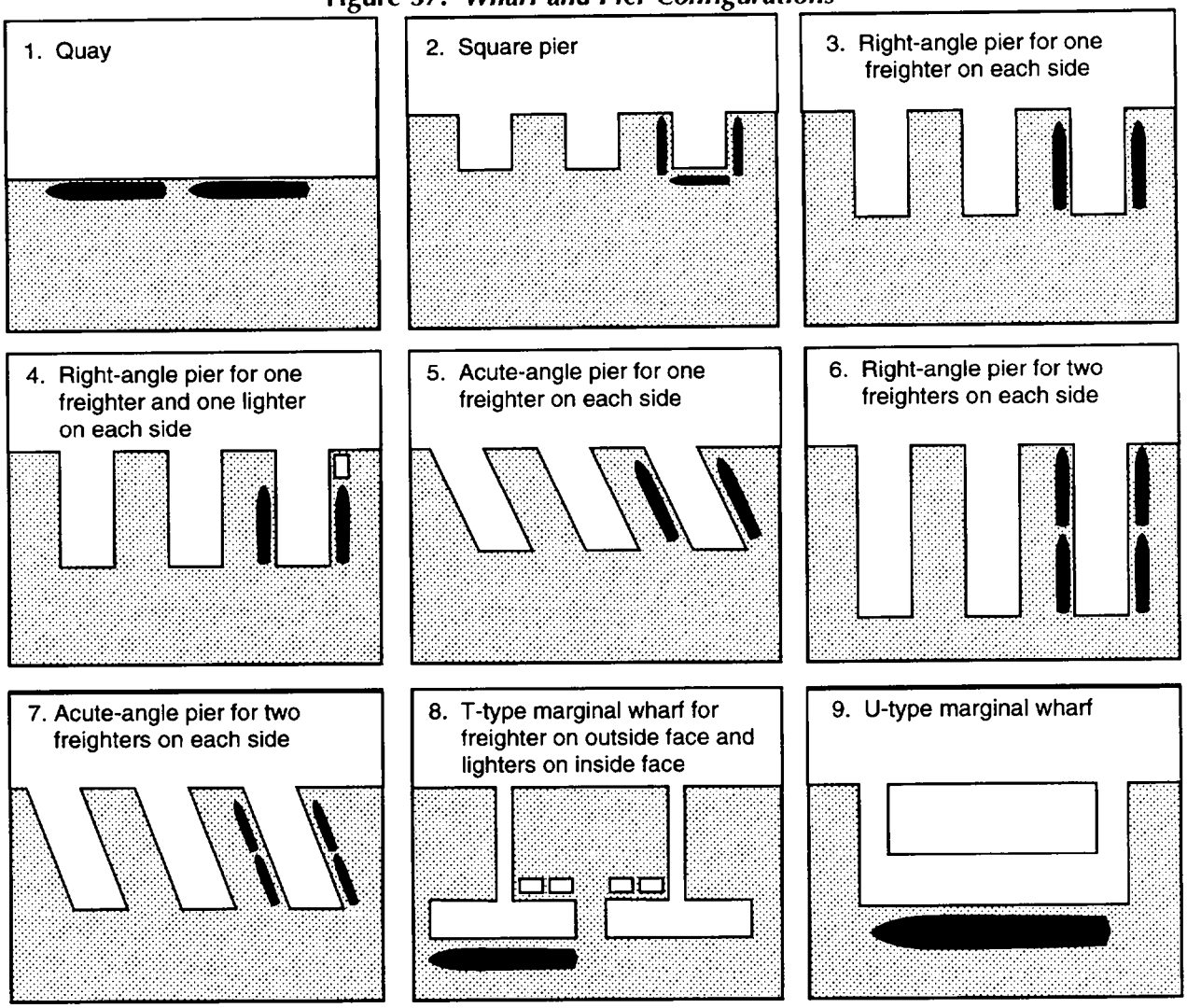


Figure 37. *Wharf and Pier Configurations*



EXPEDIENT PORT OPERATIONS

Imaginative (sometimes makeshift) operations are unavoidable when no convenient seaport is available, terminals lack modern amenities, or facilities are badly damaged. Such conditions are common in underdeveloped coastal countries and during wars.

Cold War Competition. U.S. military sealift during the Cold War was poorly prepared to compete with the Soviet Union and its surrogates, because the shrinking U.S. Merchant Marine, tailored mainly for commerce rather than military emergencies, emphasized profitable albeit inflexible container ships over self-sustaining, break-bulk tramp steamers that not only welcomed dry cargo in assorted sizes and shapes but plied much of their trade in small ports that afforded few amenities. LSTs, heavy lift helicopters, and time-consuming expedients had to help container ships unload weapons, equipment, and supplies for U.S.

armed forces in Vietnam. Soviet merchant fleets in contrast featured smaller ships well adapted for business in primitive ports plagued by shallow water and skimpy facilities.[40]

Prefabricated Harbor and Port Facilities. The most elaborate logistical operation ever attempted over open beaches took place during the Normandy invasion before Allied troops captured Cherbourg on the northern tip of the Cotentin Peninsula.[41] More than 80 ships filled with sand were sunk stem-to-stern in 12 to 15 feet (4 to 5 meters) of water where they formed five breakwaters code named Gooseberries, behind which small ships and landing craft could unload at low tide.

Large transports, however, needed better shelters. Two artificial harbors code named Mulberries A and B were designed and developed in Great Britain, towed across the English Channel by seagoing tugs, then installed off Omaha Beach at Vierville-sur-Mer and at Arromanches-les-Bains off Gold Beach 10 miles farther east. Each consisted of 50-some hollow concrete building blocks called Phoenixes, most of which measured 200 x 60 x 60 feet (61 x 18 x 18 meters). Floating breakwaters, pierheads, and causeways that rose and fell with each tide completed the complex with gratifying results: 74,000 troops, 10,000 vehicles, and 17,000 tons of supplies funneled inland during the first week.

Prospects for improvement were salutary until the worst storm in 40 years struck on June 19, 1944. Winds whipped in at 40 knots (stronger in gusts), waves washed over the Gooseberries, and spring tides amplified pounding surfs. Mulberry A was an irreparable wreck when calmer weather returned 4 days later, but that short-lived project nevertheless paid off handsomely during early days when rapid buildups were imperative.

Logistical benefits after Cherbourg fell into U.S. hands on July 26, 1944, initially were scant, because German defenders methodically destroyed most port facilities before they surrendered. Sea water poured through craters in the western breakwater; sunken ships and 20,000 cubic yards of masonry blocked basins; and quay walls and cranes were demolished or damaged so severely that Hitler awarded the Knight's Cross to Admiral Hennecke, whose forces conducted the demolitions. Rehabilitation, however, progressed so swiftly that Cherbourg within 4 weeks was handling more heavy freight than during its palmiest days in peacetime. More than one-fourth of all Allied cargo landed in Normandy passed through that port before over-the-beach operations ceased in November.

Practical Improvements. Visionaries in search of cost-effective ways to establish artificial port facilities expeditiously in out-of-the-way places have investigated an alphabet soup of candidates that variously included Logistics Over the Shore (LOTS) and a Ship-Helicopter Extended Delivery System (SHEDS). Recent proposals such as Mobile Offshore Bases (MOBs) and Landing Ship Quay/Causeways (LSQ/C) are much more ambitious, but nevertheless seem promising.[42]

LSQ/C concepts envision a large ship, likely a converted tanker, that would ballast down to rest on the ocean floor in water 40 to 50 feet deep (12 to 15 meters). Designers predict that engineers could connect each such quay with 3,000 feet of double-decked causeway (915 meters) in less than 72 hours, even if buffeted by 25-knot winds and 12-foot waves (sea state 5). Programmed capabilities would permit two container ships, break-bulk transports, or RO/ROs to moor alongside and simultaneously discharge cargoes for further conveyance ashore, while pumps and flexible pipelines would transfer petroleum and potable water. MOBs, which would function as floating logistical bases, contemplate six semisubmersible

modules apiece, each of which could, if developed, furnish more than 2.7 million usable square feet of environmentally controlled storage space (250,000 centares) for use as follows:

Options	*Dry Cargo*	*Liquid Cargo*
A	115,000 short tons	26,000,000 gallons
B	145,000 short tons	20,000,000 gallons
C	164,000 short tons	14,600,000 gallons

Proponents praise MOBs for potential capabilities that outstrip competitive proposals, while skeptics point out flaws. Whether mechanisms that link such massive structures could tolerate hurricane-force shearing strains is subject to speculation. Temporary decoupling might suffice in such situations, but total program costs could be prohibitive at $2 to $3 billion per copy in 1996 dollars, because several Mobile Offshore Bases would be needed to cover widely separated contingencies. MOBs moving at the advertised rate of 8 to 10 knots might arrive too late to be useful if positioned far from erupting crises.

SPACEPORTS AND FLIGHT PATHS

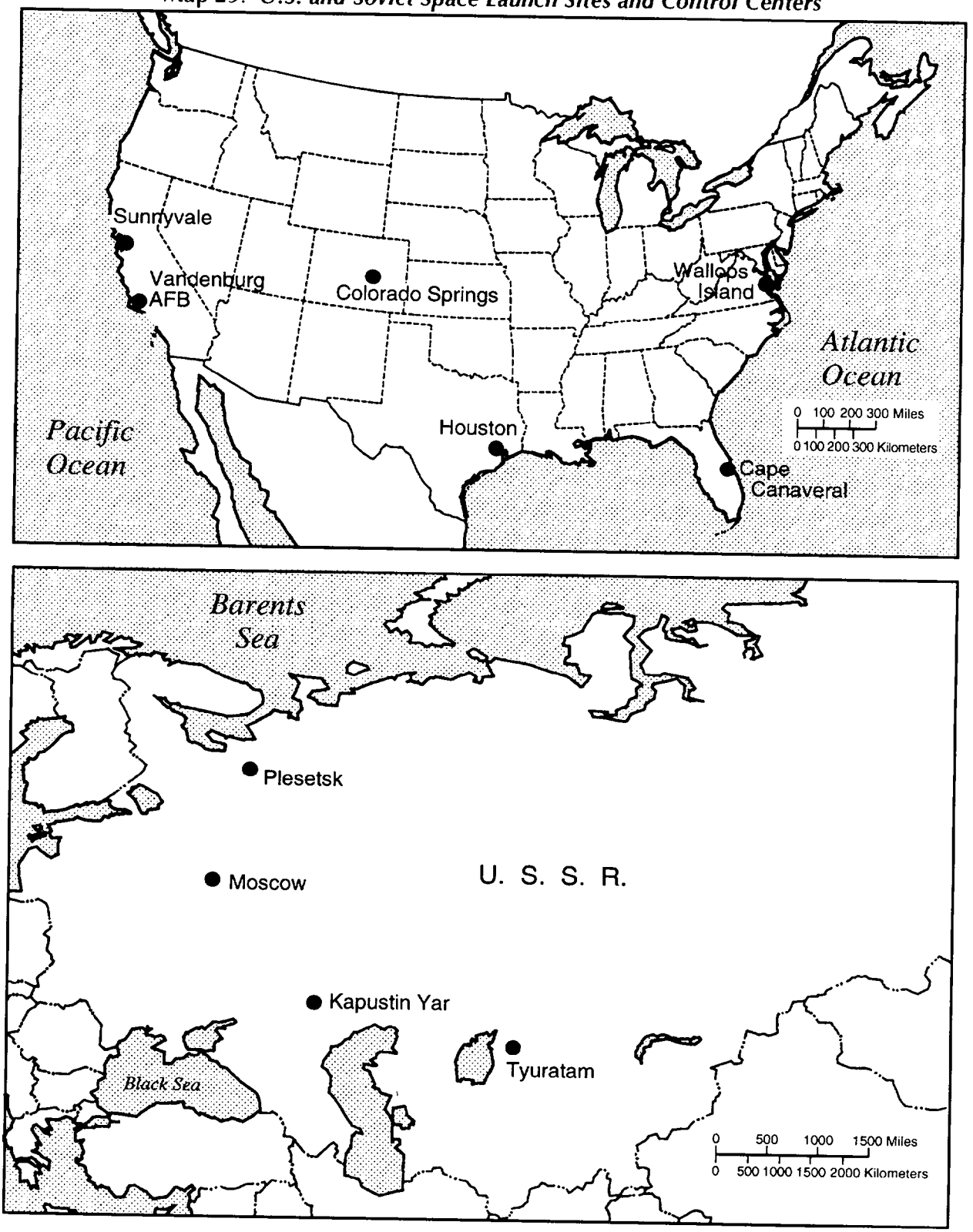
Military lines of communication to and from space start and end with spaceports that are located exclusively on Earth at this moment, but almost certainly will appear on the moon and the nearest planets at unpredictable future dates. Such installations and flight paths that connect them must satisfy operational demands that differ significantly in several respects from civilian requirements.

MILITARY SPACE INFRASTRUCTURE

Civilian spaceports able to launch and retrieve passenger and cargo flights with the same regularity and degree of confidence that commercial airlines currently enjoy would be praiseworthy indeed, whereas military spaceports additionally must be able to perform all assigned missions competently in combat. Requirements ideally include fixed-site control centers, mobile command posts, redundant communication facilities, and secure logistical installations.

Military space officials in the Soviet Union had physical security firmly in mind when they located key infrastructure in remote regions at the height of the Cold War: armed forces and fortifications between the Baltic and Barents Seas protected Plesetsk; neither Tyuratam nor Kapustin Yar was near a large city or unfriendly frontier; and all three installations were safe from long-range missile attacks unless a general nuclear war erupted (map 29). Senior U.S. officials in contrast had peacetime safety measures rather than wartime survivability in mind when they located space launch sites close to coasts at Cape Canaveral, Florida, Wallops Island, Virginia, and Vandenberg Air Force Base, California, so that unsuccessful flights would fall harmlessly into the ocean. All consequently were, and still are, vulnerable to short-range sea-launched missiles and saboteurs who inhabit urban sanctuaries. The U.S. military space control center at Sunnyvale, California not only sits on a seashore, but straddles the San Andreas Fault, a potential earthquake epicenter.[43]

Map 29. *U.S. and Soviet Space Launch Sites and Control Centers*



PREDICTABLE FLIGHT PATHS

Objects in our Universe all orbit around the Earth, its moon, other planets, the sun, or stars, which makes military flight paths in space just as predictable as the routes that roads and railways follow. Accurate antisatellite weapons (ASATs) consequently could imperil strategic warning, reconnaissance, surveillance, communications, weather, navigation, and logistical satellites on their appointed rounds (map 30) until effective countermeasures such as maneuverable spacecraft and counter-ASAT defenses become available.[44]

INLAND WATERWAYS

Navigable rivers, canals, lakes, inland seas, and intracoastal connections make militarily useful LOCs where other lines of communication are lacking or less economical. Inland waterways also supplement or supplant roads, tracks, and trails in densely forested or swampy regions where air landing zones are scarce. Logisticians who load bulk consignments onto boats and barges can reserve faster modes of transportation for high-priority shipments.

UNIQUE CONSIDERATIONS

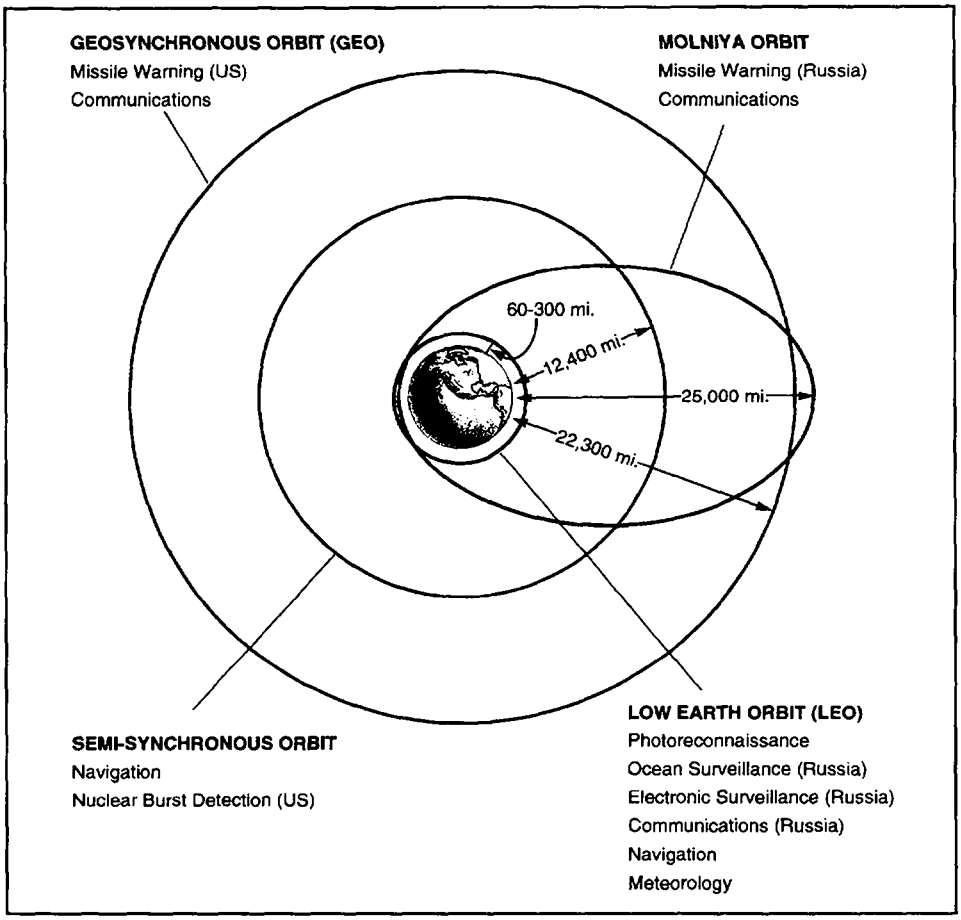
Data needed to evaluate inland waterways in many respects are much like those related to roads and railways. Common concerns include distances between selected points, horizontal and overhead clearances, obstacles, and the numbers, types, and capacities of locally available conveyances together with mechanical handling, storage, repair, and maintenance facilities. Considerations such as channel widths, controlling depths, freezing dates, navigational aids, wharfage, and dredging demands parallel those associated with seaports. Several informational requirements, however, are unique:

- Current directions, fluctuations in speed, and tendencies of channels to shift
- The condition of banks and bottoms
- The location and influence of rapids and waterfalls, plus portage possibilities
- The frequency, duration, and effects of floods and low water levels
- The presence or absence and influence of levees
- The location, description, restrictive effects, and vulnerability of locks, dams, safety gates, and ferry crossings
- The availability of bargemen and lock tenders.

TACTICALLY USEFUL WATERCOURSES

Intratheater watercourses serve military purposes to great advantage, provided they are easily accessible, mainly navigable, reasonably dense, and oriented in required directions. Webs such as those that crisscross Western Europe and the Mekong Delta have played prominent roles in the relatively recent past. Inland waterways, however, are no more immune to natural and manmade impediments than other lines of communication. Freeze-ups seasonally stop traffic in cold climes, floods that follow thaws cause depths to fluctuate, rapids and waterfalls bar the way where gradients are steep, and newly-deposited sandbars menace navigation in slowly meandering streams. Enemies and "acts of God" may damage locks, drain canals, block river channels, and destroy or dismantle facilities. The Kiel, Wilhelm, Dortmund-Ems, and other canals built above ground level behind high levees in

Map 30. *Earth Support Satellite Orbits*



Adapted from "Satellites and Anti-Satellites" by Ashton B. Carter, *International Security*, Spring 1986.

Germany oppose cross-country movement by motor vehicles, reduce flat-trajectory fields of fire and, if ruptured, would flood adjacent lowlands

Commanders with resourceful subordinates even so sometimes work miracles along unfriendly waterways. Such was the case in autumn 1944, when General William Slim, on the banks of the Chindwin River in Burma, turned to his chief engineer and said, "Billy, there's the river and there are the trees. In two months I want five hundred tons of supplies a day" down that stream. He got them. Elephants lugged huge teak logs to an improvised shipyard where Burmese laborers under British supervision built several hundred "dumb barges." They "looked like Noah's arks," but carried 10 tons apiece and three lashed together could take a Sherman tank. Marine engines, dismantled and delivered by aircraft, provided power, while two pseudo "warships," each armed with one 40-mm Bofors gun, two 20-mm Oerlikons, and a couple of .30-caliber twin Browning antiaircraft guns provided protection.[45]

STRATEGICALLY CRUCIAL CANALS

Intertheater canals, unlike intratheater counterparts, tend to be strategically rather than tactically significant. One such sluiceway connects the Barents, Baltic, and Black Seas. The

Panama Canal links the Atlantic and Pacific Oceans, while the Suez Canal simplifies movement from the Mediterranean to the Indian Ocean.

Barents to Black Sea Connections. Colonel Sir Edward May, in his seminal writings entitled *Geography in Relation to War*, noted that Czarist Russia in the interest of sea power "projected the construction of a canal from Riga on the Baltic to Kherson on the Black Sea" early in the 20th century. Soviet nuclear-powered submarines built at Gorky seven decades later followed that route to Leningrad during warm weather, where they finished fitting out and, like destroyers and smaller surface ships, thereafter joined the Northern Fleet by way of inland waterways to the Barents Sea. All Soviet naval forces assigned to the Black Sea Fleet fed into the Mediterranean through the Turkish Straits (the Bosporus, Sea of Marmara, and Dardenelles), save submarines whose passage still is restricted in peacetime by the Montreux Convention of 1936. Russian and Ukrainian surface combatants honor that treaty today.[46]

Panama Canal. The United States is twice blessed by sheltered naval bases on ice-free coasts that open onto the world's largest oceans and, in turn, on every continent. The U.S. Navy since 1914 has been able to shift forces from the Atlantic to the Pacific and back again through the Panama Canal to weight whatever effort takes priority. Table 22 illustrates time/distance savings that naval ships (excluding large aircraft carriers and supertankers) gain by passage through the Panama Canal. Treaties that granted sovereignty to Panama in 1979 and will confer operational control in the year 2000 preserve those U.S. prerogatives.

Suez Canal. The Suez Canal, which opened in 1869, remained economically beneficial to all until 1948, when the Egyptian Government banned ships en route to and from the infant state of Israel. The canal has been closed twice since then: first from November 1956 until March 1957, because Israeli, British, and French invasions prompted Egyptian President Gamal Abdel Nasser to sink ships in the narrow freeway; then from the onset of the Six-Day War in June 1967 until June 1975, when sunken ships once again choked the channel.[47]

The Suez Canal never recovered *economically* from those two prolonged closures, which prompted petroleum producers to rely increasingly on fast supertankers that took other routes, but its *strategic* importance soared. U.S. Armed Forces and their allies benefited as long as the Canal was closed, because Soviet sea lines of communication from Europe to the Indian Ocean led all the way around Africa. Competition sharpened considerably after a stream of warships flying the hammer and sickle started to use the Suez shortcut in 1975. The U.S. Navy during the 1990-91 war with Iraq found that watercourse strategically valuable, because it reduced distances between the U.S. eastern seaboard and Persian Gulf ports by about 3,000 nautical miles (5,560 kilometers) and trimmed merchant ship transit times by eight or nine days compared with trips past the Cape of Good Hope.

PIPELINES

Welded steel pipes laid under ground or on the surface are the most expeditious and economical way to transport petroleum, natural gas, and water over land. Some lines run cross-country, while others follow established routes. The capabilities of petroleum pipelines, which generally vary in diameter from 4 to more than 40 inches (10 to 100 centimeters), are calculated in barrels, metric tons, or cubic meters per day. Conduits reserved for crude oil contaminate refined products unless attendants first clean them thoroughly, a costly, time-consuming process, but most lines accept gasoline, jet fuel,

kerosene, and diesel in batches that minimize mixing. Associated facilities include pumps for liquids and compressors for natural gas, assorted valves, manifolds, and meters.

Table 22. *Advantages Available from the Panama Canal*

	Nautical Miles	*Total Elapsed Time at 20 Knots*
San Diego, CA, to the Eastern Mediterranean		
Via Panama Canal	8,875	21 days
Via Cape Horn	13,850	30 days
Time/Distance Saved	4,975	9 days
Norfolk, VA, to Pusan Korea		
Via Panama Canal	9,900	22 days
Via Cape of Good Hope	14,825	31 days
Time/Distance Saved	4,925	9 days

POLITICAL PERILS

Most civilian pipelines are unobtrusive, but a few attract strong criticism. Political and ecological complaints accompanied by land claims of irate natives could have, but did not, turn violent during the construction of giant pipelines on Alaska's North Slope after prospectors discovered extensive petroleum deposits at Prudhoe Bay.[48] Pipelines that cross international boundaries may also provoke disputes. Iraq, for example, lost three links between oil fields at Kirkuk and the outside world beginning in 1948, when Israel took control of the terminal at Haifa. Syria's President Hafez al-Assad eliminated a second outlet at Tripoli, Lebanon, when Saddam Hussein went to war with Iran in 1980 despite Syrian objections. Neither of those lines has ever reopened. Turkey turned off the third tap in 1990 after Iraq seized Kuwait and kept it closed until December 1996.[49]

MILITARY APPLICATIONS

The most innovative military pipeline, aptly dubbed Operation *Pluto* (Pipeline Under the Ocean), delivered petroleum to Allied forces in France after the Normandy invasion. Specialists welded 20-foot lengths of 3-inch pipe into 4,000-foot rolls (1,220 meters), then wound them on huge hollow bobbins, each of which fully loaded tipped scales at 1,600 tons, a weight then equivalent to that of an average destroyer. Three tugboats towed those monsters while they payed out four pipes on the sea bottom between the Isle of Wight and Cherbourg. Army engineers thus laid pipe hundreds of miles inland as fast as they could to reduce strains on already overcommitted truck drivers and overcrowded roads.[50] Petroleum pipelines that served similar purposes in NATO Europe during the Cold War as well as in Korea, Vietnam, and Southeast Asia during shooting wars seemed simple by comparison.

KEY POINTS

- The success of most military operations depends on secure LOCs of adequate capacity.
- The nodes along any line of communication are its most vulnerable and inviting targets.
- Plans and programs that underestimate the number of engineer units needed to construct, improve, and maintain suitable roads, rail lines, sea ports, space ports, inland waterways, and pipelines may seriously jeopardize military operations.
- Extensive air and missile defense forces plus large numbers of ground combat troops may be needed to secure LOCs with many weak points and bottlenecks that are vulnerable to enemy attack along lengthy routes or at terminals.
- Combat and support aircraft with very short or vertical takeoff and landing (VSTOL, VTOL) capabilities would greatly reduce airfield construction requirements and increase the number of potentially suitable sites.
- Self-sustaining, break-bulk, shallow-draft transports and RO/ROs afford far greater flexibility than container ships wherever available port facilities are poorly developed or destroyed.
- The world still awaits mobile, prefabricated harbor and port facilities that are practical as well as cost-effective.
- The first highly-capable anti-satellite weapon systems will endanger space LOCs until scientists and technologists devise effective defenses and maneuverable spacecraft.

NOTES

1. Antoine Henri Jomini discussed interior and exterior lines of communication in *The Art of War*, trans. G. H. Mendell and W. P. Craighill (Westport, CT: Greenwood Press, 1862), 91-120.
2. George S. Patton, Jr., *War As I Knew It* (Cambridge, MA: Riverside Press, 1947), 93.
3. Trevor N. Dupuy, *Elusive Victory: The Arab-Israeli Wars, 1947-1949* (New York: Harper and Row, 1978), 105-111.
4. FM 5-36: *Route Reconnaissance and Classification* (Washington, DC: Dept. of the Army, March 1985), 2-1 through 2-6, 3-45 through 3-48.
5. Ibid.
6. Dwight D. Eisenhower, *Crusade in Europe* (Garden City, New York: Doubleday, 1948), 308.
7. Thomas Macaulay, "Horatius At the Bridge," *Lay of Ancient Rome*, 1842. See also a parody by William C. Hall, "A Medal for Horatius," *Combat Forces Journal* (January 1955).
8. Ed Cunningham, "The Bridge At Remagen," *Yank—The GI Story of the War* (New York: Duell, Sloan, and Pearce, 1947), 295-207; *The Remagen Bridgehead: 7-17 March 1945* (Fort Knox, KY: The Armor School, 1948).
9. FM 5-33: *Terrain Analysis* (Washington, DC: Dept. of the Army, July 1990), 2-13 and 2-14; FM 5-36: *Route Reconnaissance and Classification*, 3-6.
10. FM 5-25: *Explosives and Demolitions* (Washington, DC: Dept. of the Army, March 1996), 4-46 and 4-47, 4-51 through 4-70 passim; FM 5-36: *Route Reconnaissance and Classification*, 3-8 and 3-9, 3-13 through 3-40.
11. FM 5-36: *Route Reconnaissance and Classification*, 2-36 through 2-47; FM 5-33: *Terrain Analysis*, 2-15 and 2-16.
12. FM 5-36: 2-22 through 2-26; FM 5-33: 2-15.

13. H. Milton Duesenberg, *Alaska Highway Expeditionary Force: A Roadbuilder's Story* (Clear Lake, IO: H&M Industries Ltd., 1994); Kenneth Coates and William R. Morrison, *The Alaska Highway in World War II* (Norman, OK: University of Oklahoma Press, 1992).

14. Frank N. Schubert, "U.S. Army Corps of Engineers and Afghanistan's Highways 1960-1967," *Journal of Construction Engineering and Management* (September 1991): 445-459.

15. Tan Pei-Ying, *The Building of the Burma Road* (New York: McGraw-Hill, 1945), 37-38. 69, 97-104. See also Leslie Anders, *The Ledo Road: General Joseph W. Stilwell's Highway to China* (Norman, OK: University of Oklahoma Press, 1965).

16. Pei-Ying, *The Building of the Burma Road*, 105-127, and Leo T. Daugherty III, "interservice and Interallied Cooperation in China-Burma-India," *Joint Force Quarterly*, no. 12 (Summer 1996): 95-105.

17. David R. Mets, *The Quest for a Surgical Strike* (Eglin Air Force Base, FL: Air Force Systems Command Monograph, Armament Division, 1987); Eliot Cohen, "A Bad Rap Against High Tech: The GAO's Misguided Missile Against Gulf War Weaponry," *Washington Post*, July 19,1996, 15.

18. FM 5-25: *Explosives and Demolitions.*

19. Edward Mead Earl, ed., *Makers of Modern Strategy: Military Thought From Machiavelli to Hitler* (Princeton, NJ: Princeton University Press, 1943), 148-152, 177; Trevor N. Dupuy, *A Genius for War: The German Army and General Staff, 1807-1945* (Englewood Cliffs, NJ: Prentice-Hall, 1977), 66.

20. George Edgar Turner, *Victory Rode the Rails: The Strategic Place of Railroads in the Civil War* (Indianapolis, IN: Bobbs-Merrill, 1953); Thomas Weber, *The Northern Railroads in the Civil War, 1861-1865* (New York: Kings Crown Press, 1952).

21. "The Great Locomotive Chase: Andrews Raiders," *Above and Beyond: A History of the Medal of Honor from the Civil War to Vietnam* (Boston, MA: Boston Publishing, 1985), 18-21.

22. John E. Murray, "Logistics, Limited War," in *International Military and Defense Encyclopedia*, vol. 3 G-L, eds. Trevor N. Dupuy, et al. (Washington, DC: Brassey's, 1993), 1517-1529.

23. *Civil Rail Lines Important to National Defense* (Newport News, VA: Military Traffic Management Command, Transportation Engineering Agency, December 1993).

24. FM 30-10: *Terrain Analysis* (Washington, DC: Dept. of the Army, March 27,1972), 97-98. Superseded by FM 5-33: *Terrain Analysis*, July 30, 1990, but contains a better checklist.

25. Richard C. Overton, "Railroads," *Microsoft Encarta 96.*

26. Ibid.; FM 5-33: *Terrain Analysis*, 2-7 through 2-9.

27. *U.S. Strategic Bombing Survey*, with an intro. by David MacIssac (New York: Garland Publishing, 1976), vol. 6, especially 1-3, 50-61, 74-79.

28. John E. Murray, "Railroaders Tour Soviet Union," *Defense Transportation Journal* (August 1987): 20-27; *Unconventional Wisdom—The Soviet Need for Sea Lines of Communication*, Memorandum for the Secretary of the Navy (Washington, DC: Office of the Secretary of the Navy, December 19, 1985).

29. Michael Dobbs, "Siberians Say 'No' to Stalin's Railroad," *Washington Post*, October 2, 1989, A1, A22

30. Jim Lackey, "Airlift's Achilles' Heel," *Armed Forces Journal International* (July 1996): 42.

31. FM 5-430-00-2, Air Force Joint Pamphlet 32-8013, *Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations*, vol. 2, *Airfield and Heliport Design* (Washington, DC: Dept. of the Army and Dept. of the Air Force, September 1994), 10-9, 11-10 and 11-11, 11-14; FM 5-36: *Route Reconnaissance and Classification*, 4-7, 4-8, 4-9 and 4-10.

32. FM 5-430-00-2: *Airfield and Heliport Design*, 11-14; FM 5-33: *Terrain Analysis*, 2-30.

33. FM 5-30: *Route Reconnaissance and Classification*, 4-9; FM 5-430-00-2: *Airfield and Heliport Design*, 11-7, 11-14; FM 5-33: *Terrain Analysis*, 7-5.

34. FM 5-430-00-2: *Airfield and Heliport Design*, 10-7 and 10-8.

35. Peter Bogart, "The Soviet Transport Air Force: Aircraft and Capabilities," *International Defense Review* (June 1979): 945-948; William Schneider, Jr., "Soviet Military Airlift: Key to Rapid Power Projection," *Air Force Magazine*, March 1980, 81-83.

36. FM 5-430-00-2: *Airfield and Heliport Design*, 10-10 and 10-11.

37. Virginia Cowles, *The Phantom Major* (New York: Harper and Brothers, 1958), especially 196-208; Callum McDonald, *The Lost Battle: Crete 1941* (New York: Free Press, 1993), 301.

38. *UK Eagle*, April 27, 1962, 1; *Bury Free Press*, April 21, 1962, 1; amplified by Robert C. Kingston on December 7, 1996.

39. FM 5-33: *Terrain Analysis*, 2-19 through 2-26.

40. John D. Chase, "U.S. Merchant Marine—for Commerce and Defense," *U.S. Naval Institute Proceedings* (May 1976): 133-134; Richard T. Ackley, "The Soviet Merchant Marine," *U.S. Naval Institute Proceedings* (February 1976): 27-37.

41. Gordon A. Harrison, *Cross-Channel Attack, United States Army in World War II: The European Theater of Operations* (Washington, DC: Dept. of the Army, Office of the Chief of Military History, 1951), 73-74, 423-426, 441-442; John M. Collins, *Military Geography of the Normandy Campaign* (Master's thesis, Clark University, Worcester, MA, 1951),120-130.

42. *Landing Ship Quay/Causeway* and *Mobile Offshore Bases*, promotional materials (Houston, TX: Brown and Root and associated companies, 1996); Dale Eisman, "By Golly! Pentagon Considering a Floating Airport," *Virginian Pilot*, October 29, 1996, 1.

43. Hans Mark, "Warfare in Space," in *America Plans for Space* (Washington, DC: National Defense University Press, 1986), 23; *Military Space Operations: Shuttle and Computer Systems do not Meet Performance Objectives* (Washington, DC: Government Printing Office, August 1988), 2-5, 27-29.

44. For basic background, see Curtis D. Cochran, Dennis M. Gorman, and Joseph D. Dumoulin, eds., *Space Handbook* (Maxwell Air Force Base, AL: Air University Press, January 1985).

45. Field-Marshal Viscount Slim, *Defeat into Victory* (New York: David McKay, 1961), 332-333.

46. Sir Edward S. May, *Geography in Relation to War* (London: Hugh Rees, 1907), 53; John M. Collins, *U.S-Soviet Military Balance, 1960-1980* (Washington, DC: McGraw-Hill, 1980), 244.

47. Alan B. Mountjoy, "Still Waters of Suez," *Geographical Magazine*, June 1971, 649-54; "Suez Canal—Key to Soviet Strategy in the Mideast," *U.S. News and World Report*, June 22, 1970, 22-24.

48. Mary Clay Berry, *The Alaska Pipeline: The Politics of Oil and Native Land Claims* (Bloomington, IN: Indiana University Press, 1975).

49. Helen Chapin Metz, ed., *Iraq: A Country Study*, 4th ed. (Washington, DC: Federal Research Division, Library of Congress, 1990), 136; "Saddam Turns on Iraq's Oil-Export Pipeline," *Washington Post*, December 11, 1996), A18.

50. Collins, *The Military Geography of the Normandy Campaign*, 130-132.

12. MILITARY BASES

The thoughts of others
were light and fleeting
of lovers' meeting
or luck and fame
Mine were of trouble
and mine were steady
so I was ready
when trouble came.

Alfred Edward Housman
More Poems, 1936

READINESS AND SUSTAINABILITY ARE EQUALLY IMPORTANT COMPONENTS OF MILITARY PREPAREDNESS, because neither rapidly deployable forces that lack staying power nor durable forces that arrive late can consistently accomplish assigned missions at conscionable costs. All armed forces consequently require home bases where they can hone essential skills while they await calls to action. Those with regional or global responsibilities additionally benefit from bases and facilities abroad, which buttress deterrence, shorten reaction times when far distant contingencies arise, and simplify sustainability.

U.S. HOME BASES

The armed forces of every nation need home bases where they can develop, organize, equip, train, administer, manage, logistically support, and otherwise prepare to accomplish assigned missions, as extensive installations in the United States amply illustrate. All U.S. military posts, camps, stations, forts, arsenals, air bases, naval bases, and space centers include living quarters, mess halls, and facilities associated with primary functions.[1] Most of them additionally contain commissaries, post/base exchanges, recreational outlets, hospitals, clinics, family housing, elementary and secondary schools, together with community services typified by child care centers.

Some installations are small, while others are comparable in size to thriving cities—populations at 10 different Army bases exceeded 10,000 in 1997 (Fort Hood, Texas, with 130,000, was the largest of the lot). Many reserve huge tracts of land for basic, advanced, combined arms, and joint training. Maneuver room at the National Training Center near Fort Irwin, California, sprawls over 636,000 acres, but that seems insignificant compared with the "shooting gallery" at Nellis Air Force Base northeast of Las Vegas, Nevada, which covers 4,700 square miles (12,175 square kilometers), an area only slightly smaller than the State

of Connecticut, within which aircraft armed with bombs and air-to-surface missiles can test new weapon systems and sharpen their skills.[2]

Some installations serve specialized purposes. The manpower intensive U.S. Army, for example, emphasizes progressive military education, which originates at the U.S. Military Academy in West Point, New York, in the Officer Candidate School at Fort Benning, Georgia, and with Reserve Officer Training Corps (ROTC) courses at many civilian colleges. Selected commissioned officers matriculate at the Command and General Staff College (Fort Leavenworth, Kansas) and the Army War College (Carlisle Barracks, Pennsylvania) only after they complete basic and advanced courses at one of the following schools:

Infantry (Fort Benning, GA)	Engineer (Fort Leonard Wood, MO)
Armor (Fort Knox, KY)	Signal (Fort Gordon, GA)
Field Artillery (Fort Sill, OK)	Transportation (Fort Eustis, VA)
Special Forces (Fort Bragg, NC)	Ordnance (Aberdeen Proving Ground, MD)
Air Defense Artillery (Fort Bliss, TX)	Quartermaster (Fort Lee, VA)
Aviation (Fort Rucker, AL)	Chemical (Fort McClellan, AL)
Intelligence (Fort Huachuca, AZ)	Military Police (Fort McClellan, AL)

The technology intensive Air Force places great store in experimental facilities typified by the Aeronautical Systems Center and Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio; the Air Force Development Test Center at Eglin AFB, Florida; Phillips Laboratory and the Air Force Operational Test and Evaluation Center at Kirtland AFB on the outskirts of Albuquerque, New Mexico; and the world famous Air Force Flight Test Center at Edwards AFB, California.

Most major U.S. Navy and Marine Corps bases, unlike those of the Army and Air Force, are close to the east and west coasts, where they respectively support the U.S. Atlantic and U.S. Pacific Fleets, as shown in the table on the next page.

U.S. COLD WAR BASES ABROAD

No nation, not even the British Empire at its zenith, deployed armed forces at as many military installations beyond its borders as the United States of America did during the Cold War. They were unusual compared with most bases abroad, being sited on the sovereign territory of allies and other friends with whom the U.S. Government negotiated mutually acceptable Status of Forces Agreements that legally prescribed U.S. rights, privileges, and limitations. All such bases and facilities exploited geographical positions that promoted U.S. security interests, affirmed U.S. global involvement, extended U.S. military reach, and strengthened U.S. alliance systems. They also positioned U.S. Armed Forces to deter Soviet aggression and respond most effectively if required.

The buildup began in 1947, after Stalin rang down an Iron Curtain in Central Europe and communism everywhere seemed to be on the march. U.S. strategists, in response, concluded eight mutual defense pacts with 42 countries by 1960, plus executive agreements and other formal pledges with 30-some others (table 23). Most U.S. military deployments on foreign

Service	*East Coast*	*West Coast*
Navy		
Surface Combatants	Norfolk, VA Mayport, FL	San Diego, CA Pearl Harbor, HA
Submarines	New London, CT Kings Bay, GA	San Diego, CA Bangor, WA
Amphibious, Specwar	Little Creek, VA	Coronado, CA
Air Stations	Jacksonville, NC Pensacola, FL Oceana, VA	Lemoore, CA Miramar, CA North Island, CA
Marine Corps		
Boot Camps	Parris Island, NC	San Diego, CA
Fleet Marine Forces	Camp Lejeune, NC	Camp Pendleton, CA
Air Stations	Cherry Point, NC New River, NC Beaufort, SC	El Toro, CA Tustin, CA

soil thereafter sought to prevent further expansion by the Soviet Union, its East European satellites, Communist China, surrogate states, and "fellow travelers" such as Cuba.

Nearly 1,700 U.S. installations, large and small, eventually circled the Northern Hemisphere in locations selected especially to monitor military activities inside the Soviet Union, ensure early warning if Soviet Armed Forces attacked, and block the most likely land, sea, and air avenues of Soviet advance. The greatest concentrations consequently crossed the Canadian arctic, crested in NATO Europe, and appeared along East Asia's rim.

ARCTIC OUTPOSTS

The United States and Canada installed a string of warning sites to alert defenders of air and intercontinental ballistic missile (ICBM) attacks launched from the Eurasian land mass over North Polar paths toward North America. Three overlapping ballistic missile early warning system (BMEWS) fans extended 3,000 miles (4,825 kilometers) northward from radar sites in Clear, Alaska, Thule, Greenland, and Fylingdales Moor, England (map 31). Their mission was to detect, identify, track, compute trajectories, and predict general impact areas for use by civil defense officials and retaliatory forces assigned to U.S. Strategic Air Command (SAC).[3]

Eighty-one Distant Early Warning (DEW) Stations, draped 4,000 miles (6,435 kilometers) along the 70th Parallel from the Aleutian Islands to the Atlantic Ocean, watched for enemy bombers in the early 1960s (map 32). Mid-Canada and Pine Tree Lines, augmented by a generous group of gap-filler radars, provided back-ups farther south, but that complex shrank considerably as soon as better technologies became available. SAC deployed "short-legged" B-47 bombers at Goose Bay, Labrador, and Thule until long-range B-52s obviated that requirement, whereupon interceptor aircraft and nuclear-capable Nike Hercules

Table 23. *U.S. Cold War Collective Security Pacts*

MULTILATERAL TREATIES

Inter-American Treaty of Reciprocal Assistance (Rio Pact), 1947

United States	Cuba (Until 1962)	Nicaragua
Argentina	Dominican Republic	Panama
Bolivia	Ecuador	Paraguay
Brazil	El Salvador	Peru
Chile	Guatemala	Trinidad and Tobago
Colombia	Haiti	Uruguay
Costa Rica	Honduras	Venezuela
	Mexico	

North Atlantic Treaty Organization (NATO), 1949

United States	Iceland	United Kingdom
Belgium	Italy	Greece
Canada	Luxembourg	Turkey (1952)
Denmark	Netherlands	West Germany (1955)
France	Norway	Spain (1982)
	Portugal	

Security Treaty Between Australia, New Zealand, and the United States (ANZUS), 1951

Australia
New Zealand
United States

Southeast Asia Treaty Organization (SEATO), 1954, dissolved 1977

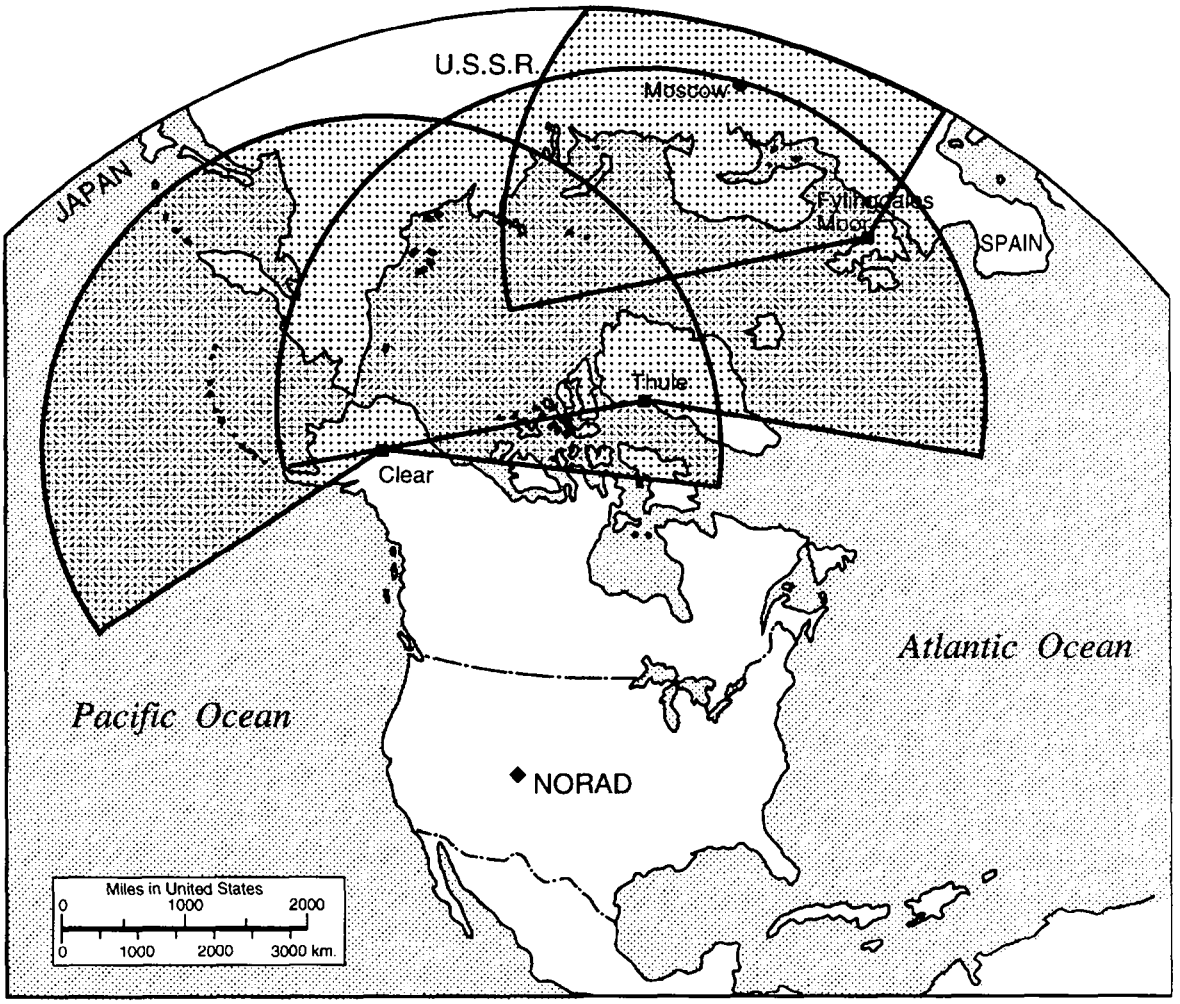
United States	New Zealand	Philippines
Australia	Pakistan	Thailand
France		United Kingdom

BILATERAL TREATIES

Mutual Defense Treaty with the Philippines (1951)
Mutual Defense Treaty with South Korea (1953)
Treaty of Mutual Security and Cooperation with Japan (1960)

surface-to-air missiles assigned to North American Air Defense Command (NORAD) occupied the latter base. Sondrestrom on Greenland's west coast and Keflavik, Iceland, served as air traffic control centers and "stepping stones" for pilots who ferried fighter planes across the North Atlantic. Patrol aircraft based at Keflavik Naval Air Station, aided by Underwater Sound Surveillance (SOSUS) systems, swept adjacent seas looking for enemy surface ships and submarines.[4]

Map 31. *Ballistic Missile Early Warning System (BMEWS)*



NATO'S NORTH FLANK

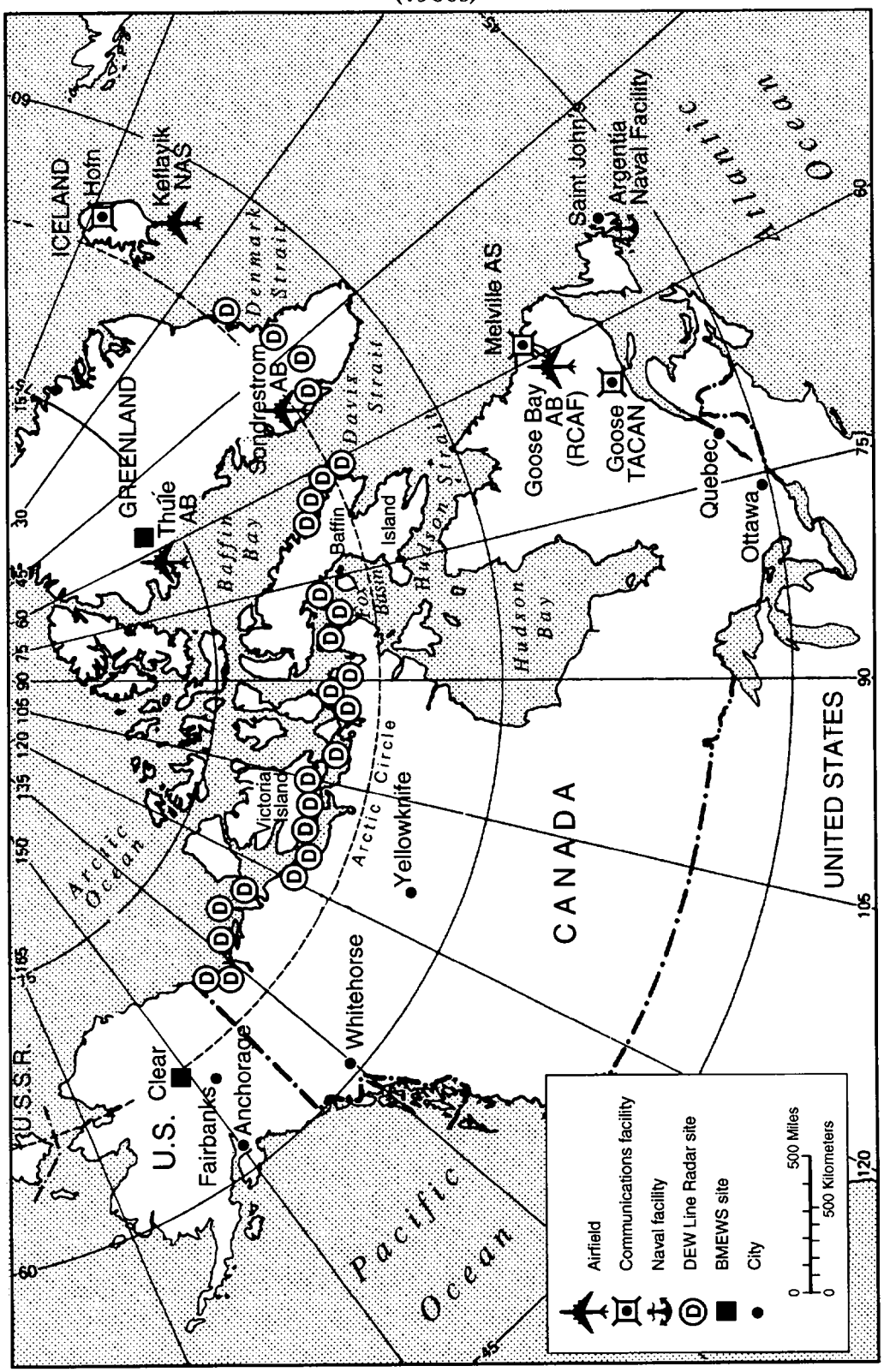
Norway's North Cape was ideally situated to observe Soviet activities along the ice-free Kola coast, which provided home ports for submarines and surface combatants of the Soviet Northern Fleet, but neither U.S. nor any other non-nordic NATO forces established permanent bases there or anywhere else in Norway, because the Norwegian Government forbade them to do so. Prepositioned stocks secured by Norwegians for use by a U.S. Marine Amphibious Force in emergency were the only U.S. assets ashore.[5]

NATO'S CENTER SECTOR

NATO's central region throughout the Cold War reached from the border between East and West Germany to the British Isles. U.S. and Allied aims during that protracted period, which lasted 40 years, were to deter aggression and, if deterrence failed, to defend NATO's territory with the fewest possible casualties, the least damage, and the least loss of territory.[6]

The Low Countries and the British Isles. Belgium, the Netherlands, and the United Kingdom (along with Italy and West Germany) briefly accepted U.S. ground-launched cruise

Map 32. *U.S. Cold War Arctic Outposts* (1960s)



Map 33. *U.S. Cold War Bases in Great Britain* (1979)



missiles (GLCMs) in the late 1980s until all were scrapped in accord with the bilateral U.S.-Soviet Intermediate Nuclear Force (INF) Treaty of May 1988.[7] U.S. military installations in the Netherlands otherwise never exceeded a tactical fighter wing at Soesterberg, three Army communication sites, a logistical center that supported Headquarters, Allied Forces Central Europe (AFCENT), and prepositioned stocks for two U.S. Army divisions. Most U.S. personnel in Belgium were associated in some way with the Supreme Headquarters, Allied Powers Europe (SHAPE) after French officials in 1967 banished the Supreme Allied Commander and his staff from Roucancourt, just outside Paris, but U.S. installations in Great Britain were diversified as well as numerous, as map 33 indicates. Six bases once housed tactical fighter wings, theater airlift aircraft, and tankers for in-flight refueling. Holy Loch, Scotland, was the forward operating base for a U.S. nuclear-powered ballistic missile submarine squadron, together with a tender. U.S. Air Force and Navy communication stations, radio relays, and logistical centers speckled the countryside.[8]

France. The French Government on March 7, 1966, declared its intent to regain "full sovereignty [over] French Territory—in other words, no longer to accept the presence of foreign units, installations, or bases in France falling in any respect under the control of authorities other than French authorities" and told NATO to comply or leave not later than April 1, 1967.[9] NATO's leaders elected eviction, whereupon the exodus code-named FRELOC (Fast Relocation) uprooted or resulted in the abandonment of many military installations accumulated at great expense over the previous 18 years.

Command and control arrangements were comparatively simple when SHAPE and Headquarters, U.S. European Command (EUCOM) were based in Parisian suburbs 15 minutes apart and lay within easy reach of AFCENT at Fontainbleau as well as Headquarters, U.S. Army Communications Zone (COMMZ), in Orléans. Not so after SHAPE displaced to Casteau, Belgium, and EUCOM took up residence in Stuttgart, 265 airline miles/425 kilometers away (maps 34-35). It took months and cost millions for U.S. and NATO command posts at every level to transplant a vast array of computers, data processors, and information retrieval gear connected by space communication satellites, tropospheric scatter stations, microwave networks, radio relays, and countless miles of cable. FRELOC, when complete, concentrated terminals, reduced routing alternatives, and thereby increased vulnerabilities among communication systems that depended heavily on redundancy to survive in wartime. Access to air defense communications in France and to French segments of ACE HIGH, Allied Command Europe's secure voice network that stretched from Norway to Turkey, was no longer guaranteed, because the French Government professed "no automaticity" policies.[10]

U.S. Air Forces Europe (USAFE) shifted several squadrons from France to Great Britain and West Germany shortly after General de Gaulle's 1959 decision to ban U.S. nuclear weapons on French soil, but USAFE even so had to vacate five fully operational bases, plus four on standby. The loss of aerial ports at Evreux and Chateauroux disrupted contingency plans to airlift armored and mechanized division personnel from the United States to France, where they could receive weapons, equipment, and supplies prepositioned at relatively secure locations.

Belgian, Dutch, and German ports, more easily overrun than counterparts in France, replaced logistical lines of communication that previously emanated from Le Havre,

Cherbourg, La Rochelle, Bordeaux, and Marseille. NATO's Central European Pipeline System and the U.S. petroleum pipeline that connected Donges with Melun, Châlons-sur-Marne, and Metz continued peacetime operations, but "no automaticity" policies made wartime availability questionable. The time required to reoccupy installations if French leaders later saw fit varied from 2 to 6 weeks under benign conditions, much longer if armed conflict interfered.[11]

FEDERAL REPUBLIC OF GERMANY

Congestion was severe in West Germany after U.S. Armed Forces completed FRELOC. U.S. Army Europe (USAREUR), two U.S. corps, five U.S. divisions, three separate brigades, an air defense command, three support commands, and Medical Command Europe stood shoulder-to-shoulder where Germany's waist was barely 150 miles (240 kilometers) wide. USAFE flew fighter, tactical reconnaissance, and C^3 missions from six saturated airfields clustered west of the Rhine (immense Rhein-Main on the east bank served Military Airlift Command). Main supply routes, perilously perpendicular to Warsaw Pact avenues of approach, ran south from Bremerhaven to feed COMZ depots in prospective combat zones.[12]

NATO'S SOUTH FLANK

NATO's south flank during the Cold War was a watery domain that stretched from the Atlantic Ocean to easternmost Asia Minor, where Turkey touched the Soviet Union. Common threats were uncommon, common fronts were infeasible, deterrent postures depended primarily on sea and air power, member nations were isolated from the center sector as well as from each other, and widely-separated U.S. bases occupied three sub-theaters. Installations on the Iberian Peninsula guarded approaches to Gibraltar, those in Greece and Turkey guarded the Dardenelles and Aegean Sea, those at midpoint in the Mediterranean were positioned to influence actions in either direction (maps 36-38).[13]

U.S. Naval Bases in the Mediterranean. Rota Naval Base, a neighbor of Cadiz, Spain, ministered to ballistic missile submarines, three of which reportedly responded to SACEUR, the rest to the U.S. Joint Chiefs of Staff. Rota additionally provided an admirable location from which to conduct aerial ASW operations for U.S. Sixth Fleet, an occupation it shared with counterparts in the Azores (a Portuguese possession) and Sicily. Patrol aircraft, in turn, worked hand-in-glove with hunter-killer submarines home-ported in Naples and La Maddalena, a small island on Sardinia's shelf. The Souda Bay complex on Crete's northwestern coast included a splendid airfield, enough anchorage to accommodate most of Sixth Fleet, and a missile range at nearby Namfi which, like the Bardenas Reales Firing Range near Zaragosa, Spain, furnished USAFE as well as naval aviators with open spaces for air-to-air and air-to-surface weapons training.

U.S. Air Bases in the Mediterranean. USAFE south of the Alps maintained fewer combat bases than the U.S. Navy—Torrejon, Spain, Aviano, Italy, and Incerlik, Turkey, were most conspicuous—but Military Airlift Command (later U.S. Transportation Command) flew countless sorties into and out of airfields from one end of the Mediterranean to the other. Lajes Air Base in the Azores was a welcome way station between the United States, southern Europe, and the Middle East even after in-flight refueling became feasible (500 to 600

transatlantic flights per month were about average in the 1970s). Hellenikon Air Base outside Athens, which handled intratheater airlift, was much busier, whereas Moron AB, on standby in Spain, simply remained ready to receive, stage and, support reinforcements whenever required.

U.S. Listening Posts Along NATO's South Flank. Electronic intelligence specialists assigned to the U.S. National Security Agency (NSA) and its affiliates conducted invaluable electronic surveillance activities at San Vito Air Base by Brindisi, Italy, at Iraklion and, perhaps most importantly, from listening posts in Turkey, the only NATO member with a "window" that overlooked the Soviet Union. Sophisticated equipment at Karamursel monitored air and naval traffic around Bulgaria's Black Sea coast and through the Turkish Straits, Sinop and Samsun devoted similar attention to the Soviet Black Sea Fleet and missile testing sites farther north, while intelligence collectors at Diyarbakir in Turkey's interior looked toward the Caucasus and Transcaucasus. Sensitive machines at Belbasi Station, a seismographic facility on the outskirts of Ankara, felt tremors from all but the smallest Soviet nuclear tests above or below ground.

U.S. Logistical Installations in the Mediterranean. Logistical support for all U.S. Military Services throughout the Mediterranean region included nuclear weapon storage sites in Italy, Greece, and Turkey, along with well-spaced conventional ammunition dumps, fuel, and general supply depots. Communication stations in the Azores, Morocco, Spain, Sicily, Italy, Crete, and Greece connected senior U.S. headquarters across NATO's south flank with principal subordinates ashore, with Sixth Fleet afloat and, through Defense Communications Agency (DCA) channels, with the United States.

MIDDLE EAST, AFRICA, AND AUSTRALIA

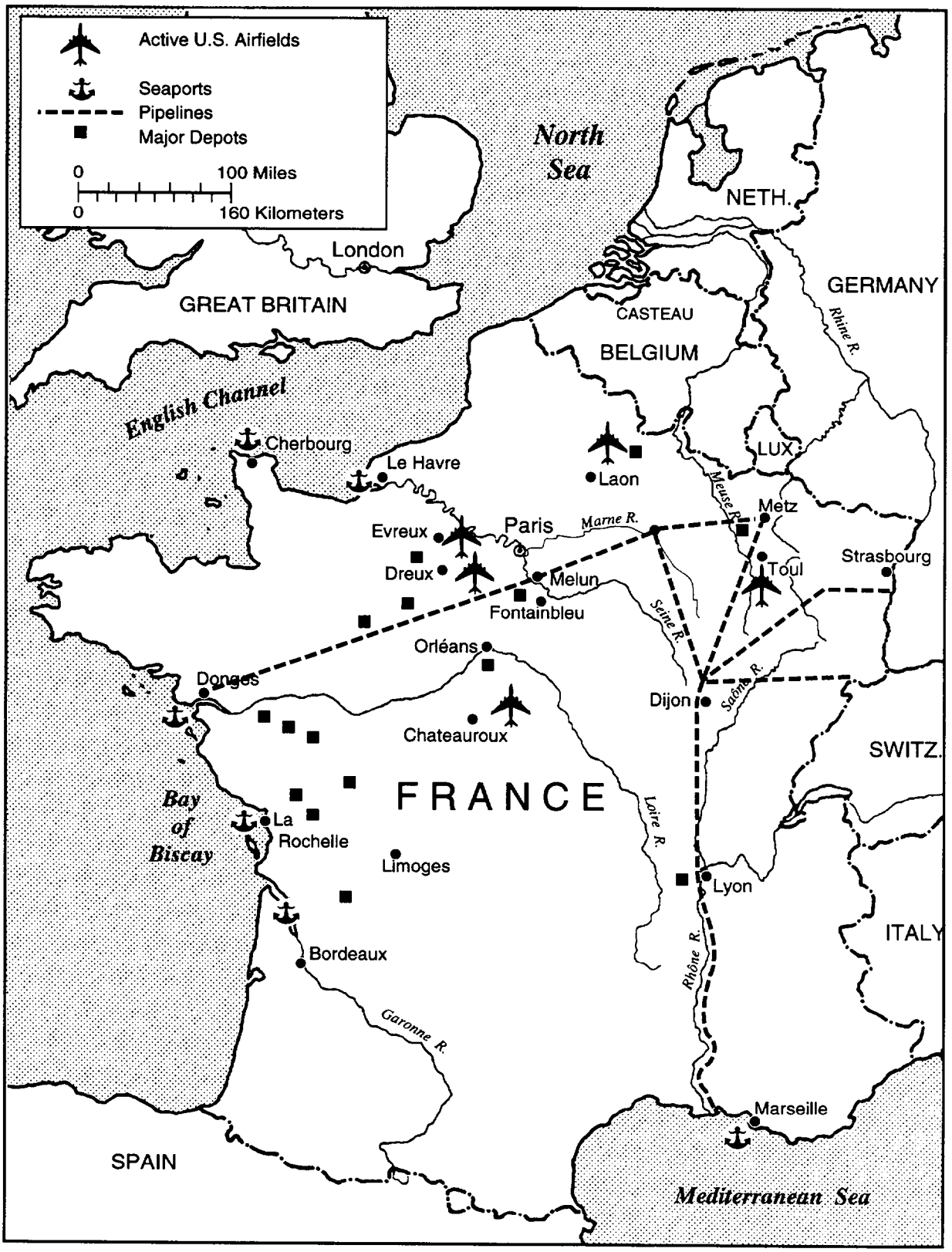
The United States maintained no Cold War military bases in Africa, save two communication stations on Morocco's coast. U.S. installations in other Arab lands were limited to berthing privileges in Bahrain for a minuscule Middle East Force (MIDEASTFOR), which consisted of a flagship and two (later four) elderly destroyers. Electronic listening posts in Iran closed down in 1980 after Islamic radicals overthrew Muhammad Reza Shah Palavi. U.S. facilities in the Indian Ocean and along its fringe were largely confined to satellite tracking stations in the Seychelles and at Alice Springs in the center of Australia, which also furnished room for a naval communications station on its Northwest Cape. Assets at Diego Garcia, which played a prominent role during U.S. and allied efforts to oust Iraq from Kuwait in 1990-91, were little developed until improvements began in 1980.[14]

EAST ASIA

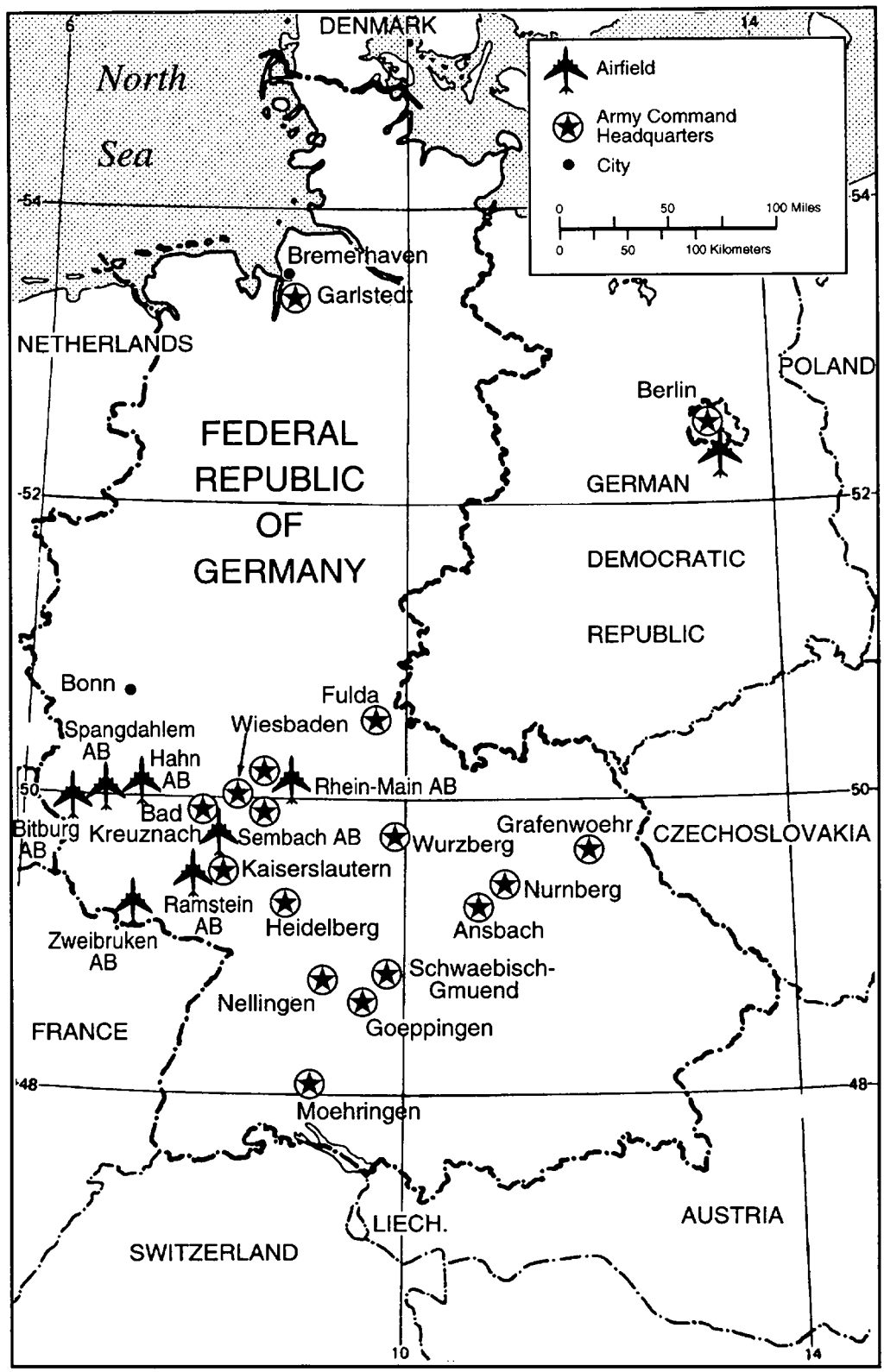
The most beneficial U.S. bases east of Suez congregated in the Philippines, Korea, Japan, and Okinawa. Together, they permitted U.S. Pacific Command to maintain a powerful military presence and stabilizing influence west of Pearl Harbor and Guam.

The Philippine Republic. Cold War bases in the Philippines, which afforded flexibility not available to U.S. Armed Forces elsewhere along the rim of East Asia, routinely proved logistically useful, especially during the Korean War (1950-53) and again from 1965 to 1972, when U.S. military involvement flourished in Vietnam.[15] Philippine installations moreover enabled U.S. Seventh Fleet to straddle critical sea lines of communication that connected Middle Eastern oil producers with Far Eastern consumers and deploy periodically in the

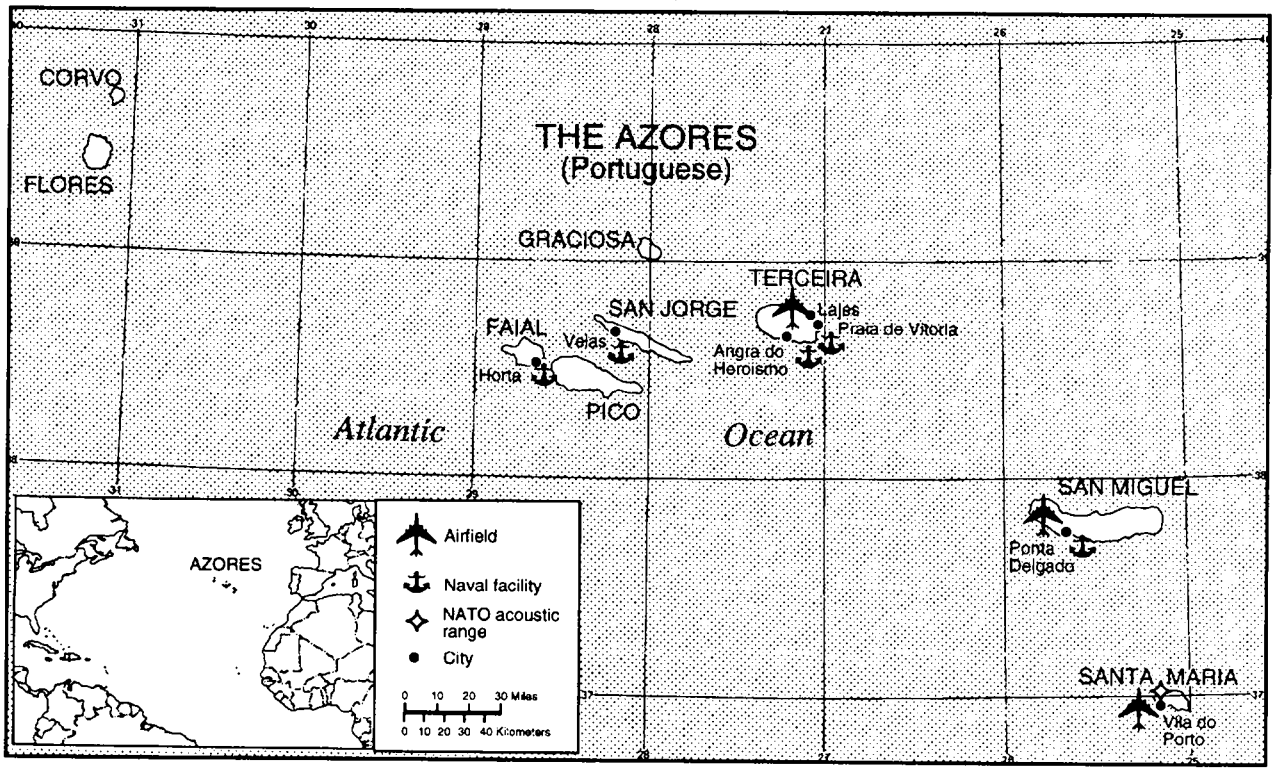
Map 34. *U.S. Cold War Bases in France* (1966)

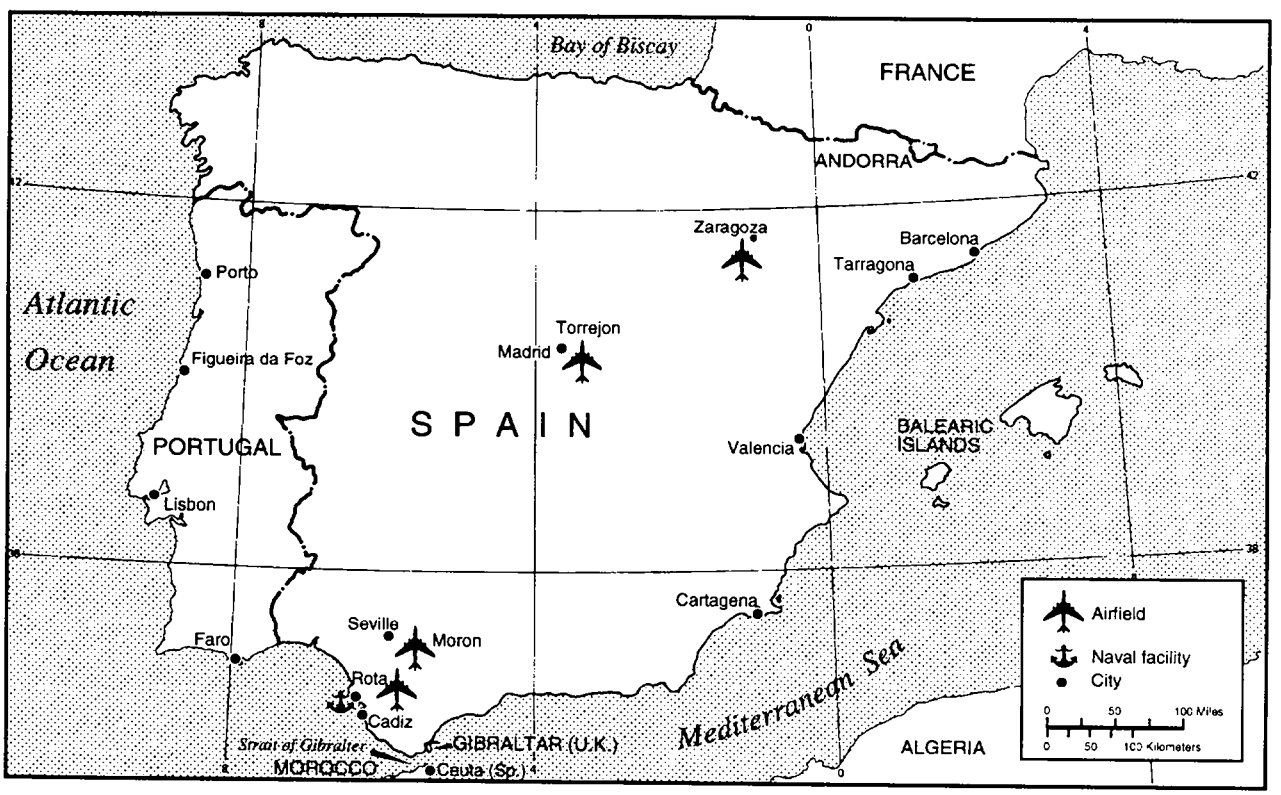


Map 35. *U.S. Cold War Bases in West Germany* (1979)



Map 36. *U.S. Cold War Bases in Iberia* (1979)

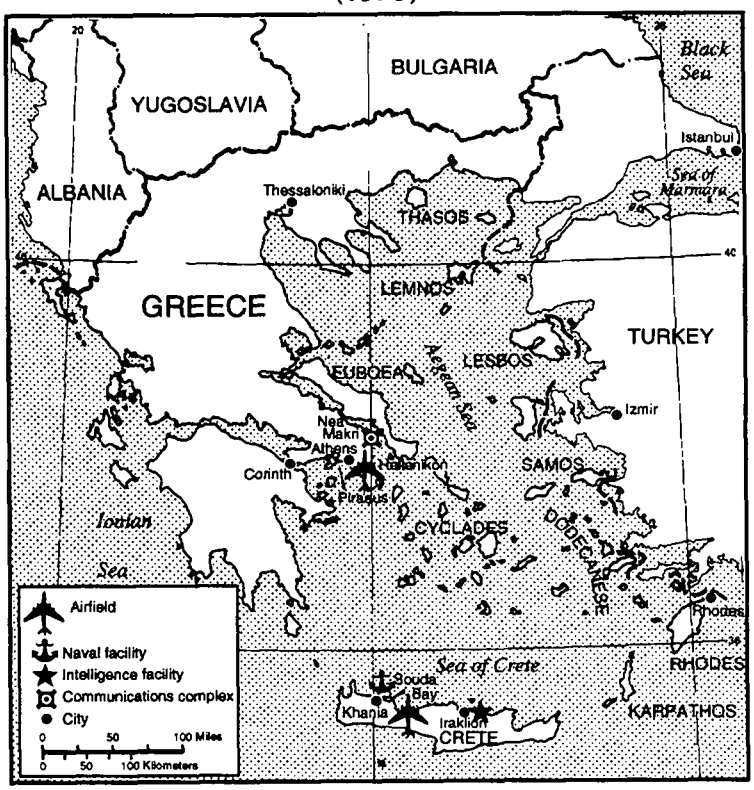


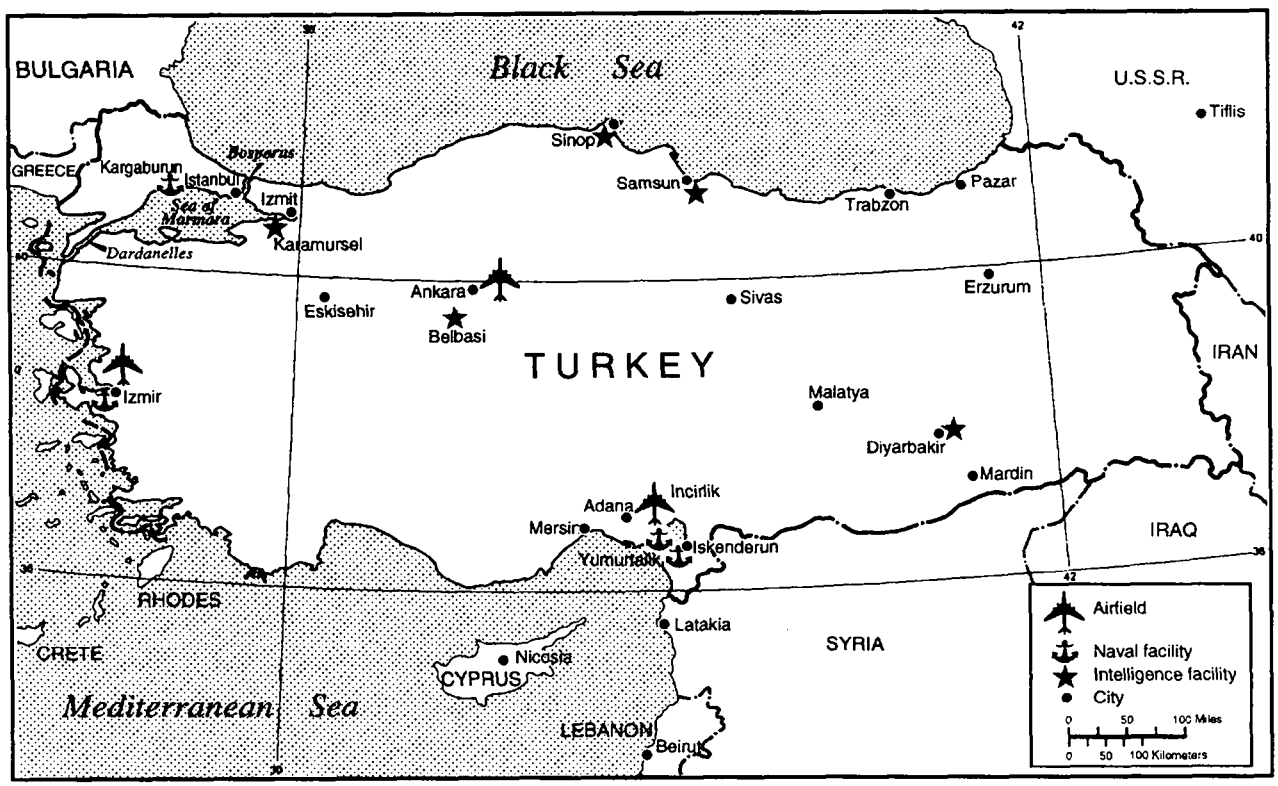


Map 37. *U.S. Cold War Bases in Italy* (1979)



Map 38. *U.S. Cold War Bases in Greece and Turkey* (1979)





Indian Ocean despite the absence of permanent base rights anywhere in that huge basin (map 39). Subic Bay Naval Base and associated facilities 50 miles (80 kilometers) west of Manila constituted the centerpiece. Port Olongapo, which boasted storage space for 110 million gallons of petroleum, oil, and lubricants, featured four floating drydocks able to overhaul all ships except aircraft carriers. Aprons at Cubi Point Naval Air Station could park a full complement of carrier aircraft next to their ship at pierside with room for an equal number elsewhere, while the Naval Magazine at Camayan Point stored 3.8 million cubic feet (107,400 cubic meters) of ammunition by a wharf that berthed the largest surface combatants. The communication station at nearby San Miguel kept U.S. naval forces ashore in constant touch with Seventh Fleet while collocated DCS facilities linked Philippine installations with the Worldwide Military Command and Control System (WWMCCS). Clark Air Base, a huge logistical hub that could handle any aircraft in the U.S. inventory, possessed immense parking space, POL storage capacities approximately comparable to those of Kennedy International Airport in New York City, 34 ammunition igloos, and superlative communication links. Aviators of all U.S. Services sharpened their skills under simulated combat conditions at Clark's Crow Valley gunnery range.

Senior U.S. defense officials in the early 1980s seriously began to consider relocation if insurgents defeated the Philippine Government and, as promised, ousted U.S Armed Forces.[16] Concerns about base rights intensified in 1985, when President Ferdinand Marcos himself threatened to abrogate base agreements and implied plans to improve relations with the Soviet Union.[17] U.S. Armed Forces indeed did depart in 1991-92, but the Cold War was over and the value of Philippine bases concurrently diminished.

Republic of Korea. The Republic of Korea (ROK) contained the only U.S. military bases anywhere on the Asian mainland after the Vietnam War wound down and relations with Red China improved in the early 1970s (map 40). The U.N. Command and U.S. Eighth Army remained in Yongson when the dust settled, while the 2d Infantry Division centered at Camp Casey stayed put along the demilitarized zone astride a high-speed avenue from Pyongyang into Seoul. An air division headquarters and one composite wing still occupied Osan Air Base, a fighter wing flew out of Kunsan, the naval base at Chinhae stood fast, and Taegu persisted as the principal U.S. supply depot. Rapid reinforcements since then have been limited to air and naval elements in Japan and on Okinawa if North Korea reinvaded, because the nearest U.S. Army troops elsewhere are in far away Hawaii.[18]

Japan and Okinawa. The Yokosua-Yokohama complex in Tokyo Bay, which served as a forward operating base for the Seventh Fleet flagship, two aircraft carriers, and a destroyer squadron, was the U.S. Navy's jewel in Japan (map 40).[19] A first-rate labor force manned first-class installations that included a naval ammunition magazine, a communications station, a supply depot, a hospital, and ship repair shops. No other U.S. base west of Pearl Harbor possessed a big enough dry dock to handle nuclear-powered Nimitz class attack carriers. Sasebo on Kyushu Island furnished additional logistical, ordnance, and dry docking facilities.

U.S. Forces Japan, Fifth Air Force, and an airlift wing held on at Yokota Air Base, which was the "Rhein-Main" of Northeast Asia. Air Force fighters and naval patrol aircraft near Honshu's northernmost tip at Misawa conducted reconnaissance, surveillance, electronic intelligence, and antisubmarine warfare missions over the Seas of Japan and Okhotsk, the

Kuril Island chain, Sakhalin, and the coast of Kamchatka. Most of the 1st Marine Air Wing remained at Iwakuni Air Station on the Inland Sea.

Four Fifth Air Force fighter squadrons were assigned to Okinawa, where (in those days) they were politically less sensitive than deployments that periodically caused disruptive demonstrations in pacifist Japan, yet within easy reach of potential "hot spots" in the western Pacific. Okinawa also housed two-thirds of the 1st Marine Division and the rest of the 1st Marine Air Wing, which together stood ready to reinforce South Korea and constituted a "fire brigade" that evacuated U.S. noncombatants and selected foreign nationals from Saigon and Phnom Penh in April 1975, retrieved the USS *Mayaguez* and rescued its crew the very next month, and performed assorted "peacetime" missions.

LATIN AMERICA

No permanent U.S. military bases blossomed in Central or South America during the Cold War, despite U.S. support for anti-Communist counterinsurgents in several countries, but major installations in the Panama Canal Zone included:

- Southern Command at Quarry Heights
- An infantry brigade at Forts Amador, Clayton, Kobbe, and Davis
- Rodman Naval Station
- Howard Air Force Base and Albrook Field
- Marine barracks and communications facilities
- A jungle warfare training center at Fort Sherman.

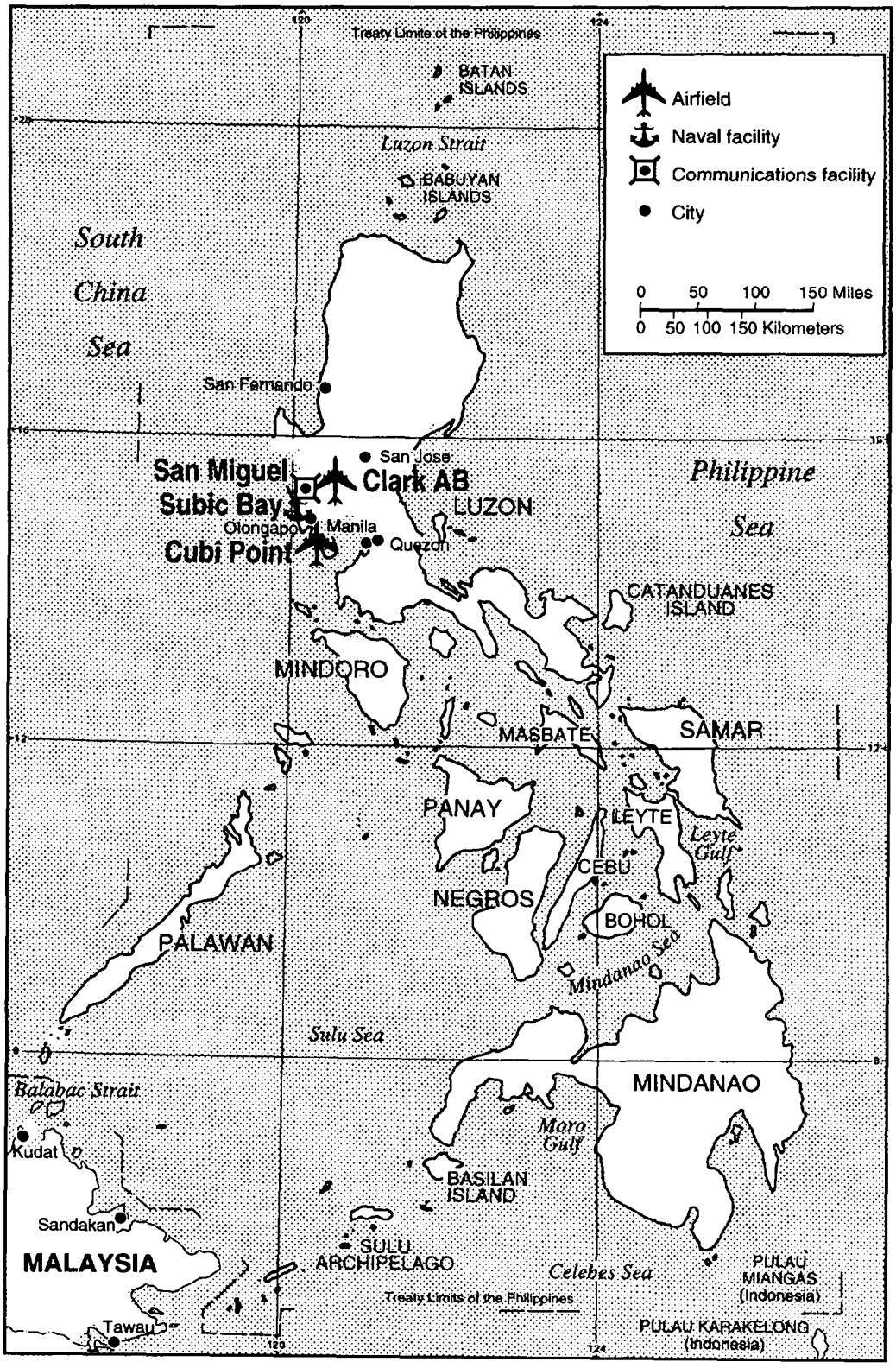
Guantanamo Naval Base and two associated airfields (Leeward and McCalla) in southeastern Cuba overlooked Caribbean Sea approaches to the Panama Canal, provided logistical support for recurring naval exercises in surrounding waters, and prepared to deal with contingencies if directed. Installations such as Roosevelt Roads Naval Station, Ramey Air Force Base, and Fort Buchanan did likewise in Puerto Rico, a self-governing U.S. commonwealth. U.S. outposts in British Bermuda and the Bahamas promoted intelligence collection, communications, and research programs.[20]

POST-COLD WAR RETRENCHMENT

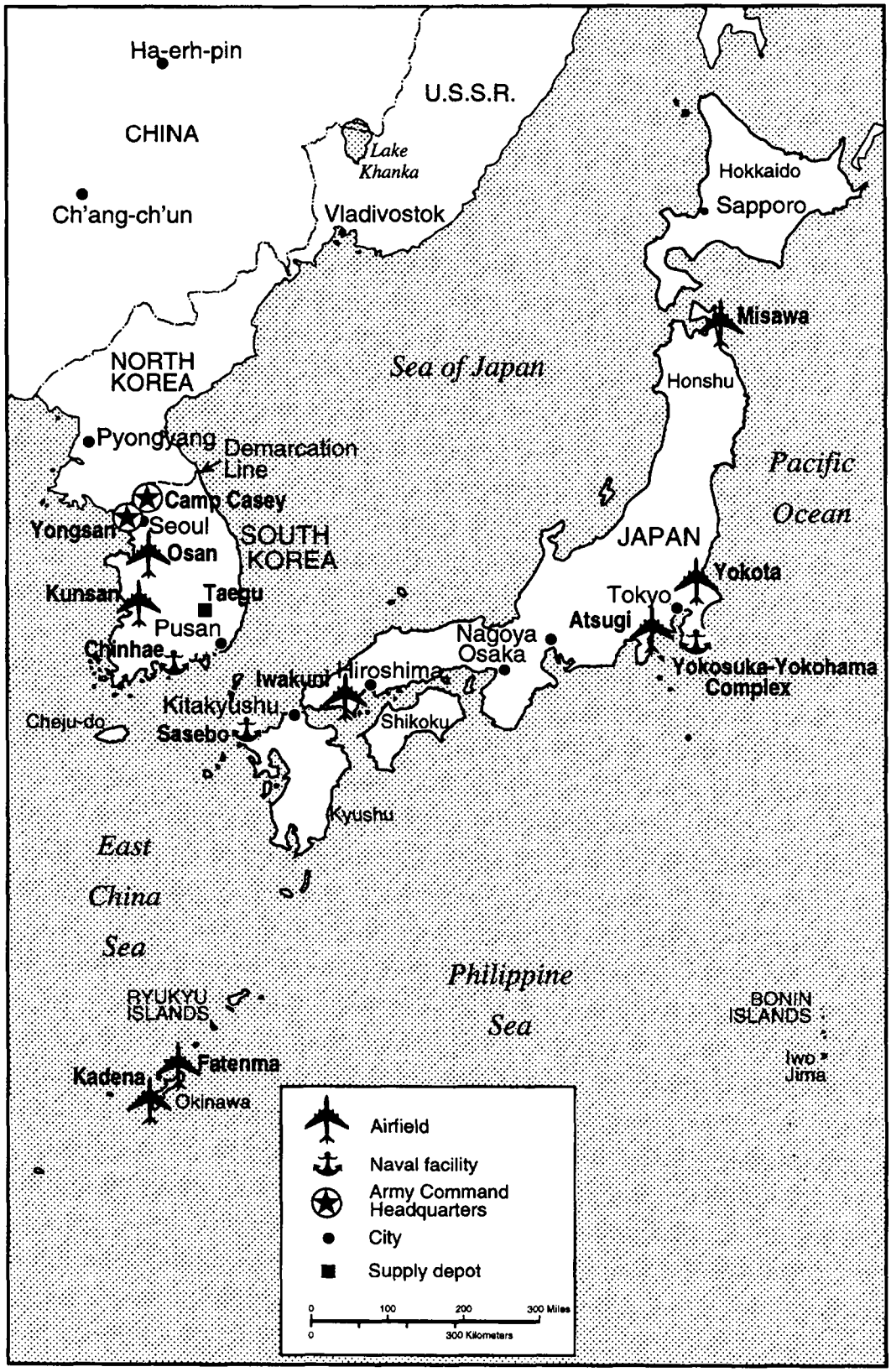
The U.S. Government began to reduce force levels and military infrastructure at home and abroad when requirements to contain the Soviet Union and the Warsaw Pact declined.[21] The Department of Defense, in response to the Defense Base Closure and Realignment Act of 1990, will have closed 97 major domestic bases and many smaller installations by the time congressionally approved recommendations of four commissions have been fully implemented.[22] About one-third of all U.S. bases and facilities overseas were scheduled to close, curtail activities, or assume standby status as early as 1991.[23] That budget-cutting process continues.

Reduced deterrent, combat, and peacetime involvement capabilities accompanied a smaller U.S military establishment and lower costs. Fewer U.S. crisis response forces were located near far distant contingencies by the late 1990s; dependence on long-haul airlift and sealift increased commensurately; naval forces relied more extensively on underway

Map 39. *U.S. Cold War Bases in the Philippines* (1979)



Map 40. *U.S. Cold War Bases in Japan and Korea* (1979)



replenishment ships; air forces leaned more heavily on tankers for in-flight refueling; and fewer convenient locations for prepositioned stocks ashore multiplied requirements for additional storage afloat. The wear and tear on overworked forces was considerable.

KEY POINTS

- The armed forces of every nation need home bases where they can prepare to perform assigned roles and missions most effectively.
- Modern armed forces require huge tracts of land to test weapon systems and train under realistic conditions.
- Bases abroad not only buttress deterrence and help cement relations with allies in peacetime but reduce reaction times when far distant contingencies occur.
- Bases and facilities abroad are most reliable when the national interests, objectives, and policies of host countries and tenants are compatible.
- Decreased military capabilities accompany monetary savings that accrue from base closings at home and abroad.

NOTES

1. *Guide to Military Installations in the U.S.: A Reference to the Top 220 Bases, Posts and Stations, Army Times, Navy Times,* and *Air Force Times*, November 4, 1996, with maps on 4-5, 32-33, and 72-73; *Defense 97 Almanac* (Washington, DC: Dept. of Defense, 1997); both documents updated periodically. William R. Evinger, ed., *Director of U.S. Military Bases Worldwide*, 2d ed. (Phoenix, AZ: Oryx Press,1995).
2. DOD officials furnished acreage figures from *Annual Summary of Operations (The Red Book)*, vol. 3, Installations Performance, FY 1995 (Washington, DC: Dept. of the Army, Directorate of Public Works, 1996), and *United States Air Force Property Totals by State and Country* (Washington, DC: Air Force Real Estate Agency, September 30, 1995).
3. Congress, Senate, *United States Foreign Policy Objectives and Overseas Military Installations*, prepared for the Committee on Foreign Relations by the Foreign Affairs and National Defense Division, 96th Congress, 1st sess., April 1979, 16-21.
4. Ibid.
5. See, for example, John C. Scharfen, "Cold Weather Training: The Absolute Necessity," *Marine Corps Gazette*, February 1981, 34-41.
6. *NATO Facts and Figures* (Brussels, Belgium: NATO Information Service, revised and updated annually). See the 1979 edition.
7. Secretary of Defense Frank C. Carlucci, *Annual Report to Congress on the Amended FY 1988/FY 1989 Biennial Budget* (Washington, DC: Government Printing Office,February 18, 1988), 242.
8. For U.S. Cold War bases in Britain, Holland, and Belgium, see Congress, Senate, *United States . . . Military Installations Overseas*, 28-35.
9. The French memorandum of March 11, 1966, and associated correspondence are reproduced verbatim as appendices in Kenneth Hunt, *NATO Without France: The Military Implications*, Adelphi Paper 32 (London: Institute for Strategic Studies, December 1966). See also 2-6.

10. Ibid., 13-17; Gordon A. Moon II, "Invasion in Reverse," *Army* (February 1967): 24-30 and "Uncertain Future," *Army* 17, no. 3 (March 1967): 38-42; David S. Yost, *France and Conventional Defense in Central Europe*, EAI Paper 7 (Marina del Rey, CA: European American Institute for Security Research, Spring 1984), 53-76.

11. David S. Yost, *France and Conventional Defense in Central Europe*, 61-63, 69-73, 75-76.

12. For U.S. Cold War bases in Germany, see Congress, Senate, *United States . . . Military Installations Overseas*, 36-44.

13. For U.S. Cold War bases in the Azores, Spain, Italy, Greece, and Turkey , see ibid., 44-70. Also Congress, House, *Greece and Turkey: Some Military Implications Related to NATO and the Middle East*, prepared for the Special Subcommittee on Investigations of the Committee on Foreign Affairs by the Congressional Research Service, 94th Congress, 1st sess., February 28, 1975.

14. For U.S. Cold War bases in the Middle East and Indian Ocean, see Congress, Senate, *United States . . . Military Installations Overseas*, 71-121; Congress, House, *Means of Measuring Naval Power With Special Reference to U.S. and Soviet Activities in the Indian Ocean*, Subcommittee on the Near East and South Asia of the Committee on Foreign Affairs, 93d Congress, 2d sess., May 12, 1974, 10-14.

15. For U.S. Cold War bases in the Philippines, see Congress, Senate, *United States . . . Military Installations Overseas*, 134-164; Subic Bay and Cubi Point facilities are described in *CINCPAC Fleet Port Directory*, prepared by the Fleet Intelligence Center (FICPAC), vol. 5, September 26, 1977, E4-1 through E4-9.

16. Lawrence E. Grinter, *The Philippine Bases: Continuing Utility in a Changing Strategic Context* (Washington, DC: National Defense University Press, 1980); *The Key Role of U.S. Bases in the Philippines* (Washington, DC: Heritage Foundation, January 10, 1984).

17. Richard J. Kessler, "Marcos and the Americans," *Foreign Policy* 63 (Summer 1986): 40-57.

18. For U.S. Cold War bases in Korea, see Congress, Senate, *United States . . . Military Installations Overseas*, 172, 176.

19. For U.S. Cold War bases in Japan and Okinawa, see ibid., 165-194; Yokosuka and Yokohama facilities are described in *CINCPAC Fleet Port Directory*, A14-1 through A14-6. See also *Navy Drydock Requirements Study*, Naval Sea Systems Command, September 1977, 23-24.

20. For U.S. Cold War bases in Latin America, see Congress, Senate, *United States . . . Military Installations Overseas*,

21. Differing views concerning base closures are contained in Stephen M. Goldfein, "The Base Realignment and Closure Commission: A Successful Strategy to Overcome Political Gridlock," unpublished student essay (Washington, DC: National War College, 1995), and Ronald P. Richardson, "Bureaucratic Politics and the Defense Budget: The Formation of the 1988 Base Realignment and Closure Commission," unpublished student essay (Washington, DC: National War College, 1995).

22. *Defense Almanac 96*, no. 5 (Washington, DC: Dept. of Defense, 1996).

23. Pete Williams, *Pentagon Briefing*, July 30,1991 (Washington, DC: News Transcripts, Inc.); Peter Grier, "The Flags Come Home," *Air Force* (October 1991): 32-35.

13. FORTRESSES AND FIELD FORTIFICATIONS

[Eban Emael] served as the southern anchor of the Albert Canal Line, and . . . ranked among the most important single defensive positions in Europe. . . . Ten minutes after the [German glider] landings, all installations and guns on top of the fort were wrecked.

John R. Galvin
Air Assault

BELGIAN FORTRESS EBEN EMAEL BARRED THE WAY BETWEEN GERMANY AND THE ENGLISH CHANNEL WHEN Hitler launched a large-scale offensive on May 10, 1940.[1] That bastion quickly succumbed to a small-scale glider assault because its architects, contrary to good advice from Carl von Clausewitz in his opus, *On War*, failed to incorporate credible active with passive defenses, failed to "present a front on every side" (of which there have been five instead of four since the advent of air power), and above all failed to "recognize the fact that the enemy, in avoiding the unconquerable parts, will alter the whole pattern of his attack."[2] Future designers of forts and field fortifications would do well to heed those wise words.

PRECEDENTS AND PROGNOSES

The earliest earthen fortifications predate written human history, which notes a massive wall, a deep ditch, and adjoining tower at Jericho circa 7000 B.C.[3] Concepts and construction techniques thereafter evolved from simple to complex over several millenia that saw reinforced steel and concrete replace wood, brick, and stone blocks as preferred materials. Legendary Crusader castles, built to protect Christian outposts from Saracens in the Holy Land, typify fortified points. Hadrian's Wall in ancient Britannia and the Great Wall of China, both of which were buffers between "civilized" communities and barbarians, exemplify fortified lines.[4] The utility of those relics now is nearly nil, and siegecraft patterned after Vauban is no longer popular,[5] but well-designed forts and field fortifications likely will remain useful in the 21st century, whether they are simply hardened shells or defenses in great depth.

FORTIFIED POINTS

Impromptu strong points may be as basic as foxholes dug with D-handle shovels or buildings embellished by sand bags, razor wire, land mines, and flares, whereas elaborate counterparts commonly include ramparts, casemates, carapaces (like turtle shells), and revetments constructed of iron, steel, concrete, stone slabs, and bricks. Armed forces benefit from both.[6]

IMPROMPTU STRONG POINTS

Famous points fortified extemporaneously include the Alamo in San Antonio, TX, where Colonel William Barrett Travis, Davy Crockett, Jim Bowie, and 185 other men on March 6, 1836, fought to the death against onslaughts by a force that numbered about 4,000 under Mexican General Santa Anna. Actions at Rorke's Drift on the Buffalo River in Natal had a happier ending for defenders —11 heroes received Victoria Crosses after fewer than 100 able-bodied men led by British Lieutenants John Chard and Gonville Bromhead converted Otto Witt's mission station into a makeshift fort, then held off 4,000 of King Cetshwayo's fearsome Zulu warriors during the long, bloody night of January 22-23,1879.[7]

Rubble heaps that result from aerial bombardments, artillery barrages, and house-to-house combat in urban areas unintentionally furnish defenders with ready-made fortresses. Clever improvisations on countless occasions have converted partially destroyed cities into impromptu strong points, of which Leningrad, Stalingrad, Manila, Seoul, and Hué were among the most widely publicized.

ELABORATE STRONGHOLDS

Early U.S. armed forces and pioneers, who were masters at improvisation, built relatively elaborate military forts and palisaded civilian settlements to protect themselves and their property as they marched from east to west and coast to coast across America.[8] National leaders elsewhere did likewise to defend against invaders.

Coastal Fortifications. Coastal defenses reached their zenith during the 19th century, when casemated artillery batteries guarded port cities and other key terrain features against onslaughts from the sea. The Star Spangled Banner still waved over Fort McHenry after a British fleet failed to land redcoats in Baltimore harbor on the night of 25-26 August 1814 and the U.S. Civil War opened at Fort Sumter, South Carolina, 47 years later (August 1861). Coastal fortifications around the world continue to serve useful purposes under favorable circumstances, but their Golden Age closed with the advent of offensive firepower that makes new construction seem cost-ineffective.[9]

Fortified Islands. Small islands make admirable fortified points, as ingenious Japanese armed forces demonstrated on every island they intended to hold in the Western Pacific during World War II, whether the terrain was flat and open or highlands honeycombed with caves. Withering fire met U.S. Marines on tiny Betio Island (Tarawa atoll), where underwater obstacles and mines barred the way to beaches. Shorelines there bristled with more than 500 interconnected blockhouses, bunkers, pillboxes, and breastworks encased in concrete reinforced with steel rods and splinter-proof coconut logs, then covered with up to 10 feet (3 meters) of sand or crushed coral, an amalgam that was practically impervious to pounding

by carrier-based aircraft and big naval guns. Bloody fighting that ensued at point-blank range, much of it with satchel charges and flamethrowers, was replicated on Saipan, Peleliu, Iwo Jima, Okinawa, and other islands, each of which was a fortress in every sense of the word.[10]

Solitary Forts Inland. Solitary forts located inland became increasingly sophisticated after two German "Big Bertha" (16-inch, 42-centimeter) howitzers demolished Belgian redoubts around Liège during a 4-day bombardment in August 1914. The most formidable, however, lacked mutually supporting fields of fire, could neither be reinforced nor resupplied if surrounded, and were vulnerable to vertical envelopment, as defenders at Eben Emael discovered. The last large-scale construction commenced before World War II.[11]

Earthen Labyrinths. No nation or subnational group has ever created earthen labyrinths as elaborate as those that Viet Cong guerrillas constructed in South Vietnam for use as headquarters, hideouts, air raid shelters, storehouses, dormitories, kitchens, classrooms, arms factories, hospital operating rooms, recovery wards, theaters, and rest centers. Construction, begun in the 1940s at the onset of serious Indochinese uprisings against French rule, took advantage of laterite soils which were almost impervious to water and very hard, especially where taproots near the surface strengthened tunnel ceilings like steel reinforces concrete. Embellishments, all dug by hand a few feet per day, continued during the next three decades until multilevel mazes north of Saigon featured concealed entrances and exits, chambers, galleries, bunkers, air shafts, crude elevators, and wells that were interconnected by twisty-turny passageways replete with false leads, dead ends, and secret trap doors designed to repel chemical warfare agents and reduce the range of underground blasts.[12]

U.S. intruders, called "tunnel rats," all volunteers armed mainly with pistols and knives, ventured into those claustrophobic confines where they battled with ingenious foes, poisonous snakes, scorpions, giant spiders, and bats in booby-trapped darkness that flashlights barely illuminated. Their searches uncovered huge caches of hand grenades, automatic weapons, ammunition, and rice, while Rome Plow bulldozers stripped vegetative cover overhead, demolition specialists sent shock waves down corridors, and riot control agents polluted crawl spaces. Tunnel warfare nevertheless continued apace for 5 years until carpet-bombing B-52s finally collapsed most installations shortly before U.S. Armed Forces departed.[13]

Fortified Areas. Fortifications that sprawl many miles in every direction, like point defenses just discussed, may be simple or complex. The German Wehrmacht, whose winter offensive of 1942-1943 left nearly a million Soviet troops inside a massive salient west of Kursk, encountered what may have been the most awesome array of field fortifications ever built when they launched Operation *Zitadelle* on July 4th to cut off that bulge at its base. The Red Army's principal works, about 12 miles (20 kilometers) wide, consisted of two fortified zones, each of which contained three successive positions buttressed by trenches (aggregate length about 1,250 miles or 6,000 kilometers), antitank ditches, pillboxes, bunkers, barbed wire entanglements, and 1,000,000 mines, all on terrain laced with water-filled ditches. Additional obstacles behind the two main lines of resistance blocked avenues most vulnerable to breakthroughs. German drives soon stalled, Soviet forces counterattacked on July 12th, and most divisions trapped inside the salient lived to fight another day, despite stupendous casualties on both sides.[14]

FORTIFIED LINES

Fortified lines, which incorporate all assets and avoid most shortcomings of isolated forts, have been fashionable since Domitian, Trajan, and Hadrian erected walls along the outer limits of the Roman Empire in the 1st and 2nd centuries A.D.[15] Sir Winston Churchill, pontificating in Fulton, Missouri, on March 5, 1946, noted that "from Stettin in the Baltic to Trieste in the Adriatic an iron curtain has descended across the [European] continent." That edifice, built to keep Warsaw Pact citizens from fleeing repressive regimes, was unusual as well as ugly, because defense against aggression is the purpose of most fortified fences.

Many linear fortifications in the latter category have been impressive: Confederate diggings around Richmond and Petersburg, Virginia, in the 1860s; trenches that lined the Western Front in Europe during World War I; the Mannerheim Line along the Russo-Finnish frontier in 1939-1940; the Gustav and Winter Lines in Italy, 1943-44; the Mortise Line that French Armed Forces built along the Tunisian border in the 1950s to keep support from reaching rebels in Algeria; and extensive fortifications that still stand along the Korean demilitarized zone immediately come to mind. None, however, rivaled the complex structures that France and Germany constructed and occupied with differing degrees of success during World War II.

THE MAGINOT LINE

The Maginot Line, an architectural marvel partly hewn from solid stone, ran 560 miles (900 kilometers) along the Franco-German frontier from Switzerland to the Ardennes Forest by the Belgian border, where it terminated for lack of funds and a high water table in Flanders. Large, self-contained works (*ouvrages*), connected by tunnels and railways, contained fixed and retractable cupolas, two-tiered pillboxes, ferro-concrete blockhouses, fireproof armored doors, air intakes, exhaust vents, and gas filters near the surface, with living quarters, mess halls, magazines, communication centers, and power supplies disposed well below. Barbed wire entanglements, mines, and antitank traps completed the complex. Resultant installations, in the words of Marshal Henri Philippe Pétain, assured "minimum danger and maximum comfort," all to little avail: German *Blitzkriegs* through Belgium and Holland in May 1940 maneuvered around the Maginot Line without hitting it head on. Some enterprising farmers in Alsace-Lorraine later bought a few blockhouses with dark, damp cellars, where they still grow mushrooms for grateful French chefs.[16]

THE SIEGFRIED LINE

The so-called Siegfried Line (*Westwall*), which shielded Germany's industrial heartlands against invasions from the Low Countries, Luxembourg, and France, was less ambitious but, unlike the Maginot Line, necessitated frontal attacks because it was much harder to outflank. Row after seemingly endless row of fearsome Dragon's Teeth with minefields for fillings dared U.S. tank commanders to trespass. Two fortified belts rather than one, together with natural obstacles such as the Rhine, Roer, and Kyll Rivers, afforded depth in front of the Ruhr and Saar-Palatinate. Serious efforts to penetrate ceased for several months after U.S. Armed Forces in hot pursuit punched one sizable hole in October, 1944, then literally ran out of gas. Tremendous concentrations of power on narrow fronts tore through the following March, but not before slugging matches spilled barrels of blood on both sides— "Bitche was a bitch" was

the way one trooper put it after breaching stubborn defenses around that Alsatian stronghold.[17]

THE ATLANTIC WALL

An impregnable wall along the Atlantic coast from northern Norway to the Pyrenees Mountains was a figment of Hitler's imagination, but the segment between Calais and Cherbourg, France, was indeed a troublesome stretch after Field Marshal Erwin Rommel took charge in November 1943. "Believe me, Lang," he told his aide, "the war will be won or lost on the beaches. We'll have only one chance to stop the enemy, and that's while he's in the water . . . struggling to get ashore."[18]

Improvements proceeded at a feverish pace while half a million laborers poured so much concrete that little was left elsewhere in Western Europe. Flat-faced structures took precedence over curved surfaces to save time. They used steel sparingly, since it was in short supply, but builders cannibalized parts of the Maginot Line to compensate. More than 9,000 strong points appeared, some with walls up to12 feet thick (3.6 meters). Rommel personally designed medieval-like obstacles and emplaced half a million astride high water marks before D-Day: concrete tetrahedrons, Czech hedgehogs that consisted of three railway rails set in concrete at right angles, and telephone pole-sized stakes pointed seaward, some capped with land mines or tipped with "can opener" blades to rip the bottoms off landing craft. Other mines by the millions covered beach exits, anti-airborne "Rommel asparagus" stakes strung together with trip wires discouraged glider landings in open fields, and deliberately flooded lowlands impeded movement from landing sites inland. Most fortified resort hotels and summer homes could sweep beaches at point-blank range with overlapping automatic weapon and artillery fire.[19]

General Eisenhower, with last-minute misgivings before the D-Day assault, scribbled a note to himself that read, "Our landings in the Cherbourg-Havre area have failed to gain a satisfactory foothold and I have withdrawn the troops . . . . If any blame or fault attaches to the attempt, it is mine alone."[20] Allied forces, of course, seized lasting lodgments on June 6, 1944, at less cost in lives than the most optimistic predictions, despite touch-and-go situations in the U.S. sector, where First Army's after-action report recorded 1,465 dead, 3,184 wounded, 1,928 missing, and 26 captured on what became known as "the longest day."

OFFENSIVE FORTIFICATIONS

Security always has been, and still is, the primary function of fortifications, but tunnels that go under rather than over, around, or through enemy positions occasionally appeal to devotees of strategically and tactically indirect approaches that take devious paths to achieve objectives through surprise.

SUBTERRANEAN EXPLOSIVES

Offensive armed forces balked on the surface have long burrowed beneath enemy positions to inflict damage, a classical siegecraft technique. Belligerents on the Western Front during World War I applied that practice on a scale never duplicated before or since. The biggest blast behind or under enemy lines erupted in Belgium between Ypres and Warneton on June 7, 1917, when Australians and Canadians at 11 sites along an 8-mile (13-kilometer) stretch

of Messines Ridge detonated 933,000 pounds of explosives (466 tons), mainly ammonol. No official estimate of German casualties ever was released, but 10,000 men were missing and 7,350 were prisoners of war when the battle was over.[21]

SUBTERRANEAN SPEARHEADS

Investigators in the Republic of Korea (ROK), alerted by suspicious subterranean explosions, found three large tunnels in the mid-1970s and a fourth in 1990, each deeply embedded beneath the mountainous demilitarized zone and each large enough to accommodate quarter-ton trucks together with enemy troops four abreast. Searches for 16 more along that 155-mile (250-kilometer) demarcation line continued in response to further audible rumblings, information derived from sensors, and North Korean defectors. ROK officials all the while feared that if war occurred North Korean light infantry, commandos, and other special operations forces would pour through, surround Seoul, cut off reinforcements, sever supply lines, and form a second front south of the DMZ. Speculators alternatively suggested that decisionmakers in Pyongyang might deposit nuclear weapons at mid-point in one or more tunnels, detonate them when windborne fallout from subsurface bursts would drift south, then launch a full-scale offensive through cracked coalition lines while confusion reigned and electromagnetic pulse blacked out U.S. and ROK radio communications as well as computers. Eruptions along Messines Ridge would seem minor in comparison.[22]

FORTIFICATIONS IN THE NUCLEAR AGE

The advent of the Nuclear Age increased the value of subterranean fortifications by some orders of magnitude, because the strongest installations on or near the surface simply could not survive assaults by accurate weapons with yields measured in kilotons (much less megatons).

MILITARY "HARDENING" PROGRAMS

Neutrals as well as potential belligerents sought sanctuaries beneath bedrock. Sweden, for example, early on created a gigantic cavern with more than 1,000 rooms and tunneled from shorelines into mountainsides to shelter its fleet.[23] The United States and the Soviet Union installed intercontinental ballistic missiles (ICBMs) in silos, some of which could withstand overpressures of 10,000 pounds (4,535 kilograms) per square inch, but super lethal weaponry outclassed super hardening. Senior officials of North American Air Defense Command (NORAD), ensconced in the bowels of Cheyenne Mountain near Colorado Springs, often wondered whether a huge direct hit would vaporize their headquarters despite blast-proof doors and several thousand feet of overburden. How well such shelters might have worked will never be known, because none ever were tested in combat, but most students of nuclear war are skeptical about survival prospects.[24]

CIVIL DEFENSE PROGRAMS

The Berlin crisis of 1961 precipitated the first U.S. civil defense shelter program, but only half the sites in existing structures ever were marked or stocked with rudimentary survival kits. Half of those were located in business districts that were heavily populated only during daylight hours and empty on weekends as well as holidays. All save the most avid advocates

soon lost interest in do-it-yourself family shelters, which were widely advertised in the early 1960s, but never became numerous.[25]

Soviet emphases on civil defense conversely were strong throughout the Cold War. Urban planners accordingly sought to restrict population densities, develop satellite towns around large cities, and create firebreaks. Some contemporary sources cited new production facilities, dispersed and hardened. Soviet programs reportedly included actions to replace glass with solids; fireproof roofs; reinforce weak structures; and improvise shields for or bury selected utility stations, plus power and water conduits. Redundant structures and stockpiles were standard procedures.[26] U.S. defense analysts agreed that such *plans* were imposing on paper, but extents to which they were implemented remain debatable.[26]

CITADELS VERSUS CW AND BW WEAPONS

Chemical and biological warfare (CW, BW) agents that creep into nooks and crannies can overcome occupants of citadels able to survive the blast, heat, and radiation that accompany high-yield nuclear detonations, unless secure ventilating systems and vapor locks safeguard every entry. Surefire protective measures are conceivable, but are costly to install.

KEY POINTS

- The simplest field fortifications offer significant protection against conventional and nuclear weapons.
- The strongest fortifications are buried in solid bedrock with few fractures.
- Amphibious landing forces can bring less military power to bear against small islands than ground foces can exert against solitary forts inland.
- Fortified lines are most effective if topographical obstructions make it impossible for them to be outflanked.
- Subterranean fortifications can protect inhabitants against all effects of nearby nuclear detonations, but few will be able to withstand direct hits by high-yield weapons.
- Fortifications that lack secure ventilating systems and vapor locks are vulnerable to chemical and biological warfare attack.

NOTES

1. John R. Galvin, *Air Assault: The Development of Airmobile Warfare* (New York: Hawthorn Books, 1969), 21-28; Rudolf Böhmler and Werner Haupt, *The German Paratroops* (Dorheim, West Germany, and New York: Altmark International, 1971), 37-47.

2. Carl von Clausewitz, *On War*, eds. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 393-414 (quotations and other key points on 397, 407, 414).

3. Yigal Yadin, *The Art of Warfare in Biblical Lands*, vol. 1 (Norwich, England: Jarrold and Sons, International Publishing, 1963), 32-35.

4. Surveys that cover prehistory to modern times include Martin H. Brice, *Forts and Fortresses* (New York: Facts on File, 1990); Ian Hogg, *The History of Fortification* (New York: St. Martin's Press,

1981). See also Dale E. Floyd, *Military Fortifications: A Selective Bibliography* (New York: Greenwood Press, 1992).

5. Christopher Duffy, *Siege Warfare: The Fortress in the Early Modern World, 1494-1660*, and *Siege Warfare*, vol. 2, *The Fortress in the Age of Vauban and Frederick the Great, 1660-1789* (Boston, MA: Routledge and Kegan Paul, 1979 and 1985).

6. FM 5-15: *Field Fortifications* (Washington, DC: Dept. of the Army, June 27, 1972) (superseded by FM 5-103: *Survivability*, June 10, 1985, restricted distribution); Hogg, *The History of Fortification*, 200-207.

7. Donald R. Morris, *The Washing of the Spears: The Rise and Fall of the Zulu Nation* (New York: Simon and Schuster, 1965), 389-420. For a tongue-in-cheek but nevertheless perceptive assessment of lessons learned, see E. D. Swinton, *The Defence of Duffer's Drift* (Wayne, NJ: Avery Publishing, 1986; orginally published in 1907).

8. Robert B. Roberts, *Encyclopedia of Historic Forts: The Military, Pioneers, and Trading Posts of the United States* (New York: Macmillan, 1987).

9. Brice, *Forts and Fortifications*, 134-145, and Hogg, *The History of Fortification*, 168-181.

10. Rafael Steinberg, *Island Fighting* (New York: Time-Life Books, 1978), 104-131, 166-191. For detailed topographical descriptions, see William Herbert Hobbs, *The Fortress Islands of the Pacific* (Ann Arbor, MI: J. W. Edwards, 1945).

11. Hogg, *The History of Fortification*, 190-194, 196-198.

12. Tom Mangold and John Penycate, *The Tunnels of Cu Chi* (New York: Random House, 1985).

13. Ibid.

14. *The Value of Field Fortifications in Modern Warfare*, prepared for Defense Nuclear Agency (Washington, DC: Historical Evaluation and Research Organization (HERO), December 1, 1979), 14, 18-28.

15. Brice, *Forts and Fortifications*, 34-35.

16. Ibid., 146-147, 161; Hogg, *The History of Fortification*, 208-213; Norman Runnison, "For Sale: The Maginot Line," *Arizona Republic*, April 2, 1967, 12B.

17. Charles B. McDonald, "The Siegfried Line Campaign," in *The United States Army in World War II, The European Theater of Operations* (Washington, DC: Dept. of the Army, Office of the Chief of Military History, 1963), especially 30-35, 44-47, 56-57, 66-69, 72-75; Franklin M. Davis, Jr., *Across the Rhine* (New York: Time-Life Books, 1980), 22, 25, 28, 73, 76-77; Dwight D. Eisenhower, *Crusade in Europe* (New York: Doubleday, 1948), 450; Hogg, *The History of Fortification*, 212-214.

18. Cornelius Ryan, *The Longest Day* (New York: Simon and Schuster, 1954), 27.

19. Gordon A. Harrison, "Cross-Channel Attack," in *U.S. Army in World War II, The European Theater of Operations* (Washington, DC: Dept. of the Army, Office of the Chief of Military History, 1951), 249-265; ibid., 22-29; Patrice Boussel, *D-Day Beaches Pocket Guide*, trans. F.M. Watkins (Paris: Libraire Polytechnique Béranger, Département Technique des Presses de la Cité, 1964), 15-20; Hogg, *The History of Fortification*, 228, 236-237.

20. John Keegan, *Six Armies in Normandy* (New York: Viking Press, 1982), 66.

21. Alexander Barrie, *War Underground: The Tunnellers of the Great War* (London: Tom Donovan, 1961). See especially chapter 16.

22. *Defense White Paper, 1990*, Seoul, Ministry of National Defense, Republic of Korea, 75-79; John M. Collins, *Korean Crisis, 1994: Military Geography, Military Balance, Military Options*, Report No. 94-311S (Washington, DC: Congressional Research Service, April 11, 1994), 14.

23. G. Alison Raymond, "Sweden Digs In," *U.S. Naval Institute Proceedings* 80, no. 11 (November 1954): 1223-1225.

24. Jonathan E. Medalia, *MX, "Midgetman," and Minuteman Missile Programs*, Issue Brief IB77080 (Washington, DC: Congressional Research Service, archived March 1, 1991), 2-3.

25. *Civil Defense in the Mid-1970s and Beyond* (Washington, DC: Defense Civil Preparedness Agency, February 14, 1975).

26. Leon Gouré, *War Survival in Soviet Strategy* (Coral Gables, FL: Center for Advanced International Studies, University of Miami, 1976), 131-160; *Industrial Survival and Recovery after Nuclear Attack*, A Report to the Joint Committee on Defense Production (Seattle, WA: Boeing Aerospace, November 18, 1976).

PART THREE: POLITICAL-MILITARY GEOGRAPHY

14. MILITARY SERVICE PREDILECTIONS

Everyone is entitled to his own opinion.
No one is entitled to his own facts.

James R. Schlesinger
Testimony before Congress, 1973

EVERYONE HAS OPINIONS THAT INTENTIONALLY OR INADVERTENTLY DISTORT FACTS TO SUIT PREDILECTIONS, whether they are entitled to or not. Spokesmen for each Armed Service, who advise chiefs of state, foreign ministers, and senior defense officials, commonly possess dissimilar views concerning political-military problems and corrective actions, because they operate in distinctive geographic mediums and genuflect before different geopolitical gurus who variously advocate land, sea, air, or space power. Many (not all) members of each service are firmly convinced that their convictions are correct and believe competing opinions are flawed. The dominant school of thought in any country or long-standing coalition (such as NATO and the now defunct Warsaw Pact) consequently exerts profound effects on military roles, missions, strategies, tactics, plans, programs, and force postures.

DIVERSIFIED VIEWPOINTS

Warfare was confined largely to conflicts on land, the natural habitat of all human beings, until about 700 B.C., when Phoenician strategists introduced ships designed explicitly for combat at sea. Persian armed forces initiated major amphibious operations at Marathon in 490 B.C. and a decade later engaged a Greek fleet at Salamis in the first large-scale naval battle.[1] Land and sea thereafter remained the only military arenas until the 20th century,

when air forces, then military operations in space, added third and fourth dimensions that generate ceaseless interservice jockeying to consolidate or expand geographical jurisdictions. The four thumbnail sketches that follow illustrate fundamental philosophical differences.

TERRACENTRIC VIEWS

Army generals, who revere the Clausewitzian treatise *On War*,[2] subdivide continents into theaters, areas of operation, and zones of action within which terrain features limit deployments, schemes of maneuver, weapon effectiveness, and logistical support. Ground forces engaged in conventional combat are loath to lose contact with adversaries until they emerge victorious and, if necessary, impose political-military control by occupying hostile territory. Armies once were self-sufficient, but dependence on aerial firepower currently is pronounced and, unless circumstances allow them to move overland, they can neither reach distant objective areas nor sustain themselves after arrival without adequate airlift and sealift. Senior army officials consequently tend to favor command structures and relationships that assure essential interservice support whenever and wherever required.[3]

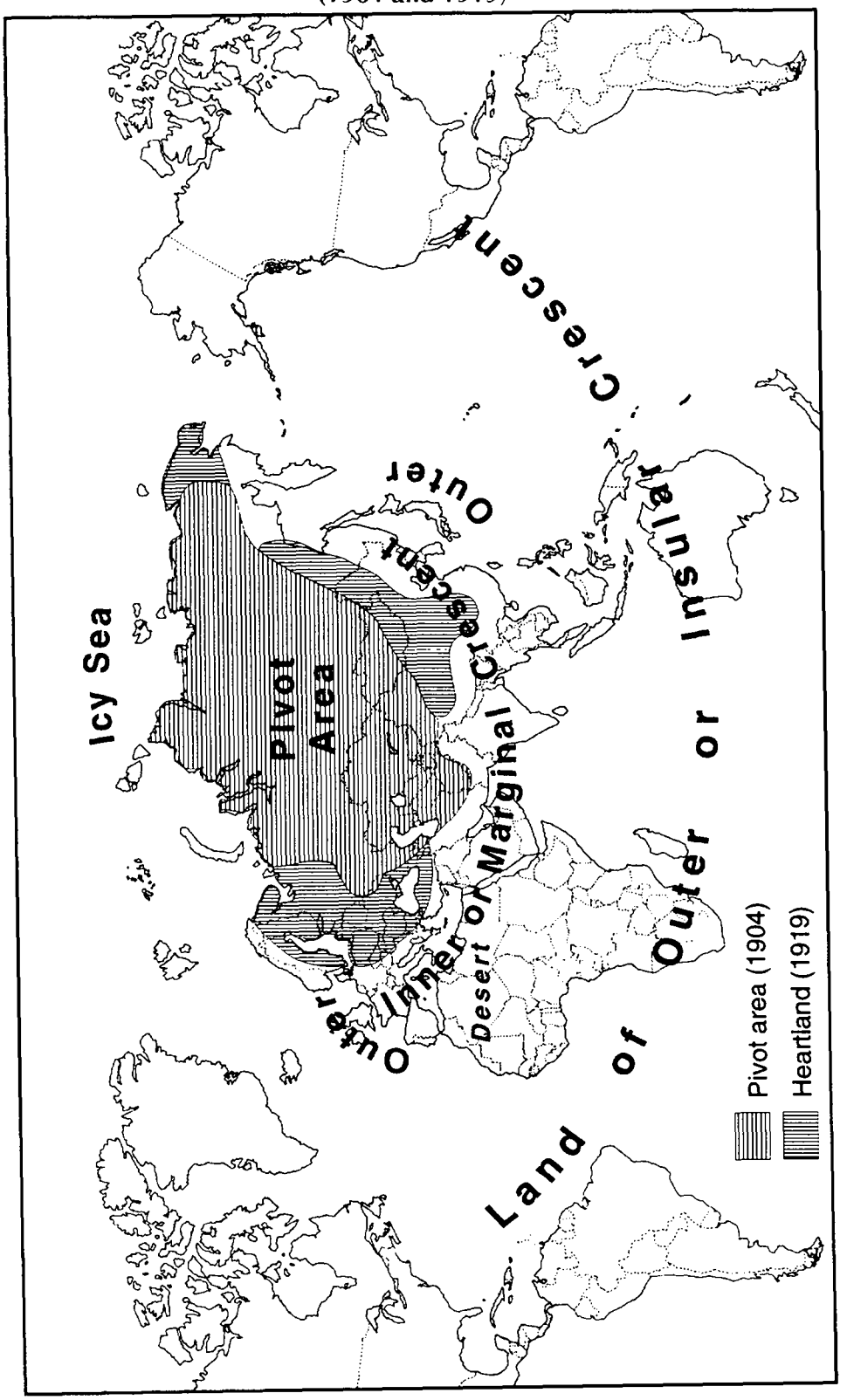
Terracentric advocates of land power trace their roots to Friedrich Ratzel who, in 1897, for the first time formally correlated continental land masses with political-military power. James Fairgrieve, Karl Haushofer (who made *Lebensraum* a household word in Nazi Germany), and Nicholas J. Spykman were subsequently prominent,[4] but none attracted greater international attention than Sir Halford J. MacKinder, whose 1904 study entitled, "The Geographical Pivot of History," assigned prime importance to central Eurasia which, because it coupled splendid isolation with vast space and resources, seemed to comprise a defensible base from which to project decisive power. MacKinder in 1919 added a good deal of Eastern Europe to the Pivot Area, designated it as the Heartland, recognized the rest of Eurasia as an Inner or Marginal Crescent (sometimes called the Rimland), and conceived an Outer or Insular Crescent that included Africa south of the Sahara, Australia, Britain, Japan, large archipelagos like Indonesia, and the Americas (map 41). Europe, Asia, and Africa became the World-Island, at which point he postulated:

> Who rules East Europe commands the Heartland.
> Who rules the Heartland commands the World-Island.
> Who rules the World-Island commands the world.[5]

MARECENTRIC VIEWS

Free-wheeling marecentric forces, unlike armies, rely little on joint service cooperation, enjoy a global reach channelized only by geographic choke points, and generally determine unilaterally whether, where, and when to fight, because they most often are able to make or break contact with enemy formations as they see fit. Admirals as a rule accordingly resent bureaucratic restrictions on naval freedom of action and defy anybody to draw recognizable boundaries across their watery domain, which is a featureless plane except along littorals where land and sea meet [6] (go-it-alone policies during World War II made Secretary of War Henry L. Stimson lament the "dim religious world where Neptune is God, Mahan is his prophet, and the U.S. Navy the only true church"[7]). Topographic obstacles other than shallows, islands, and ice are foreign to surface sailors—submariners have different perspectives—but one prominent geographic limitation is inescapable: even navies with

Map 41. *The World According to Mackinder*
(1904 and 1919)



superlative underway replenishment capabilities ultimately are tied to vulnerable bases ashore.[6]

The basic naval wartime objective, articulated in the early 1900s by British strategist Sir Julian Corbett, "must always be directly or indirectly either to assure command of the sea or to prevent the enemy from securing it."[8] U.S. Navy Captain (later Rear Admiral) Alfred Thayer Mahan, in his political-military exposition entitled *The Influence of Sea Power Upon History*, preached that sea control indeed can determine decisions ashore.[9] Blockades were the principal instrument when he penned that document in 1904, but carrier-based aircraft, specialized amphibious assault forces, and guided missiles enable modern navies to project power far inland. Admiral Mahan additionally predicted that armed forces positioned around Eurasia could contain land power emanating from MacKinder's Heartland, a postulation that the United States and its allies put to good use first during World War II, then during their prolonged Cold War confrontation with the Soviet Union and its associates (map 42).[10]

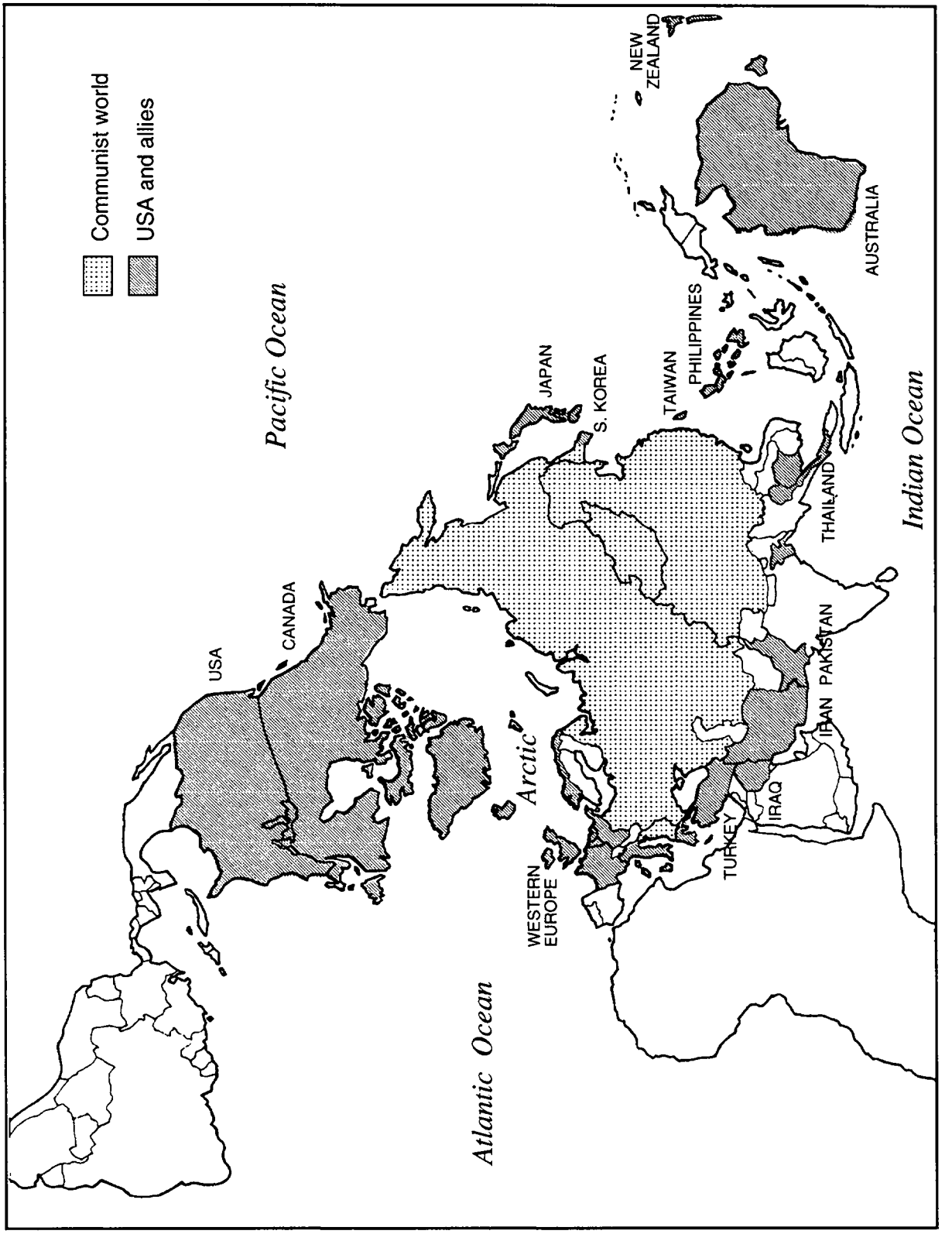
AEROCENTRIC VIEWS

Land-based air forces operate in a medium that surface navies might envy, where there are three dimensions rather than two, *no* choke points, *no* topographic impediments, and visibility to far distant horizons, being less limited by Earth's curvature, is restricted only by clouds except in mountainous terrain. Global reach is truly obtainable, given secure airfields, secure launch pads for long-range missiles, and essential logistical support from other services. Small wonder, therefore, that aerocentric generals (like admirals) prefer the greatest possible autonomy and are leery of boundaries that limit flexibility because, in the main, they believe that unfettered air power could be the decisive military instrument and make protracted wars obsolete. All services attach top priority to air superiority, without which most combat missions ashore or afloat become excessively costly, even infeasible.[11]

Italian Brigadier General Guilio Douhet began prophesying about the future of air power five scant years after the Wright Brothers first took flight. His *Command of the Air* (1921), which visualized air strikes to destroy enemy population centers, industrial bases, and war-making potential, laid the foundation for strategic bombing concepts. Douhet, whose disciples are legion, vastly overrated the destructive potential of munitions then available and underrated rival air defenses, but nuclear weapons seemed to vindicate his theories during the Age of Assured Destruction.[12] Alexander de Seversky, whose book *Air Power: Key to Survival* (1950) updated and supported Douhet, unequivocally subordinated armies and navies to air forces.[13] His postulations not only put a north-south rather than east-west spin on superpower confrontations during the Cold War but identified an "Area of Decision" around the North Pole, where U.S. and Soviet dominance appeared to overlap (map 43). Nuclear-armed intercontinental ballistic missiles (ICBMs) with north-south trajectories strengthened his arguments in the 1960s, whereas submarine-launched ballistic missiles (SLBMs) had the opposite effect, because they could attack from diverse directions.

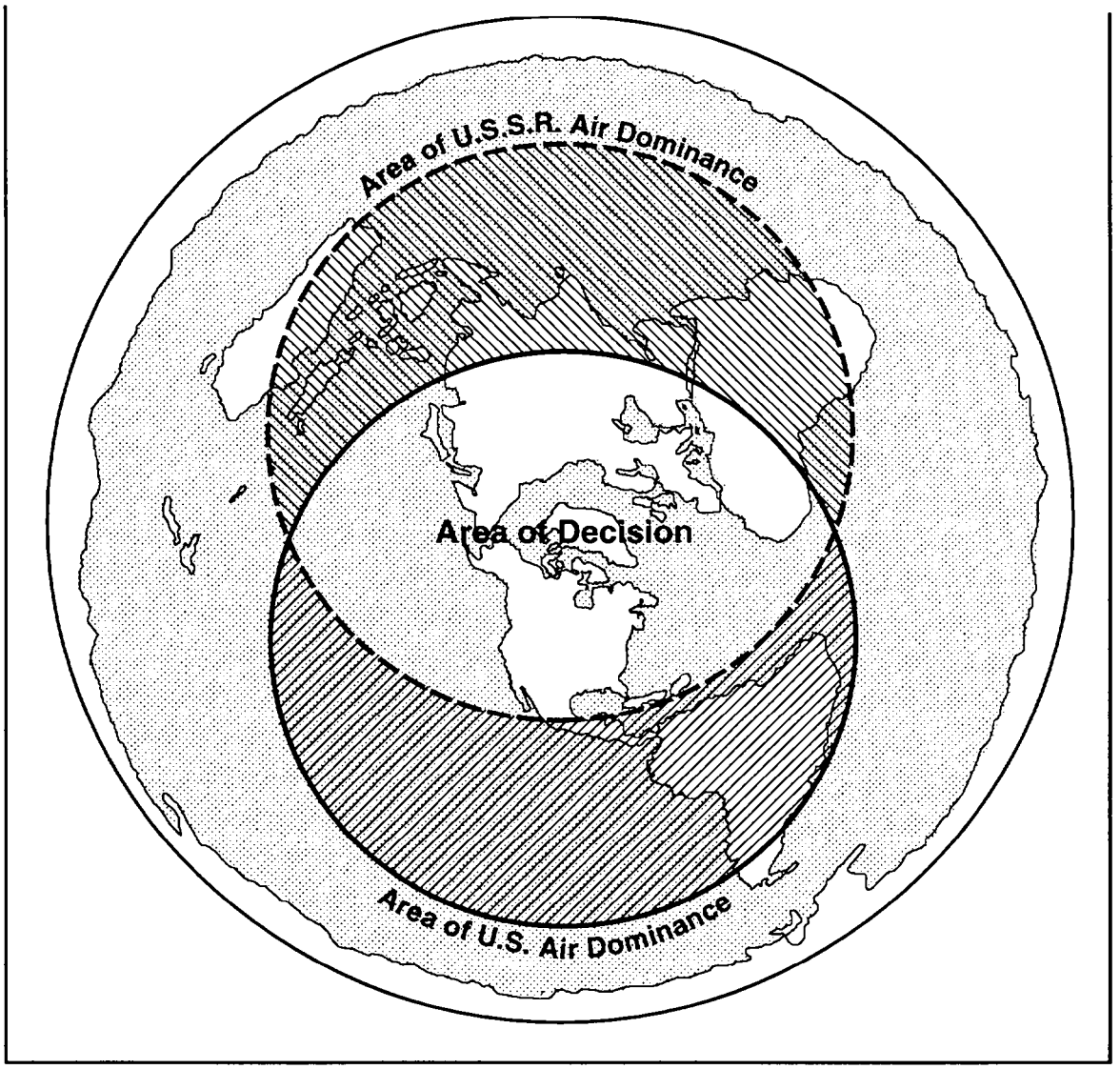
No comparable philosophies with persistent and widespread approval underpin theater air power doctrines. Brigadier General William "Billy" Mitchell, who conceived division-sized parachute assaults in 1918 and twice demonstrated the potency of air power against naval surface combatants (1921, 1923), may have come closest to "sainthood" but, like Douhet before him, was persecuted for his prescience.[14]

Map 42. *U.S. and Allied Encirclement of the Soviet Union*



Adapted from Gérard Chaliand and Jean-Pierre Rageau, *Strategic Atlas*, 3rd ed.

Map 43. *De Seversky's View of the Globe*



ASTROCENTRIC VIEWS

An astrocentric school of thought devoted to military space, in early formative stages at this moment, concentrates on the Earth-Moon System (chapter 7), because interplanetary conflicts seem far in the future. The central theme is still indistinct, but may well revolve around lunar libration points L-4 and L-5, then adapt MacKinder's Heartland Theory with words something like these:

> Who rules circumterrestrial space commands Planet Earth;
> Who rules the moon commands circumterrestrial space;
> Who rules L-4 and L-5 commands the Earth-Moon System.

INTEGRATED AND UPDATED VIEWS

Conflicting advice from land, sea, air, and space power advocates is valuable, because it provides senior officials with service-oriented opinions on any given political-military topic before they reach decisions. Former Secretary of Defense Robert S. McNamara even so was right when he wrote, "We can imagine many different kinds of wars the United States must be prepared to fight, but a war in which the Army fights independently of the Navy, or the Navy independently of the Air Force is not one of them."[15]

Each service as it stands is superior in some environments and inferior in others. Armies generally function more efficiently than air forces in heavily forested regions and rugged terrain, whereas air power is especially advantageous over sparsely covered plains. Ballistic missile submarines at sea, being mobile as well as invisible to enemy targeteers, are less vulnerable to prelaunch attacks than "sitting duck" intercontinental ballistic missiles (ICBMs) in concrete silos ashore. Reasonable degrees of centralized control coupled with joint doctrines, joint education, and joint training programs that effectively integrate multiservice capabilities thus seem desirable.

Some opinions that Mackinder, Mahan, de Seversky, and other geopolitical savants expressed many years ago may still be sound, but all require periodic reexaminations followed if necessary by fresh interpretations or replacements, because political, economic, social, scientific, and technological developments continually alter relationships between geographic circumstances and political-military power.[16] Mackinder, well aware of change, not only tacked Mongolia and the Tibetan Plateau onto his Heartland in 1943 but, in light of events during World War II, repudiated his 1919 pronouncement, "Who rules the Heartland commands the World-Island."[17] Not everyone concurred with his judgments, but his openminded attitude remains worth emulating in this turbulent world.

KEY POINTS

- Land, sea, air, and space forces operate in distinctive geographic mediums that vest them with very different perspectives, predilections, capabilities, and limitations.
- Each military service is superior to the others in its particular environment, but none performs equally well in all geographic milieus.
- Senior political-military officials benefit immeasurably from the unvarnished views and professional advice of each individual service before they reach decisions on any given topic.
- The military service that national leaders favor at any given time is well positioned to exert profound influence on military matters of all kinds at every level.
- Military dogmas and doctrines require periodic updating to keep pace with ever-changing relationships between geography and political-military power.

NOTES

1. R. Ernest and Trevor N. Dupuy, *The Harper Encyclopedia of Military History*, 4th ed. (New York: Harper Collins, 1993), 1-41; J. F. C. Fuller, *A Military History of the Western World*, vol. 1 (New York: Funk & Wagnalls, 1954), 1-52.

2. Carl von Clausewitz, *On War*, eds. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976).

3. J. C. Wylie, *Military Strategy: A General Theory of Power Control* (New Brunswick, NJ: Rutgers University Press, 1967), 49-56.

4. Saul Bernard Cohen, *Geography in a World Divided* (New York: Random House, 1963), chapter 2, Geopolitical Perspectives; Edward Mead Earle, ed., *Makers of Modern Strategy: Military Thought from Machiavelli to Hitler* (Princeton, NJ: Princeton University Press, 1943), chapter 16.

5. Halford J. MacKinder, "The Geographical Pivot of History," *Geographical Journal* XXIII (1904): 421-444, and *Democratic Ideals and Reality* (New York: Henry Holt and Co., 1942; original publication in London, 1919).

6. Wylie, *Military Strategy*, 39-42, 49, 50, 56.

7. Secretary Stimson is quoted in William Reitzel, "Mahan on the Use of the Sea," *Naval War College Review* (May-June): 1973, 73.

8. Julian Corbett, *Some Principles of Naval Strategy* (Annapolis, MD: U.S. Naval Institute Press), 87. For elaboration, see B. Mitchell Simpson, III, ed., *The Development of Naval Thought: Essays by Herbert Rosinski* (Newport, RI: Naval War College Press, 1977).

9. Alfred Thayer Mahan, *The Influence of Sea Power Upon History, 1660-1783*, American Century Series (New York: Hill and Wang, 1957; originally published in 1890).

10. Alfred Thayer Mahan, *The Problem of Asia and Its Effect Upon International Policies* (Boston: Little, Brown, 1900).

11. Wylie, *Military Strategy*, 42-48, 56; Dennis M. Drew, "Joint Operations: The World Looks Different from 10,000 Feet," *Airpower Journal* 2, no. 3 (Fall 1988): 4-16.

12. Guilio Douhet, *Command of the Air*, eds. Richard H. Kohn and Joseph P. Harahan, trans. Dino Ferrari (Washington, DC: Government Printing Office, 1983). See also Bernard Brodie, "The Heritage of Douhet," *Air University Quarterly Review* VI (1953): 64-69, 120-126.

13. Alexander de Seversky, *Air Power: Key to Survival* (New York: Simon and Schuster, 1950); *Makers of Modern Strategy*, chapter 20.

14. Burke Davis, *The Billy Mitchell Affair* (New York: Random House, 1967).

15. Robert S. McNamara, *The Essence of Security: Reflections in Office* (New York: Harper & Row, 1968), 91.

16. Preston E. James, "Dynamics of National Power," *Military Review* (May 1963): 17-25.

17. Sir Halford J. MacKinder, "The Round World and the Winning of the Peace," *Foreign Affairs* (July 1943): 595-605.

15. GEOPOLITICAL FRICTION

Good fences make good neighbors.

Robert Frost
Mending Wall, 1914

MOST GEOPOLITICAL FRICTION, INCLUDING WARS, ORIGINATES ON LAND OR ALONG LITTORALS WHERE masses of humanity pursue conflicting purposes. Many sore spots and flash points have geographic origins, of which contentious territorial claims and environmental altercations perhaps are most common. Good fences may not always make good neighbors, but mutually agreeable boundaries and environmental practices that avoid adverse regional (even global) side effects generally help reduce the number of potentially explosive international disputes that otherwise could lead to armed combat.

TERRITORIAL LIMITS

Sparsely settled or empty spaces separated sovereign territories when small human populations were widely scattered, valuable resources were relatively abundant, and surveying skills were rudimentary. The first sharply-defined political boundary appeared on May 4, 1493, when Pope Alexander VI promised Portugal all newly found lands east of a north-south line 100 leagues (300 miles, 483 kilometers) west of the Azores and Cape Verde Islands and allocated to Spain all newly-found lands west of that latitude. Brazil formally became a Portuguese possession after the Treaty of Tordesillas drew the line 810 miles (1,285 kilometers) farther west the following year and Pope Julius II approved in 1506. *De jure* boundaries rapidly replaced *de facto* borders and ill-defined frontiers early in the 17th century when nation states proliferated.

TERRESTRIAL BOUNDARIES

Boundaries are much easier for cartographers to draw on maps than for statesmen and armed forces to find on Earth's surface, because markers at best are intermittent and at worst are nonexistent. Approximately 8,200 pillars are distributed along the 3,146-mile (5,063-kilometer) border that separates the United States from Canada, for example, whereas only 22 dot the 970-mile (1,560-kilometer) wasteland between Mauritania and Western Sahara, of which half are located around Cap Blanc.

Topographical Boundaries. Easily recognizable topographic features may seem to be ideal boundaries, but marks that follow the loftiest mountain crests displease governments that, for various reasons, want lines along watersheds. River boundaries that stick to either bank, a median line, or the deepest channel are subject to shifts that add territory on one side, subtract from the other, and raise questions concerning islands in stream[1]—recurrent clashes between Soviet and Chinese border guards in the Amur and Ussuri Valleys were tightly controlled during tense days after the Sino-Soviet split in the 1960s, because local brawls could have escalated to dangerous levels.[2] Lake boundaries cause similar problems that neolithic Nipmuc Indians near present day Webster, Massachusetts, solved when they named their lake *Chargoggagoggmanchaugagoggchaubunagungamaugg* ("you fish on your side, I'll fish on mine, no one fishes in the middle").

Abstract Boundaries. International boundaries often follow straight lines that cut across landscapes with little or no regard for people who live thereon. Several abstractions of that sort on the Arabian Peninsula disappear without a trace in the Rub' al-Khali (the Empty Quarter), which is lightly populated by only a few Bedouin tribes but contains potentially rich natural resources. European colonists long ago laced Africa with straight lines.[3] The 38th Parallel arbitrarily separated North and South Korea from August 1945 until July 1953, when an armistice line that bisected a demilitarized zone (DMZ) replaced it. The 17th Parallel and DMZ similarly separated North and South Vietnam for 21 years between July 1954 and April 1975.

Squiggly as well as straight line boundaries sometimes correlate poorly with real world considerations, a fact perhaps best confirmed by Israel, which has been barricaded behind armistice lines and the unofficial borders of occupied territories since 1948. States that contain two or more discontinuous segments seldom enjoy great longevity. Hitler, for example, forcibly reunited East Prussia with the German Fatherland in 1939, just 20 years after the Treaty of Versailles interposed the Danzig Corridor between that province and its parent. East Pakistan and West Pakistan, 900 miles apart (1,450 kilometers), persisted fewer than 25 years from their inception in 1947, when they separated from India, until East Pakistan became politically independent Bangladesh in 1971.

Some terrestrial boundaries drawn with little regard for physiographic, cultural, or economic realities stabilize sooner or later (the United States and Canada settled their last significant border dispute in 1903), but many become geopolitical sore spots. Historical experiences bear close observation, lest troubles erupt unexpectedly.

TERRITORIAL WATERS

Offshore boundaries that separate territorial waters from high seas and limit the sovereignty of adjacent coastal states raise highly-charged political-military and economic questions for which statesmen and lawyers have not yet found universally acceptable answers, even though 112 states and other entities by 1997 had ratified a comprehensive United Nations Convention on Law of the Sea (UNCLOS) which included the following provisions:[4]

- A 12-nautical mile (22 kilometer) limitation on territorial seas within which foreign vessels are authorized to exercise the right of "innocent passage" in peacetime

- A contiguous zone up to 12 more nautical miles within which coastal states are authorized to exercise control over laws and regulations concerning customs, fiscal matters, immigration, and sanitation
- A 200-nm (370-kilometer) exclusive economic zone (EEZ) within which coastal states are authorized to exercise sovereignty over natural resources and jurisdiction over some scientific research and environmental projects
- EEZs may extend seaward a maximum of 350-nm (650 kilometers) wherever the true continental shelf extends that far
- All areas beyond the continental shelf are reserved for "the common heritage of mankind"
- Naval ships and merchant marines are authorized freedom of navigation in narrow territorial waters, more than one-third of which are less than 24 nautical miles wide.
- All states are authorized to overfly EEZs.

Loopholes nevertheless remain. Each coastal state is free to define "innocent passage" in ways that promote its interests. Sovereignty claims still range from 3 to 200 nautical miles (5.5 to 370 kilometers), with several African and South American countries in the latter category. The Maldives and Philippines both profess territorial water rights within boundaries that include their outermost islands and atolls. The United States, which opposes provisions that deter development of deep sea-bed mineral resources, has not ratified the Convention.[5]

TERRITORIAL CLAIMS OVERHEAD

"How high is up?" will remain an enigma until laws of air and space complement laws of the sea, which seek to answer the question, "How far is out?" The atmosphere over every country to some unspecified altitude currently is sovereign territory that allows owners to forbid transit without their approval, which is not always forthcoming.[6] Italy, Greece, Austria, and Switzerland denied U.S. Armed Forces direct routes from Germany to staging bases in Turkey when the President of Lebanon requested military help in 1958.[7] U.S. attack aircraft based in Britain had to take long detours around France and Spain en route to Libya, where they bombed parts of Tripoli and Benghazi on April 15, 1986, in retaliation for a terrorist attack that "Revolutionary Leader" Mu'ammar al-Qadhafi previously backed in Berlin.[8] The spectacularly successful hostage rescue operation at Entebbe, Uganda, in July 1976 was possible only because Israeli flight crews violated the air space of African countries that lacked modern air defense systems.[9] No document yet prescribes vertical or horizontal boundaries that define territorial sovereignty on the moon or in free space.

STRATEGIC FRICTION

Ancient words warn, "You shall hear of wars and rumors of wars . . . for nation shall rise against nation and kingdom against kingdom."[10] Certainly, there is no shortage of geopolitical friction as the 20th century draws to a close, nor any sign that armed conflicts will soon cease (table 24).[11] Boundary disputes, contentious sovereignty claims, galloping population growth, insufficient natural resources, drought-induced starvation, resultant mass migrations, religious rivalries, racial-ethnic-tribal tensions, and intolerable environmental conditions are contributing factors. Contingency planners who try to put the lot in rough priority concentrate on embranglements that could endanger the globe, followed by apparent

threats to regional security. Altercations that seem to have strictly local implications get shorter shrift, but accurate determinations often are elusive, because even small civil wars are liable to spread with little warning and unintended consequences.

Table 24. *Typical Trouble Spots, Mid-1990s*

CIVIL STRIFE

Afghanistan	Mexico
Algeria	Northern Ireland
Bosnia	Peru
Burundi	Rwanda
Cambodia	Sri Lanka
Congo	Sudan
Kurdistan	Timor

CONTENTIOUS TERRITORIAL CLAIMS

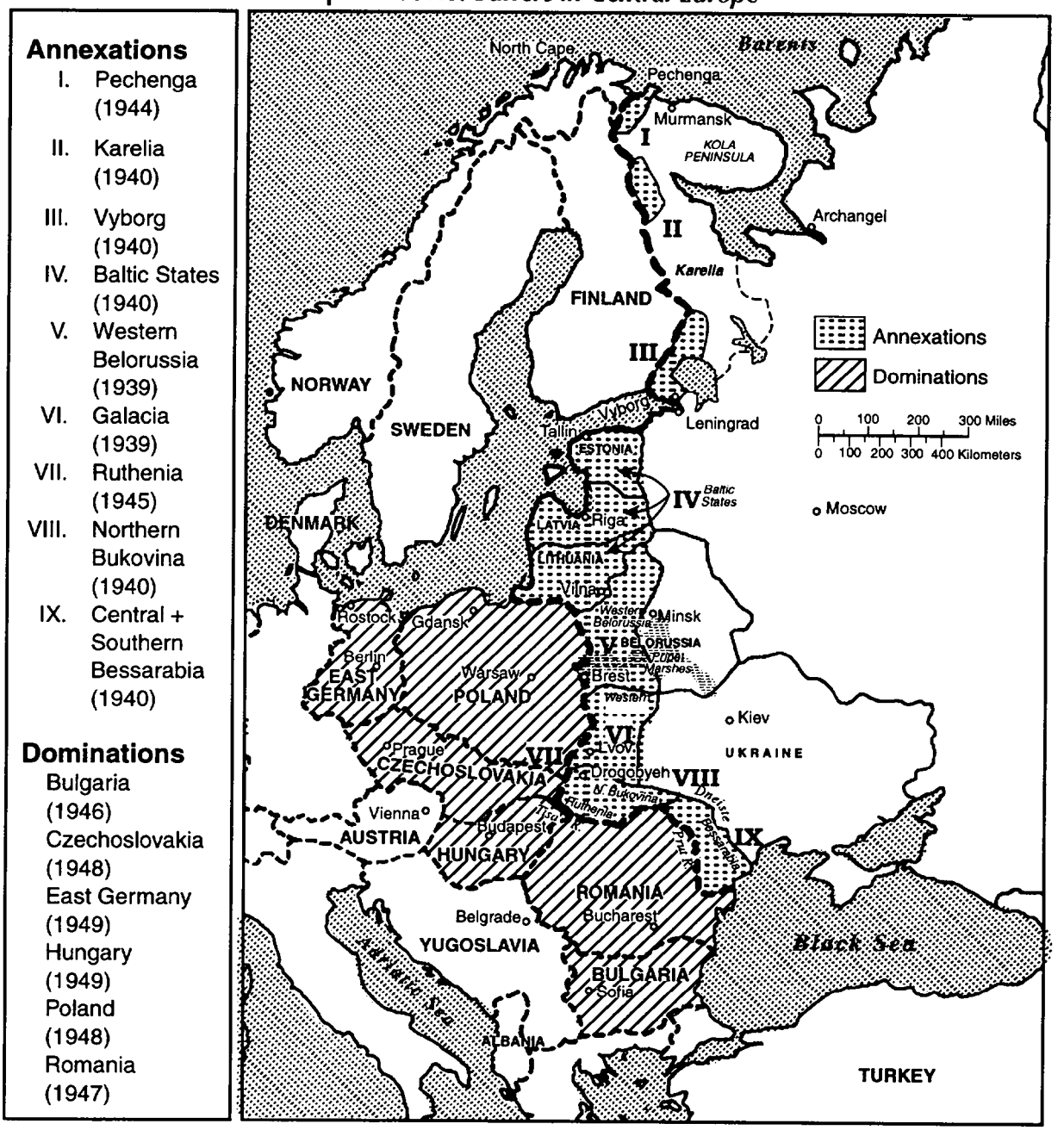
Argentina vs. Chile	India vs. Pakistan
Britain vs. Spain	Indonesia vs. Malaysia
China vs. India	Iran vs. United Arab Emirates
China vs. Russia	Iraq vs. Iran
China vs. Taiwan	Iraq vs. Kuwait
China vs. Vietnam	Iraq vs. Saudi Arabia
Cuba vs. United States	Israel vs. Palestinians
Ecuador vs. Peru	Israel vs. Syria
Egypt vs. Sudan	Libya vs. Chad
Ethiopia vs. Somalia	North vs. South Korea
Greece vs. Turkey	Russia vs. Japan

Two strategic altercations on a grand scale are described below. One involved the Soviet absorption of buffer states in Central Europe, the other concerns simmering disputes between China and its Soviet neighbor. Disputes about the control of key straits illustrate strategic standoffs at a lower level.

SOVIET BUFFER ZONE

Generalissimo Joseph Stalin annexed three countries and parts of five others to provide a buffer zone between the Soviet Union and perceived enemies in Western Europe beginning in 1939 (map 44). Estonia, Latvia, and Lithuania, Western Belorussia and Galicia (stripped from Poland), together with Northern Bukovina and most of Bessarabia (wrested from Romania), gave the Soviet Union relatively ice-free windows on the Baltic Sea and added depth farther south before Hitler invaded in June 1941. Soviet Armed Forces occupied all direct approaches to Leningrad from the west after Stalin acquired Karelia and the Vyborg District from defeated Finland in 1940. Finland's Pechenga Territory, 60 miles (95 kilometers) west of Murmansk, afforded a bit more breathing room between that crucial port and Nazi-occupied Norway in 1944. The absorption of Ruthenia (Transcarpathian

Map 44. *Soviet Buffers in Central Europe*



Czechoslovakia) in 1945 not only extended the Soviet buffer zone all the way from the Baltic to the Black Sea but, as a bonus, united Slavic minorities with kindred Ukranians.[12]

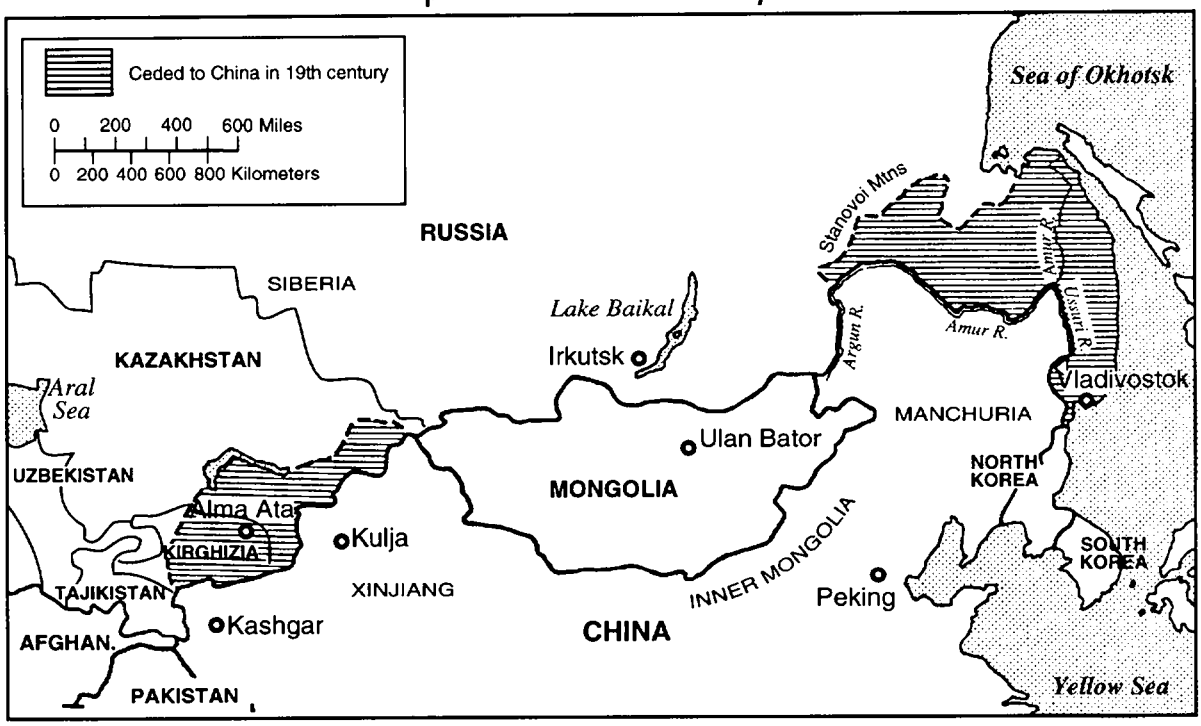
Stalin thereafter swallowed most of Central Europe, then rang down an infamous Iron Curtain. Seven countries with communist-dominated regimes—Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and RomaniaCsigned the Warsaw Treaty of Friendship, Cooperation, and Mutual Assistance in 1955, after which all but one served as Soviet cat's paws and pawns until a bit before the Warsaw Pact formally disintegrated in July 1991 (Albania severed ties in 1968 because of policy disputes).[13] East and West Germany

reunited on October 3, 1990; Russia soon thereafter relinquished the three Baltic States and annexed lands in what now are Belarus, Ukraine, and Moldavia; several nations, despite Russian objections, sought membership in NATO, most notably Poland, Hungary, the Czech Republic, and Slovakia[14] The buffer zone that Stalin had assembled so methodically forty some years earlier in short disappeared.

CHINESE BORDER DISPUTES

Boundaries that Chinese emperors and Russian tsars established in the mid-1800s gave Russia sovereignty over 185,000 square miles (480,000 square kilometers) north of the Amur River, huge maritime territories east of the Ussuri, and 350,000 square miles (900,000 square kilometers) in Central Asia (map 45). Subsequently installed regimes in the Soviet Union and Republic of China agreed to reconsider mutual boundaries in 1924, but related actions remained in abeyance for the next 25 years, because Chinese leaders were preoccupied with civil wars and Japanese invaders. Eleven more years passed peacefully after Communist China emerged victorious in 1949 and established strong links with Moscow, even though *A Short History of Modern China*, published in Beijing, laid claim to large parts of the Soviet Far East, Kazakstan, Kirghistan, and Tajikistan as "Chinese territories taken by imperialism."[15]

Map 45. *Chinese Border Disputes*



Boundary disputes bubbled in earnest about 1960, when the Sino-Soviet entente started to split. The first large-scale clashes occurred in Xinjiang Province during early autumn 1964, when Muslim resentment against repressive Chinese rule motivated about 50,000 Kazakhs, Uighurs, and other ethnic groups to riot, then take shelter in the Soviet Union. Tensions along the Far Eastern frontier reached a fever pitch in 1967 after howling mobs besieged the Soviet

Embassy in Beijing for more than 2 weeks. Both sides briefly massed a total of 600,000 troops along the border—nearly 40 divisions on the Soviet side and perhaps 50 or 60 Chinese counterparts. Damansky Island (Zhanbao to the Chinese) was twice the site of stiff fighting in March 1969, followed in August by confrontations at Xinjiang's Dzungarian Gate, after which both sides took pains to defuse situations, partly because each at that point possessed nuclear weapons with delivery systems that could reach the other's core areas.[16] China, however, has never renounced its claims, which future leaders might vigorously pursue if Chinese military power continues to expand while Russian armed strength subsides.

CHOKE POINT CONTROL

Arguments between Iran and the United Arab Emirates over control of Abu Musa, a tiny island that sits in the Strait of Hormuz like a cork in a bottle,[17] and squabbles between Britain and Spain about Gibraltar, where the Atlantic Ocean meets the Mediterranean Sea,[18] typify trouble spots that are of less strategic significance to disputants than to bystanders who routinely rely on sea lanes that pass through. Controversies that involve Argentina and Chile, both of whom claim sovereignty over the Strait of Magellan,[19] and rancorous relations between Russia, which has held the Kuril Islands since World War II, and Japan, typify quarrels that are of greater interest to the contestants than to outsiders.[20]

ECONOMIC FRICTION

"Have not" nations, like children with noses against candy store windows, hunger for what "have" nations have. Speculation about what would happen after Hong Kong passed from British to Chinese sovereignty on July 1, 1997, centered on that city's commercial value as a trading center at international crossroads.[21] The destitute Democratic People's Republic of Korea clearly would like to embellish its economic power base by absorbing diversified industries, rich agricultural lands, and technologically advanced work forces south of the demilitarized zone, where the poorest inhabitants of South Korea are infinitely better off than all but elitists up north.[22]

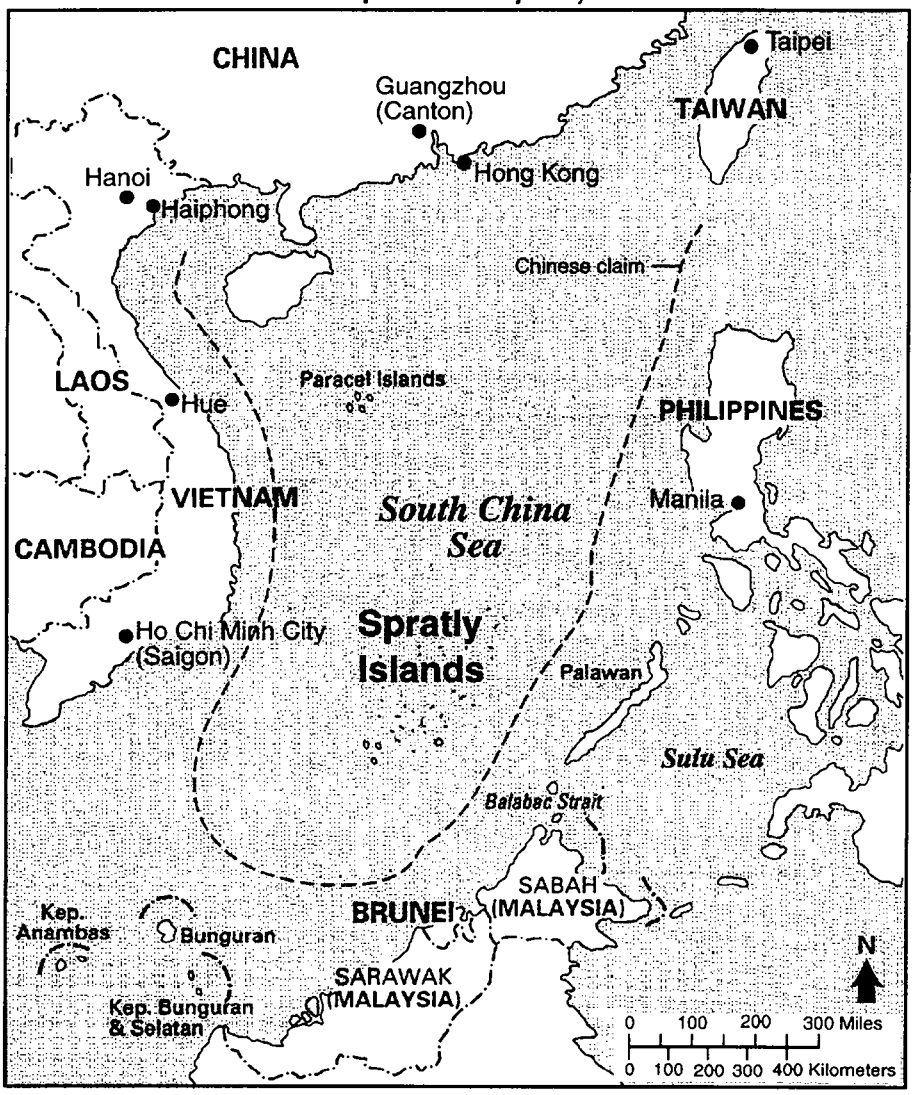
Two economically driven trouble spots deserve elaboration, because both involve several competitors and both are barren on the surface. Six countries currently covet all or some of the Spratly Islands essentially because geological surveys suggest vast untapped oil and gas reservoirs offshore. Seven countries eventually could collide in Antarctica if, as expected, natural resources beneath the ice prove extensive, scientists devise cost-effective extraction procedures, and conflicting real estate claims prove irreconcilable.

THE SPRATLY ISLANDS

The Spratly Islands consist of 12 main islets and 600-odd cays, rocky outcroppings, coral reefs, atolls, sand bars, banks, and shoals in the South China Sea about 250 miles (360 kilometers) east and southeast of Ho Chi Minh City, which most outsiders remember as Saigon (map 46).[23] The total land area, some of which is visible only at low tide, covers less than one square mile (about 2.3 square kilometers)—Ito Abu, the largest islet, occupies 90 acres. Few creatures other than turtles and sea fowl were fond of that forbidding habitat before competition for potentially rich oil reserves turned the Spratly Island complex into a Southeast Asian flashpoint. China, Taiwan, and Vietnam claim the Spratlys in toto, the Philippines seek entitlements to most of them, while Brunei and Malaysia covet small

segments in the southern sector, although no nation maintains civilian settlements anywhere and none established a continuous military presence until after World War II. Taiwan, however, currently deploys a battalion-sized force on Ito Abu, where it built what passes for a small port and a short airstrip. All other contenders except Brunei position troops on several islets, and all take great pains to mark their claims prominently. The sharpest skirmish thus far occurred in March 1988, when Chinese gunboats sank three Vietnamese ships that together lost 77 sailors, but most claimants continue to destroy rival markers, arrest rival fishermen, and take other actions that infuriate adversaries.[24]

Map 46. ***The Spratly Islands***



Prospects that China might seek sovereignty over the entire South China Sea, as its spokesmen repeatedly imply, couples strategic with economic friction, because lifelines between Middle East oil fields and Northeast Asia pass through that body of water.

Reconciliation of disputes in the Spratlys, perhaps by military means, consequently could some day have destabilizing effects that reach far beyond the immediate region.

ANTARCTICA

Isolated Antarctica, which surrounds the South Pole, is twice the size of Europe during its "summer" season and four times as large in winter, when ice shelves form along peripheries. No native land-based vertebrates save penguins brave the brutal cold that frequently dips below -100 ^{0}F (-73.3 ^{0}C) and blizzards whipped by winds that sometimes surpass 200 miles per hour (320 kilometers per hour), but economically valuable whales, food fish, and protein-rich crustaceans called krill teem in the frigid waters, while some explorers suspect the presence of lucrative oil reserves as well as abundant mineral deposits.

Argentina, Australia, Britain, Chile, France, New Zealand, and Norway currently claim slices of Antarctica that, in several instances, overlap. Argentina and Chile additionally declare 200-nautical mile exclusive economic zones (EEZs) off the sectors they say they own; the South Shetland Islands are subjects of tripartite disputes by Argentina, Britain, and Chile; and Argentina and Britain contest possession of the South Orkneys, South Georgia, and South Sandwich Islands, plus tiny Shag Rocks (map 47).[25]

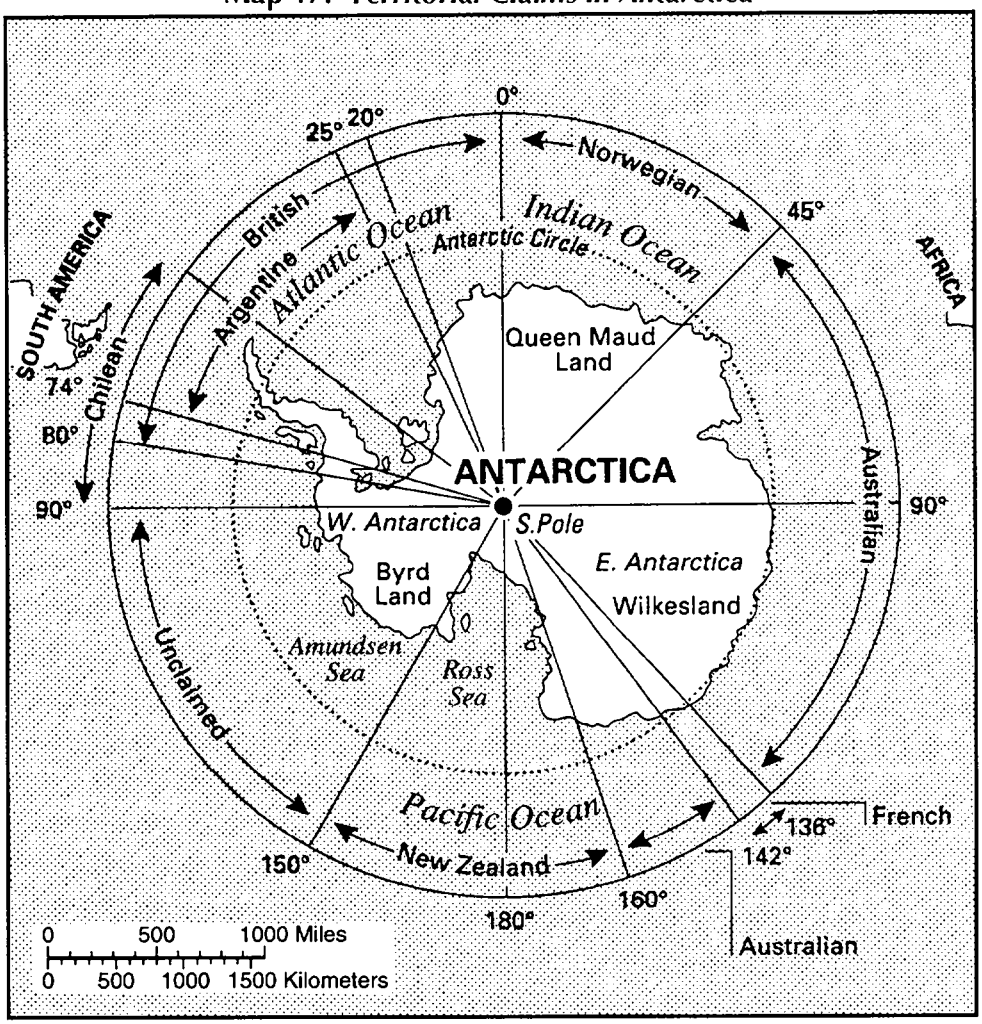
The Antarctic Treaty of 1961, signed by 42 nations as of 1997, froze existing territorial claims for 30 years, forbade new ones, banned military operations, outlawed nuclear weapons, and prohibited the disposal of radioactive waste anywhere on that continent to maintain in a pristine state the only place on Planet Earth that has escaped war, pestilence, and environmental pollution. Amendments in 1980 restricted the exploitation of marine resources and in 1991 imposed a 50-year ban on mining. Loose ends dangle nonetheless, because neither Argentina nor Chile has relinquished territorial claims that coincide with those of Britain, and neither the United States nor Russia recognizes the claims of other powers or waives the right to establish its own. Ice-cold Antarctica could heat up if confirmed natural resources make neutral positions unprofitable.

CULTURAL FRICTION

Bloodlines foster enduring enmities when cultural interests and lifestyles collide, because blood indeed is thicker than water. Catholics and Protestants have not yet found a formula that lets them coexist peacefully in Northern Ireland.[27] Stateless Kurds beset by all and befriended by none wander ceaselessly across mountainous frontiers in southeastern Turkey, northeastern Iraq, and northwestern Iran in search of a homeland.[28] Genocidal combat between Hutu and Tutsi tribes continues in Rwanda and Burundi, with spillovers into eastern Congo, where refugee camps became death traps in 1996-97.[29] Ancient ethnic, religious, and linguistic animosities, accompanied by "ethnic cleansing" in Bosnia-Herzegovina, flared throughout former Yugoslavia in the 1990s among Orthodox Christian Serbs, Roman Catholic Croats, Slovines, Slavic Muslims, Albanians, Macedonians, Montenegrins, and perhaps 15 smaller groups.[30]

Some cultural conflicts are local or regional, while others have widespread ramifications. Uncordial relations that involve conventionally-armed Ethiopians, Somalis, Kenyans, and Sudanese in the Horn of Africa, for example, seem unlikely to spread far beyond present boundaries, whereas altercations in Kashmir could quickly escalate in scope as well as intensity, because China, India, and Pakistan brandish nuclear weapons.

Map 47. *Territorial Claims in Antarctica*



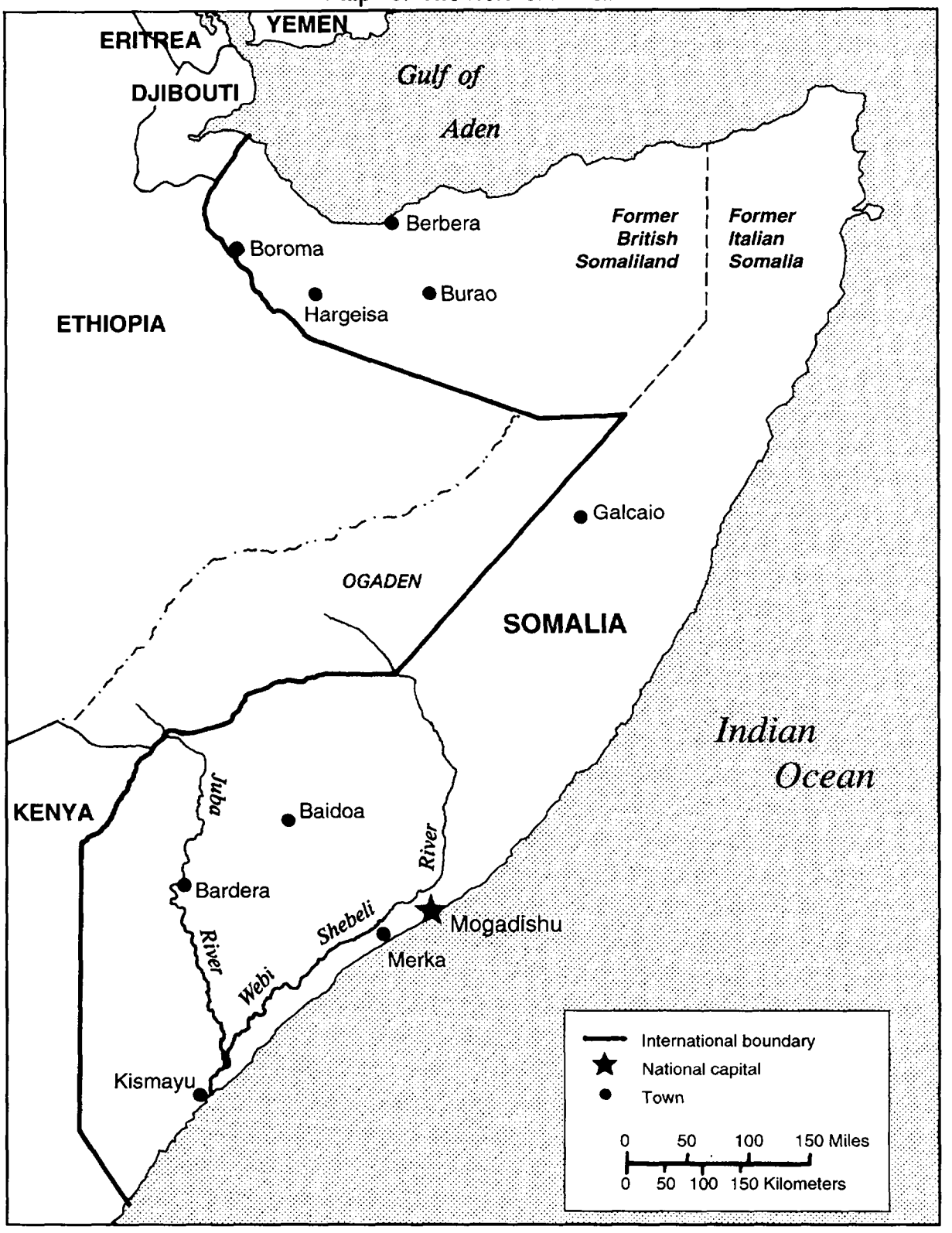
THE HORN OF AFRICA

The Horn of Africa, which British military historian John Keegan with good reason calls "the hungry lands," has long been a hazardous place to live (map 48).[31] Starvation stalks, racial, linguistic, and religious antagonisms are rife, mutually exclusive social systems are endemic.

Cultural Friction in Ethiopia. Nine states with ethnic groups as their nuclei, at least 70 languages spoken as the mother tongue, and two distinctive religions make Ethiopia less cohesive than it seems on small-scale maps. Amharic-speaking Christians in the north, most of whom who practice subsistence agriculture, oppose nomadic Muslims in the Ogaden who have more in common with Islamic Somalia than with the government in Addis Ababa. Several insurgent and secessionist movements are active or waiting in the wings.

Eritreans fought for freedom from 1961 until they finally formed a separate state in 1991, but sporadic combat continued into the 1980s, related problems continue to fester, and malcontents in both countries could upset fragile relationships. The Ethiopian People's Revolutionary Democratic Front (EPRDF), which in 1991 ousted the detested Marxist dictator Mengistu Haile Mariam, subsequently approved a constitution that grants special rights to

Map 48. *The Horn of Africa*



ethnic minorities, but it will take deeds as well as words to unite so many disparate factions on peaceful terms.[32] As if domestic troubles were not enough to keep the new government gainfully employed, strife along the western border began to brew in 1996 when Ethiopia and Eritria (both slated to receive U.S. military assistance) decided to assist Sudanese insurgents who oppose the radical regime in Khartoum.[33]

Cultural Friction in Somalia. Poverty-stricken Somalia, which is much more homogeneous than Ethiopia, is populated primarily by Sunni Muslims who are ethnic Somalis, speak one of three main Somali dialects and, except for refugee-crowded Mogadishu, are pastoral peoples. A volatile mixture nonetheless is present, because six major clan families that revel in warrior traditions vie for internal control. Connivance and cunning are stocks in trade. The meek by no means inherit any part of their earth, as United Nations "peacekeepers" with no peace to keep discovered in 1993, when they tried unsuccessfully to impose law and order.[34] Wars over water, cattle, wives, land, and political "turf" (not necessarily in that order) are national pastimes. Irredentist claims in the Ogaden and parts of Kenya where Somali kinsmen live and the status of splinter groups who have proclaimed an independent Republic of Somaliland along the Gulf of Aden are muted but unrevolved.[35]

Prospects for Peace. Combustible situations that involve Ethiopia, Somalia, Kenya, and the Sudan consequently could develop in Africa's hazardous horn. Dangerous escalation could occur if, as some suspect, Islamic fundamentalists in Iran and elsewhere foment a *jihad* (holy war) in retaliation against Ethiopian and Eritrean intervention in Sudan.

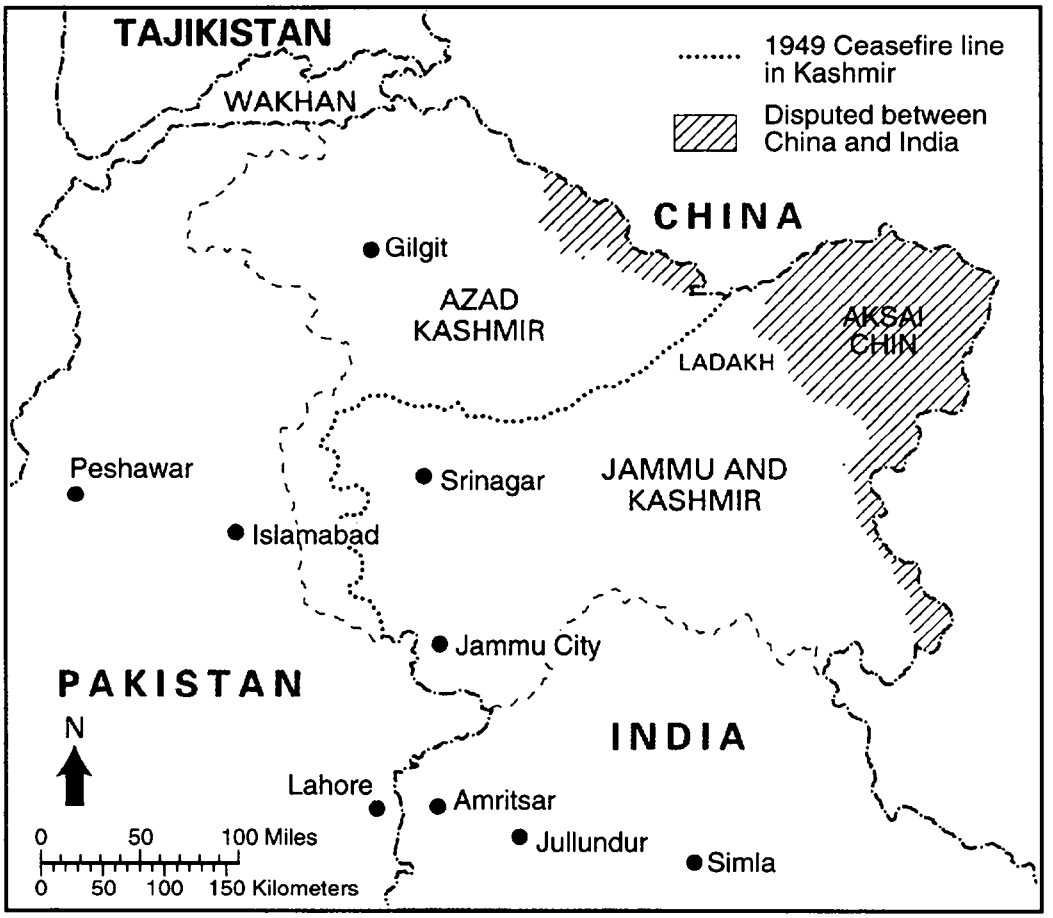
JAMMU AND KASHMIR

Jammu and Kashmir, which nestle beneath south slopes of the Hindu Kush, Pamirs, Karakorum Mountains, and Himalayas, possess some of the world's most spectacular scenery (map 49). Pakistani farmers depend extensively on irrigation waters from the Indus, Chenab, and Jhulum Rivers, but religious disputes rather than land rights make the region a perennial trouble spot.

The Schism. The populations of Jammu and Kashmir were overwhelmingly Muslim (77 percent) whereas Hindus (20 percent) comprised a clear majority mainly in Jammu City when India and Pakistan became independent nations on August 15, 1947. The local maharajah nevertheless was loath to decide on accession to either side until impatient Pakistani tribesmen applied pressure the following October, whereupon he formally asked then Governor-General Lord Louis Mountbatten for help from the Indian Dominion, acknowledging that "naturally they cannot send help asked for by me without my state [Jammu and Kashmir] acceding to India. I have accordingly decided to do so and attach the Instrument of Accession." The newly formed Pakistani government predictably found that Athe accession of Kasmir to India is based on fraud . . . and as such cannot be recognized."[36] Repetitious violence followed.

Elusive Reconciliation. A U.N. commission arranged a cease-fire that terminated the first Indo-Pakistani war on January 1, 1949, and later established a 480-mile (770-kilometer) control line that allocated a bit more than one-third of Jammu and Kashmir to Pakistan and left the heavily Islamic Vale of Kashmir in Hindu hands. Further combat ensued in 1965, 1971, and 1990 after repeated mediations failed. The presence of several hundred thousand Indian troops and terrorist attacks by militant Islamic separatist groups against targets in the beautiful Vale have devastated tourist trade that might benefit Muslims.[37]

Map 49. *Boundary Disputes in Jammu and Kashmir*



Sovereignty over the Aksai Chin salient, once described as a frozen, uninhabited wilderness without a blade of grass, has been subject to dispute since the 1950s when China occupied about 6,000 square miles (15,000 square kilometers) and built a road that connects Tibet with Xinjiang Province. Chinese Armed Forces consolidated their positions in 1962 after fierce fighting with Indian troops and have remained solidly ensconced ever since. Additional Sino-Indian border disputes developed in 1963 because Pakistan, despite Indian objections, ceded to China a sizable chunk of its sector in Kashmir. Neither that bit nor the Aksai Chin boundary has ever been demarked to the satisfaction of all concerned.[38]

How long the current hiatus will last is subject to speculation. Deep-seated grievances, strong emotions, and possibilities that nuclear warfare might some day erupt meanwhile make Jammu and Kashmir a tinderbox, arguably one of the most perilous trouble spots anywhere on this globe.[39]

ENVIRONMENTAL FRICTION

Humanity needs habitats that ensure passably clean air, potable water, sources of sustenance, and sufficient wherewithal to make life worth living, but pollution, despoliation, and other degradations make it ever more difficult for Planet Earth to satisfy even minimum requirements of rapidly expanding world populations.[40] Befouled atmosphere, deforestation,

agricultural mismanagement, over-harvested fisheries, oil spills, wanton use of water, and careless waste disposal typify environmental practices that degrade local, regional, even global habitats with short-, intermediate-, and long-term effects on ecosystems and human living conditions.[41]

Some consequences are clear, while the full relevance of others awaits further investigation. Corrective actions that increase short-term costs, exact sacrifices, exacerbate inequities, limit national power, or place lids on political ambitions are sourly received in every country that believes it might lose leverage. Acrimonies already have triggered trade conflicts that conceivably could culminate in armed combat.[42]

ATMOSPHERIC POLLUTION

Atmospheric pollutants travel freely wherever capricious winds take them, without regard for international boundaries, checkpoints, or toll gates. Radioactive nuclear fallout periodically circled the globe during a 35-year period, mainly between 1955 and 1966, then ceased in October 1980, when China conducted the last atmospheric test in the desert near Lop Nor,[43] but fossil fuels annually pump several billion tons of carbon dioxide, sulfur, and nitrogen into the air. Acid rain had damaged almost one-fourth of all woodlands in Europe by 1990, according to a U.N. survey, and some lakes are so acidic that fish find them intolerable. Stratospheric ozone depletion, probably caused by manmade chemicals such as chlorofluorocarbons (CFCs), decreases the ability of Earth's atmosphere to shield the surface from ultraviolet radiation which, in turn, increases risks of cancer, cataracts, and respiratory ailments as well as lower crop yields.[44]

DEFORESTATION

Gigantic rain forests, such as those in the Amazon Basin, Equatorial Africa, and Southeast Asia, are disappearing at a rate that knowledgeable observers estimate to be about 16,750 square miles (46,000 square kilometers) each year, with monetary rewards from harvested timber and newly-available agricultural lands as basic objectives. Additional carbon dioxide emissions, soil erosion, and floods that often follow encourage mass migrations from poverty-stricken regions to destinations where governmental leaders have neither suitable spaces within which to accommodate many penniless immigrants nor the inclination to accept them. The extinction of countless plant and animal species that depend on woodland habitats moreover may have consequences that as yet are incalculable.[45]

Environmental warfare was widespread in the jungles of Vietnam, where something like 46,000 toxic tons of a U.S. herbicide called Agent Orange defoliated woodland refuges in the 1960s. Rome Plows uprooted vegetation to eliminate enemy ambush sites along-heavily traveled roads and remove covered enemy approaches to isolated U.S. fire bases.[46] The Principle of Military Necessity, which legally concedes "the right to apply that amount and kind of force [required] to compel submission of the enemy with the least possible expenditure of time, life, and money," implicitly justified those practices,[47] but the extent to which Agent Orange unintentionally afflicted U.S. military personnel and Vietnamese civilians as well as crops and livestock still prompt debates about relations between environmental costs and military benefits.[48]

OIL SPILLS

Accidental oil spills in the Age of Supertankers (250,000 to 400,000 deadweight tons), the largest of which carry nearly 3 million barrels of crude oil apiece, understandably cause consternation among coastal countries that could suffer the loss of fisheries, tourist trade, other economically attractive advantages, and catastrophic environmental deprivation. The ill-starred U.S. tanker *Exxon Valdez*, for example, leaked 260,000 barrels into Alaska's Prince William Sound after it hit a reef in March 1989. Damage was confined only because the crew safely transferred another million barrels to sister tankers, but even so the slick eventually coated 1,100 miles (1,770 kilometers) of pristine shoreline and islands. Marine birds and mammals perished wholesale, sludge seriously threatened salmon and herring schools, and restitution payments totaled more than $1 billion.

Iraqi President Saddam Hussein in January 1991 made the *Exxon Valdez* accident seem picayune when he dumped several million barrels of crude oil into the Persian Gulf from his Sea Island transshipment terminal, from five tankers tied up in port at Mina al-Ahmadi, and from huge storage tanks ashore. He eclipsed those abominations soon thereafter when he ordered henchmen to torch more than 650 producing wells and dynamite 82 others in Kuwait. Oily lakes formed death traps for birds around sabotaged wells, a sickening stench made human stomachs churn, 200-foot (60-meter) tongues of flame fed half a million tons of pollutants per day into the atmosphere, and greasy clouds towered 100 times that high before they wafted with winds that deposited "black rain" in Iran. Overall results, according to speculation by the U.S. Environmental Protection Agency, may represent "one of the most extraordinary manmade environmental disasters in recorded history."[49]

POTENTIAL WATER WARS

Water requirements often outstrip sources in regions where agricultural and industrial expansion coincide with arid climates and rampant population growth creates unprecedented demands. Poor sanitation practices, contaminated runoff from tilled fields, industrial pollutants, and raw sewage discharged upstream make potable supplies a luxury in many such countries.[50]

Scarcities accompanied by fierce competition have spawned the term "hydropolitics" in the Middle East, where more than half of the people depend on water that originates in or passes through at least one foreign country before it reaches consumers. Twenty-one dams and 17 hydroelectric power stations under construction along the upper Euphrates River in Turkey provoke protests by the Governments of Syria and Iraq, whose senior officials foresee future deprivation. Uncoordinated water control projects in Syria cause additional complaints in Baghdad. Nearly all water in Egypt flows down the Nile from catch basins in eight other countries that include unfriendly Sudan.[51]

Central and South Asia experience similar water supply problems. Deforestation in Nepal intensifies flooding along the Ganges while India, in turn, pursues water diversion projects that deprive delta dwellers in Bangladesh. The Aral Sea, once the world's fourth largest inland body of water, has split into two sections that altogether cover half as much area, contain one-fourth the volume, and are three times as saline as in 1960, because irrigation programs siphon so much water from the Amu and Syr Darya Rivers, which are its only feeders. Frequent dust storms full of salty sediments, toxic fertilizers, and pesticide residues from the exposed sea bed contribute to high infant mortality and low life expectancy rates

in Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, where impure water causes typhoid fever, hepatitis, and kidney disorders.[52]

DEPLETED FISHERIES

Fishermen the world over quadrupled their catch between 1950 and 1990, after which takes slumped largely because the best spots were "over fished." Coast guards deployed to protect dwindling resources work overtime to ward off plundering fleets equipped with fish-finding sonars and nets that can haul in tens of tons on a single outing. Acrimonious encounters commonly occur 200 miles or so offshore in gaps that contain some of the globe's most lucrative fishing grounds between Exclusive Economic Zones. Poachers, well aware that increasing demands coupled with declining supplies cause prices to soar, penetrate far into EEZs when anticipated gains seem to outweigh risks, but international efforts to establish legal limits on harvests thus far fall on deaf ears.[53]

HAZARDOUS WASTE DISPOSAL

Toxic and infectious wastes in sufficient quantities or concentrations may cause or exacerbate insidious, often incapacitating (even irreversible) illnesses when improperly treated, stored, transported, or otherwise mismanaged. Flammable, corrosive, explosive, and radioactive substances also qualify as hazardous materials (HAZMAT). Means of disposal range from land fills and incineration to chemical conversion, burial underground or beneath the sea, and indiscriminate dumping.[54] Imprudent methods in many instances cause solely domestic concerns, but HAZMATs that contaminate other countries or international waters are increasingly sources of friction.

Some authorities believe that the safest disposition of the most harmful HAZMAT may be watertight canisters buried on abyssal plains at the bottom of oceans where extremely deep, sticky sediments would seal them in protective cocoons that precipitating silts and decomposing organisms would strengthen eternally. One Texas-sized plot under consideration lies 600 miles (965 kilometers) north of Hawaii several miles below the surface on a seabed that has been geologically stable for the last 65 million years.[55]

CHEMICAL WARFARE AND NUCLEAR WASTES

Unwanted chemical warfare munitions [56] and nuclear materials [57] are exceedingly difficult to discard safely at acceptable costs. The former Soviet Union, indifferent to consequences at home and abroad, was one of the worst offenders. Feckless overseers dumped outdated nuclear reactors, spent fuel, and other radioactive waste along the coast of Novaya Zemlya, in the Kara Sea, and in the Seas of Okhotsk and Japan, where fragile ecosystems are especially sensitive to environmental insults. Few pollutants apparently have migrated from those locales thus far, but leakage and contamination of marine food chains eventually could be extensive.[58]

EMERGING MILITARY COUNTERMEASURES

Members of the world community who view environmental plunder as a problem that threatens their respective lifestyles seek sensible solutions,[59] whereas exploiters who see opportunities for enrichment employ rapacious practices. U.S. National Security Strategy in 1995 warned that "increasing competition for the dwindling resources of uncontaminated

air, arable land, fisheries, other food sources, and water, once considered 'free goods'" have become "a very real risk to regional stability around the world." Its authors predicted that "environmental depredation and resource depletion . . . will feed into immense social unrest and make the world substantially more vulnerable to serious internal frictions," despite generous allowances for scientific and technological countermeasures.[60] U.S. Armed Forces, which intend to be part of the solution rather than part of the problem, have begun to reexamine doctrines, tactics, techniques, targeting procedures, and rules of engagement that perhaps gratuitously endanger environments.[61]

KEY POINTS

- Political-military friction often has geographic roots.
- Territorial boundaries that statesmen draw with scant regard for geographic realities often become political-military trouble spots.
- Limitations that statesmen impose on territorial sovereignty at sea are difficult to enforce, partly because there are no visible terrain features.
- Territorial disputes in Earth's atmosphere and in space eventually will arise unless statesmen clearly specify how high.
- Contingency planners who put geopolitical trouble spots in order of priority should keep options open, because localized, small-scale conflicts of scant international interest are liable to spread with little or no warning and unintended consequences.
- Inconsiderate environmental practices are joining boundary disputes, contentious sovereignty claims, insupportable population growth, insufficient natural resources, religious rivalry, racial-ethnic-tribal tensions, and other facets of physical and cultural geography as potential causes of war.
- Military plans and operations designed to deal with geopolitical friction do best if they address causes of conflict as well as symptoms.

NOTES

1. *Boundary Concepts and Definitions*, Geographical Report No. 1 (Washington, DC: The State Department Geographer, April 28, 1961).
2. Ernst Kux, "Tension on the Ussuri," *Military Review* (June 1969): 25-28.
3. Ian Brownlie, *African Boundaries: A Legal and Diplomatic Encyclopedia* (Berkeley, CA: University of California Press for the Royal United Services Institute, 1979).
4. Marjorie Ann Brown, *Law of the Sea: The International Seabed Authority—Its Status and Participation Therein*, Rpt. Nr. 96-772F (Washington: Congressional Research Service, September 16, 1996); *Maritime AffairsCA World Handbook: A Reference Guide to Maritime Organizations, Conventions and Disputes, and to the International Politics of the Sea*, a Keesings Reference Publication compiled and written by Henry W. Degenhardt, ed., consultant Brian Mitchell, gen. ed. Allan J. Day (Detroit, MI: Gale Research, 1985), 3-14 and appendix 1; *Limits of the Sea 36, National Claims to Maritime Jurisdictions* (Washington, DC: U.S. Dept. of State, Office of the Geographer, March 6, 1985), updated telephonically.
5. *Limits of the Sea 36.*

6. "Convention on International Civil Aviation," in *Treaties and Other International Agreements of the United States of America, 1776-1949*, vol. 3, Dept. of State Publication 8484, ed. Charles I. Bevans (Washington, DC: Government Printing Office, November 1969).

7. William B. Quandt, "Lebanon, 1958," in *Force Without War: U.S. Armed Forces as a Political Instrument*, eds. Barry M. Blechman and Stephen S. Kaplan (Washington, DC: Brookings Institution, 1978), 222-257.

8. Anthony Cordesman, "The Emerging Lessons from the U.S. Attack on Libya," *Armed Forces Journal* (August 1986): 355-360.

9. William Stevenson, *90 Minutes at Entebbe* (New York: Bantam Books, 1976).

10. *The Holy Bible*, Matthew 24: 6-7.

11. For overviews and analyses, see Ewan W. Anderson, *An Atlas of World Flashpoints: A Sourcebook of Geopolitical Crises* (New York: Facts on File, 1993); *Border and Territorial Disputes*, A Keesing's Reference Publication, 2d ed., ed. Alan J. Day (Detroit, MI: Gale Research Co., 1987); John Keegan and Andrew Wheatcroft, *Zones of Conflict: An Atlas of Future Wars* (New York: Simon and Schuster, 1986).

12. Saul Bernard Cohen, *Geography and Politics in a World Divided* (New York: Random House, 1963), 193-203.

13. Robin A. Remington, *The Warsaw Pact* (Cambridge, MA: MIT Press, 1971); Malcolm Macintosh, *Evolution of the Warsaw Pact*, Adelphi Papers No. 58 (London: Institute for Strategic Studies, June 1969).

14. Julie Kim, *Poland, Czech Republic, Slovakia, Hungary: Recent Developments*, Issue Brief 91089, April 1997, updated regularly; Paul Gallis, *NATO: Congresses Addresses Expansion of the Alliance*, Issue Brief 95076, April 1997, updated regularly; Steve Woehrel, *NATO Enlargement and Russia*, Rpt. Nr. 97-477F, April 21, 1997; all Washington, DC: Congressional Research Service.

15. *Border and Territorial Disputes*, 288-300.

16. Ibid., 291, 293; Tai Sung An, *The Sino-Soviet Territorial Dispute* (Philadelphia, PA: Westminster Press, 1974); Raymond L. Garthoff, ed., *Sino-Soviet Military Relations* (New York: Praeger, 1966), 171-182.

17. *An Atlas of World Political Flashpoints*, 1-4.

18. *Border and Territorial Disputes*, 90-101.

19. *An Atlas of World Political Flashpoints*, 123-126; *Border and Territorial Disputes*, 379-384.

20. *An Atlas of World Political Flashpoints*, 113-116.

21. Kerry Dumbaugh, *Hong Kong's Return to China: Implications for U.S. Interests*, Issue Brief 95119 (Washington, DC: Congressional Research Service, 1997, updated periodically).

22. Eui-Gak Hwang, *The Korean Economies: A Comparison of North and South* (New York: Oxford University Press, 1993); Andria Matles Savada, ed. *North Korea: A Country Study*, DA Pamphlet 550-81 (Washington, DC: Federal Research Service, Library of Congress, 1994).

23. Mark J. Valencia, *China and the South China Sea Disputes*, Adelphi Paper 298 (London: International Institute for Strategic Studies, 1995); Henry J. Kenny, "The South China Sea: A Dangerous Ground," *Naval War College Review* 49, no. 3 (Summer 1996): 96-108.

24. Ibid.; John H. Noer, *Maritime Interests in Southeast Asia* (Washington, DC: National Defense University Press, 1996).

25. Ibid.

26. *An Atlas of World Flashpoints*, 13-15; *Border and Territorial Disputes*, 439-442.

27. Tim Pat Coogan, *The Troubles: Ireland's Ordeal 1966-1996* (Boulder, CO: Roberts Rinehart, 1996); J. Bowyer Bell, *The Irish Troubles: A Generation of Violence, 1967-1992* (New York: St. Martin's Press, 1993); *Border and Territorial Disputes*, 57-72; *An Atlas of World Flashpoints*, 143-148.

28. Alfred Prados, *Iraq: Attack on Kurdish Enclave and U.S. Response*, Report No. 96-739F (Washington, DC: Congressional Research Service, October 17, 1996); U.S. Congress, *Situation of*

Kurds in Turkey, Iraq and Iran: Briefing by the Commission on Security and Cooperation in Europe (Washington, DC: Government Printing Office,1993); Gérard Chaliand, *The Kurdish Tragedy*, trans. Philip Black (Atlantic Highlands, NJ: Zed Books, 1994).

29. John Pomfret, "Killing Spree Blamed on Troops of New Congo Leader," *Washington Post,* June 8, 1997, A1, A28; Congress, House, *The Crisis in Rwanda*, Hearing Before the Subcommittee on Africa of the Committee on Foreign Affairs, 103d Congress, 2d sess., May 4, 1994; Richard F. Nyrop et al., *Rwanda: A Country Study*, Dept. of the Army Pamphlet 550-84 (Washington: Foreign Area Studies, American University, 1982).

30. Edgar O'Ballance, *Civil War in Bosnia, 1992-94* (New York: St. Martin's Press, 1995); Roy Gutman, *A Witness to Genocide: The 1993 Pulitzer Prize Winning Dispatches on the "Ethnic Cleansing" of Bosnia* (New York: Macmillan, 1993).

31. Graham Hancock, *Ethiopia, The Challenge of Hunger* (London: V. Gollancz, 1985); John L. Hirsch and Robert B. Oakley, *Somalia and Operation Restore Hope: Reflections on Peacemaking and Peacekeeping* (Washington, DC: U.S. Institute of Peace Press, 1995). The quotation is from John Keegan, *Zones of Conflict*, 90.

32. Thomas P. Ofcansky and LaVerle Berry, eds., *Ethiopia: A Country Study*, Dept. of the Army Pamphlet 550-28 (Washington, DC: Federal Research Division, Library of Congress, 1993).

33. John Lancaster, "Decades of Death on the Nile," *Washington Post*, February 6, 1997, A25, A28. For background, see Helen Chapin Metz, ed., *Sudan: A Country Study*, Dept. of the Army Pamphlet 550-27 (Washington, DC: Federal Research Division, Library of Congress, 1992).

34. *Military Operations in Somalia: Message from the President of the United States Transmitting a Report on Military Operations in Somalia* (Washington, DC: Government Printing Office, 1993); Raymond W. Copson, *Somalia: Operation* Restore Hope *and* UNOSOM II, Issue Brief 92131 (Washington, DC: Congressional Research Service, updated 1994).

35. Metz; *Border and Territorial Disputes*, 126-132, 144-150.

36. Richard P. Cronin and Barbara Leitch LePoer, *The Kashmir Dispute: Historical Background to the Current Struggle*, Report No. 91-563F (Washington, DC: Congressional Research Service, July 19, 1991); William C. Johnstone, "Jammu and Kashmir (1947-1949)," in *Challenge and Response in Internal Conflict*, vol. 1, *The Experience in Asia*, eds. D. M. Condit, Bert H. Cooper, Jr., et al. (Washington, DC: Center for Research in Social Systems, American University, February 1968), 306-329. The maharaja's request is reproduced in *Border and Territorial Disputes*, 318.

37. *Border and Territorial Disputes*, 317-329; *An Atlas of World Flashpoints*, 100-102. For additional background, see Richard F. Nyrop, ed., *Pakistan: A Country Study*, Dept. of the Army Pamphlet 550-48 (Washington, DC: Foreign Area Studies, American University, 1984).

38. *Border and Territorial Disputes*, 279-286.

39. Barbara Leitch LePoer and Nina Srinivasan, *India and Pakistan Border Conflict: Background and Ongoing Problems,* Report No. 96-437F (Washington, DC: Congressional Research Service, May 15, 1996).

40. Robert Leider, *From Choice to Determinant: The Environmental Issue in International Relations* (Washington, DC: Strategic Research Group, National War College, February 15, 1972); Joseph C. Conrad, *Environmental Considerations in Army Operational Doctrine*, a White Paper (Fort Leonard Wood: U.S. Army Engineer School, January 1995), 1, 5, 6.

41. Early warnings were contained in Rachel Carson, *Silent Spring* (Boston, MA: Houghton Mifflin, 1962).

42. For a survey of contemporary issues, see Susan A. Fletcher, *International Environment: Current Major Global Treaties*, Report No. 96-884ENR (Washington, DC: Congressional Research Service, November 5, 1996).

43. *Nuclear Wastes in the Arctic: An Analysis of Arctic and Other Regional Impacts from Soviet Nuclear Contamination*, OTA-ENV-623 (Washington, DC: Government Printing Office, September 1995), 34.

44. *Forest Conditions in Europe: The 1992 Report* (Geneva, Switzerland: U.N. Economic Commission for Europe, September 14, 1992); Michael E. Kowalok, "Common Threads: Research Lessons from Acid Rain, Ozone Depletion, and Global Warming," *Environment* (July/August 1993): 12-20, 35-38.

45. *Environmental Quality: The Twenty Third Annual Report of the Council on Environmental Quality* (Washington, DC: Government Printing Office,1993).

46. Arthur F. McConnel, Jr., "Mission: Ranch Hand," *Air University Review* (January-February 1970): 89-94; Joseph M. Kiernan, "Combat Engineers in the Iron Triangle," *Army* (June 1967): 42-45.

47. Morris Greenspan, *The Modern Law of Land Warfare* (Berkeley, CA: University of California Press, 1959), 313-314. See also, James P. Terry, "The Environment and the Laws of War: The Impact of Desert Storm," *Naval War College Review* 45, no. 1 (Winter 1992): 61-67.

48. The effects of Agent Orange on human remains argumentive. See, for example, John E. Murray, *Report to the White House Agent Orange Working Group, Science Subpanel on Exposure Assessment* (Washington, DC: Executive Office of the President, Office of Science and Technology Policy, May 27, 1986); Frank R. Finch, *This Land Is Ours: The Environmental Threat of Army Operations*, a presentation at the Naval War College Symposium on the Protection of the Environment During Armed Conflict and Other Military Operations, September 20, 1995; Karlheinz Lohs, *Delayed Toxic Effects of Chemical Warfare Agents*, a monograph (Stockholm, Sweden: Stockholm Peace Research Institute, 1975), 19-22.

49. Walter G. Sharp, Sr., "The Effective Deterrence of Environmental Damage During Armed Conflict: A Case Analysis if the Persian Gulf War," *Military Law Review* (Summer 1992): 24-28; John A. Miller, "Countering the Iraqi Eclipse," *Military Engineer* (January/February 1992): 4-7.

50. Sandra Postel, "Carrying Capacity: Earth's Bottom Line," in *State of the World, 1994: A World Watch Institute Report on Progress Toward Sustainable Society*, ed. Lester R. Brown (New York: W. W. Norton, 1994), 3-21; Wade Roush, "Population: The View from Cairo," August 26, 1994, 1164-1167.

51. Joyce R. Starr, "Water Wars," *Foreign Policy* 82 (Spring 1991): 17-25; Elizabeth Anne Green, "Hydropolitics in the Middle East," *Strategic Review* 21, no. 2 (Spring 1993): 72-76; Carol Migdalovitz, *Iraq-Kuwait Crisis: Is Water a Weapon?*, Report No. 91-105F (Washington, DC: Congressional Research Service, January 23, 1991).

52. Ibid.

53. Tim Zimmerman, "If World War III Comes, Blame Fish," *U.S. News & World Report*, October 21, 1996, 59-60.

54. E. Willard and Ruby M. Miller, *Environmental Hazards: Toxic Waste and Hazardous Material, A Reference Handbook* (Santa Barbara, CA: ABC-CLIO, 1991); K. A. Gourlay, *World of Waste: Dilemmas of Industrial Development* (Atlantic Highlands, NJ: Zed Books, 1992).

55. P. J. Skerrett, "Nuclear Burial at Sea," *Technology Review*, February/March 1992, 22-23.

56. *Chemical Weapons: Destruction and Conversion* (New York: Crane, Russak for Stockholm International Peace Research Institute, 1980).

57. Zdenek Dlouhý, *Disposal of Radioactive Wastes* (New York: Elsevier Scientific Publishing, 1982).

58. M. Feshback, *Ecological Disaster: Cleaning the Hidden Legacy of the Soviet Regime* (New York: Twentieth Century Press Fund, 1995); *Nuclear Wastes in the Arctic*, especially 1-17.

59. Secretary of State Warren Christopher, "American Diplomacy and the Global Environmental Challenges of the 21st Century," address delivered at Stanford University, California, April 9, 1996.

60. *A National Strategy of Engagement and Enlargement* (Washington: The White House, February 1995, 18-19).

61. *Agreement Reached on Environmental Security Plan* (Washington, DC: Office of the Assistant Secretary of Defense, Public Affairs, July 16, 1996). For some related requirements, see Kent Hughes Butts, *Environmental Security: What Is DoD's Role?* (Carlisle Barracks, PA: Strategic Studies Institute, U.S. Army War College, May 28, 1993); David Rubenson et al., *Marching to Different Drummers: Evolution of the Army's Environmental Program* (Santa Monica, CA: Arroyo Center, RAND, 1994); Joseph C. Conrad, *Environmental Considerations in Army Operational Doctrine*, 2, 17-22, 23-24.

16. MILITARY AREAS OF RESPONSIBILITY

Abbott. *Well, lets see now. We have on our team Who's on first, What's on second, I Don't Know's on third.*
Costello. *Well, go ahead! Who's on first?*
Abbott. *Who is on first.*
Costello. *What are you asking me for? I'm asking you who is on first? . . .*
Abbott. *Who.*
Costello. *I'm asking a simple question. Who's on first?*
Abbott. *Yes.*
Costello. *I'm asking you what's the guy's name on first base?*
Abbott. *Oh, no. What's on second.*

Who's on First
Bud Abbott and Lou Costello
First Broadcast on NBC, 1942

MILITARY COMMANDERS AT EVERY LEVEL IN EVERY MILITARY SERVICE NEED TO KNOW "WHO'S ON FIRST?" because confusion can put formations at cross-purposes that at best cause wasteful duplications and at worst leave key terrain uncovered. Sensible answers to that question commonly call for cleanly-cut areas of responsibility (AORs) that foster unity of effort, afford sufficient room for armed forces of particular types to operate effectively, and avoid overlaps that could needlessly incur casualties from so-called "friendly fire."

Predominantly political, strictly military, or political-military considerations in some combination determine the size and shape of each AOR, depending on circumstances that feature physical and cultural geography. Areas of interest and abilities to influence actions usually extend well beyond assigned AORs, but plans and operations that overlap parts of neighboring bailiwicks require prior consultation and continuing coordination with all parties concerned.

GLOBAL SUBDIVISIONS

Nations that couple cosmopolitan interests with a global reach subdivide the world into areas of responsibility that best distribute military strength and maximize flexibility. The United States and Great Britain did so to mutual advantage during World War II. The U.S. Department of Defense has put lessons learned to good use ever since.

ALLIED AORS DURING WORLD WAR II

President Franklin Delano Roosevelt, in correspondence to British Prime Minister Winston Churchill on February 18, 1942, opined, "The United States is able because of our geographical position to reinforce [Australia and New Zealand] much better than you can. . . . Britain is better prepared to reinforce Burma and India and I visualize that you would take responsibility for that theater."[1]

Two weeks later President Roosevelt proposed, and the British Chiefs of Staff agreed, that the Allies should subdivide the globe into three AORs to deal with Axis opponents: the Pacific (a U.S. responsibility); the Middle East and Far East (a British responsibility); and shared responsibility for Europe plus the Atlantic. Newly minted Major General Dwight D. Eisenhower, Chief of the U.S. Army's Operations Division in the Pentagon, thereupon prepared a War Department study that defined those three areas as follows:

- The Pacific AOR included North and South America, China, Australia, New Zealand, the Dutch East Indies less Sumatra, and Japan.
- The Middle East and Far East included the Mediterranean Sea, the Red Sea, the Persian Gulf, the Indian Ocean, and all land areas contiguous thereto from Gibraltar to Singapore.
- The European and Atlantic AOR reached from the U.S. east coast to Russia.

Churchill advised President Roosevelt on March 18, 1942, that he saw "great merits in simplification resulting from American control over the Pacific sphere and British control over the Indian sphere and indeed there is no other way," provided operations everywhere be directed by "the Combined Chiefs of Staff acting directly under you and me." He accordingly concluded that U.S. "proposals as I have ventured to elaborate and interpret them will achieve double purpose namely (a) integrity of executive and operational action and (b) opportunity of reasonable consultation for those whose fortunes are involved."[2] Implementing measures took shape almost immediately.

U.S. COMBATANT COMMAND BOUNDARIES

U.S. experiences during World War II demonstrated that commanders in chief (CINCs) of unified combatant commands can bring military power to bear most efficiently and effectively only if some rational system fosters joint operations, dampens jurisdictional disputes, avoids undesirable duplication of effort, and leaves no significant gaps. Related requirements became urgent at the onset of the Cold War, when apprehensive allies on six continents looked to the United States for leadership and global responsibilities settled on U.S. Armed Forces for the first time since their inception in 1775.[3]

Original U.S. Areas of Responsibility. President Harry S Truman on December 14, 1946, approved the first in a long series of unified command plans, the *Outline Command Plan,* which prescribed seven geographically oriented unified commands with the following fundamental missions and areas of responsibility:[4]

- Far East Command (FECOM): Perform occupation duties in Japan, Korea, the Ryukyus, Philippines, Marianas, and Bonin Islands; command U.S. Armed Forces in China if required; prepare for a general emergency. Established January 1, 1947.

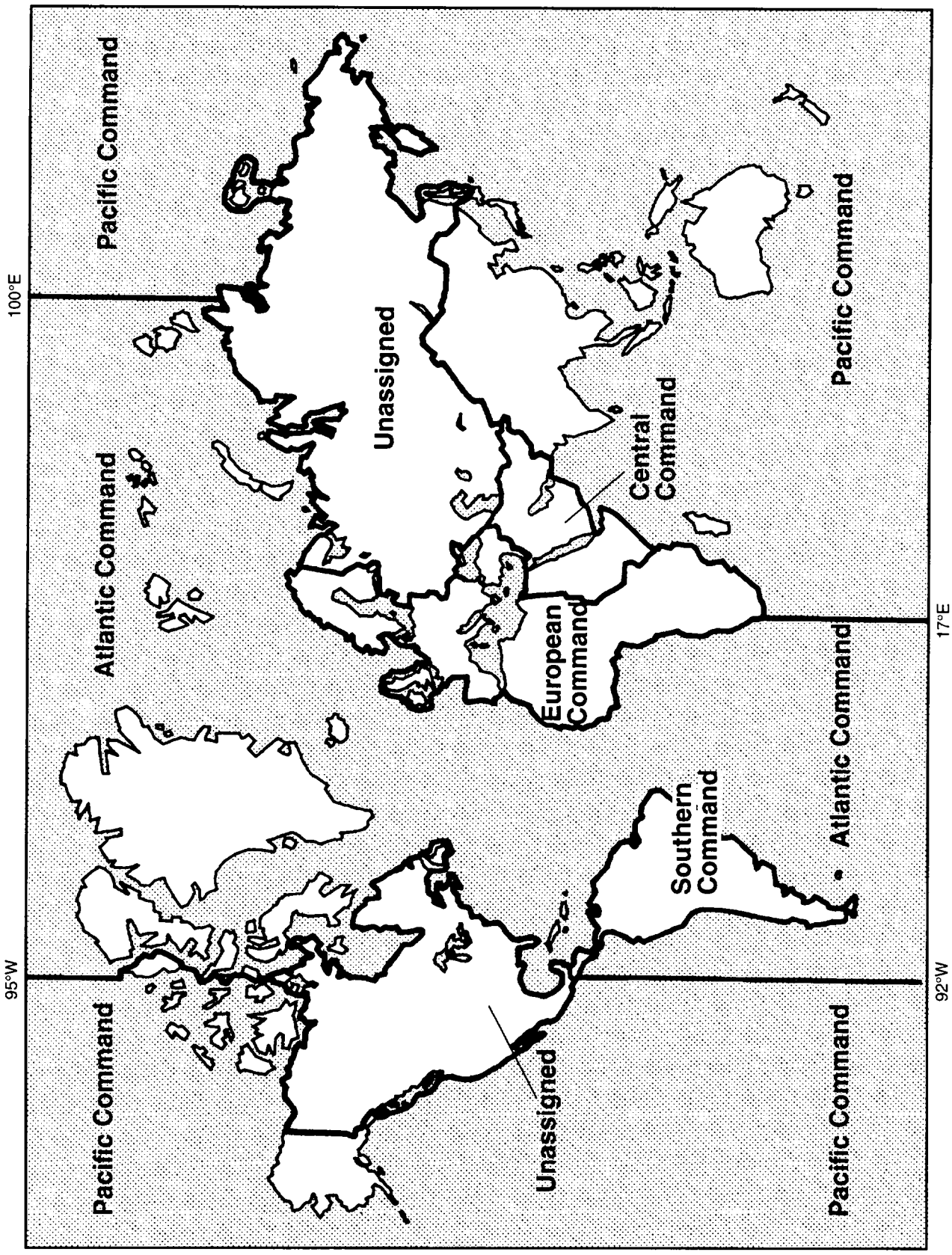
- Pacific Command (PACOM): Conduct operations to secure sea and air lines of communication across the Pacific Ocean; protect the United States against attacks from that quarter; prepare for a general emergency. Established January 1, 1947.
- Alaska Command (ALCOM): Defend Alaska, including the Aleutian Islands; protect the United States against attacks through Alaska and adjacent arctic regions; prepare for a general emergency. Established January 1, 1947.
- European Command (EUCOM): Occupy Germany; support U.S. national policy in Europe; plan for a general emergency. Established March 15, 1947.
- Caribbean Command (CARIBCOM): Defend the United States, the Panama Canal, and U.S. outposts in the Caribbean from bases in Panama and the Antilles; defend sea and air lines of communication in collaboration with Atlantic Command; support U.S. Atlantic Fleet; prepare for a general emergency. Established November 1, 1947.
- Atlantic Command (LANTCOM): Defend the United States against attack across the Atlantic Ocean; support U.S. Armed Forces in Europe, the Mediterranean, the [North American] Northeast, and the Caribbean; prepare for a general emergency. Established December 1, 1947.
- U.S. Northeast Command (USNEC): Maintain security in Newfoundland, Labrador, and Greenland; protect sea and air lines of communication in area; protect the United States against attack from that quarter; prepare for a general emergency. Established October 1, 1950.

Subsequent U.S. Areas of Responsibility. Twenty-one U.S. unified commands have been established at various times since 1947, of which nine remained 50 years later. EUCOM, ACOM (formerly LANTCOM), PACOM, U.S. Central Command (CENTCOM), and U.S. Southern Command (SOUTHCOM) focus on geographic areas. All expressed intense interest in the Soviet Union during the Cold War, but none could apply military power selectively across such a huge AOR (map 50). The President and the Secretary of Defense therefore retained oversight responsibilities and delegated duties as they saw fit until UCP changes put Ukraine, Belarus, Moldava, Georgia, Armenia, and Azerbaijan within the EUCOM AOR (effective October 1, 1998), while CENTCOM picked up Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan (effective October 1, 1999). Only Russia among the former Soviet republics will remain unassigned.

Periodic Boundary Revisions. *Title 10, United States Code*, requires the JCS Chairman not less than every 2 years to review "missions, responsibilities (including geographic boundaries) and force structures for the combatant commands and recommend [changes]." AORs in particular require close scrutiny in this rapidly changing world, taking political ideological, topographical, cultural, technological, and military considerations into account, because boundary revisions may create problems more serious than those they solve unless planners are sensitive to many subtle implications.[5]

The current *Unified Command Plan*, for example, assigns to three CINCs areas of responsibility that include parts of Islamic Africa, Southwest Asia, and neighboring bodies of water. CENTCOM's AOR covers the Persian Gulf, the Red Sea, the Gulf of Aden, the Gulf of Oman, and 18 countries, all of which except Kenya are entirely Muslim or have Muslim pluralities. European Command's AOR incorporates Israel, Syria, and Lebanon, together with four Islamic states along Africa's Mediterranean littoral (Morocco, Algeria, Tunisia, and

Map 50. *U.S. Cold War Areas of Responsibility*
(1983-1991)



Libya). Pacific Command's AOR, which abuts CENTCOM at the border between India and Pakistan, embraces the Indian Ocean and the Arabian Sea.

Such rough seams complicate coordination and invite miscalculations when troubles crop up, yet adjustments that initially seem simple almost always appear complex after investigation. Some problems are traceable to Service chiefs and CINCs who prefer the status quo for bureaucratic reasons,[6] while others have their roots in the region. Central Command's AOR indeed could cover all Middle Eastern countries, but redrawing boundaries to do so likely would alienate U.S. Arab allies who see Israel as their enemy, put a serious crimp in intelligence-sharing, and make coalition planning practically impossible. Similar friction would ensue if the *Unified Command Plan* put religious rivals like India and Pakistan within one AOR. Sensitivity for Muslim concerns ostensibly makes CENTCOM better suited than EUCOM to deal with explosive situations in Islamic North Africa, but land, sea, air, and amphibious assets assigned to European Command are located more conveniently. And so on. Few *prima facie* cases that favor AOR boundary adjustments are evident anywhere else.

REGIONAL AREAS OF RESPONSIBILITY

Political sensitivities, traditional spheres of Service influence, threats, and available combat power as well as geographic circumstances commonly shape regional as well as global areas of responsibility. The subdivision of NATO's Allied Command Europe (ACE) into three major subordinate commands and repeated revision of AORs for U.S. unified commands illustrate associated problems.

AOR PROBLEMS IN NATO EUROPE

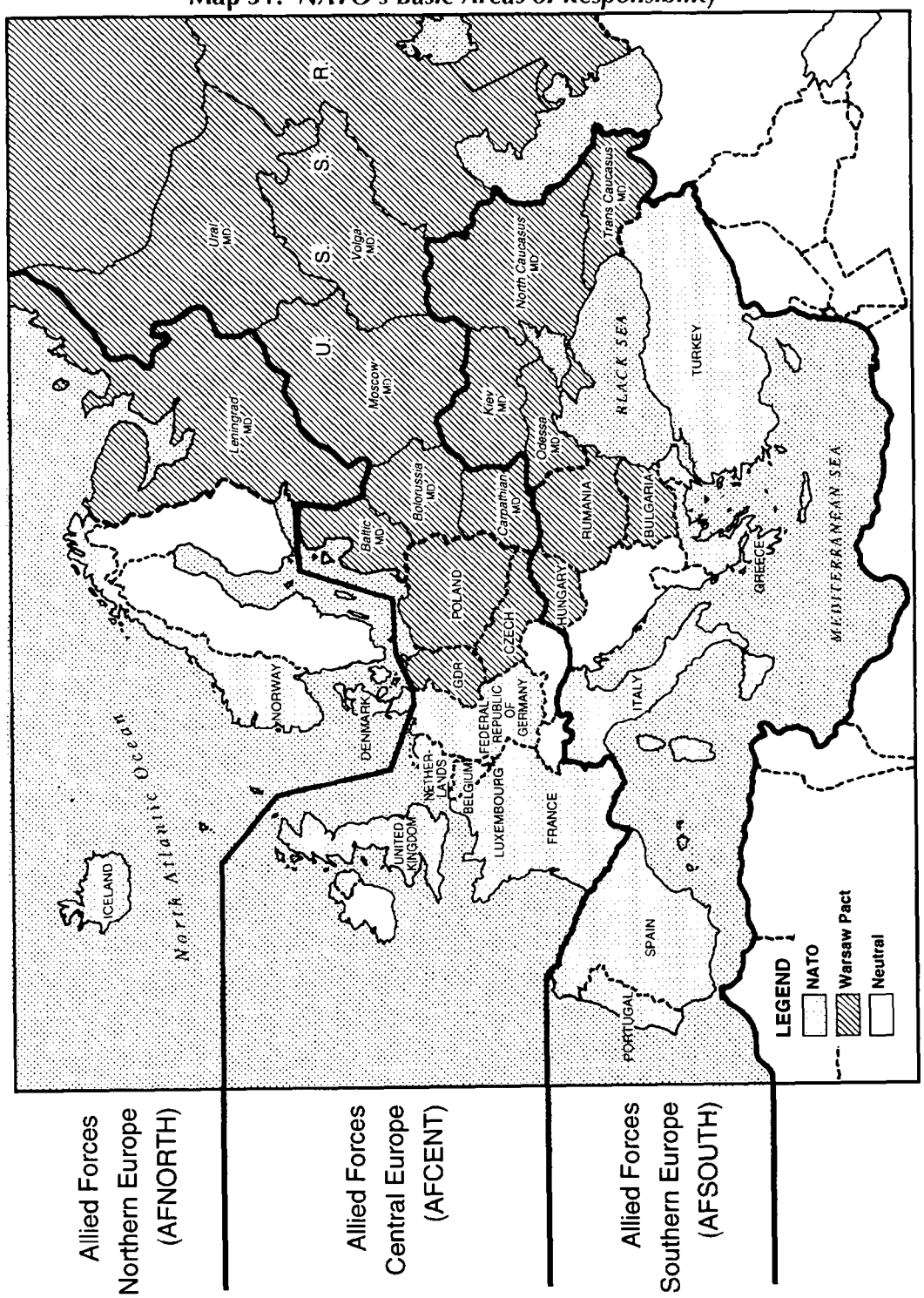
General of the Army Dwight D. Eisenhower, in his first annual report as Supreme Allied Commander, Europe (SACEUR), perceptively analyzed his area of responsibility:

> Western Europe, from North Cape to Sicily, had to be surveyed as a whole. There is the main land mass, stretching from the Baltic to the Adriatic peninsula, when viewed in perspective, of that greatest of all land masses, which is Europe and Asia combined. On the flanks of this main peninsula we have two main outcrops—apart from the Iberian peninsula and the British Isles. The one is Denmark, almost touching the tip of Scandinavia, whose western half, Norway, is among our brotherhood of nations sworn to defend freedom. The southern outcrop is Italy, projecting into the Mediterranean, and affording us its strong position for flanking forces with valuable air and sea bases. It seemed sound to divide the command of Western Europe into three main sectors: Norway and Denmark as one buttress, Italy and the adjacent waters as the other, and the central mass as the main structure.[7]

NATO's Basic Subdivisions. NATO in April 1951 accordingly began to form three geographically oriented AORs, stacked from north to south (map 51). Allied Forces Northern Europe stood guard on the Nordic flank, Allied Forces Southern Europe did likewise south of the Alps, while Allied Forces Central Europe became the bulwark in between.

Denmark and West Germany's Schleswig-Holstein Province, although topographically inseparable from NATO's center sector, were assigned to CINCNORTH because, in collaboration with Norway, they controlled straits that connect the Baltic and North Seas. U.S. Sixth Fleet furnished most combat power for the south flank, but interim command

Map 51. *NATO's Basic Areas of Responsibility*



arrangements had to suffice until 1953, when the British Mediterranean Fleet became the nucleus of a new lashup under Admiral Lord Louis Mountbatten whose status was coequal with that of NATO's CINCSOUTH, an American.[8]

Haphazard AORs in AFCENT. Three land corridors cut across the Iron Curtain from Warsaw Pact countries into West Germany, which was AFCENT's forward line of defense. The most dangerous avenue, tailor-made for armored thrusts, traversed the North German Plain over first-rate highways and rolling farmlands that facilitated cross-country movement, whereas rough, wooded terrain farther south generally restricted vehicular traffic to the Fulda Gap, which points toward Frankfurt-am-Main, and to the Hof Corridor which heads for Munich (map 52).

NATO's dispositions athwart those three approaches resulted from historical accidents rather than design, because British, French, and U.S. areas of responsibility generally paralleled their respective occupation zones at the end of World War II and all Allied forces took full advantage of West German peacetime garrisons. Northern Army Group (NORTHAG) covered the crucial North German Plain with four corps, of which the Netherlands, West Germany, Britain, and Belgium provided one apiece. Central Army Group (CENTAG), in sharp contrast, was positioned on far more defensible terrain and possessed far greater combat power that included two U.S. corps, two more that belonged to the West German *Bundeswehr*, and a Canadian mechanized brigade in reserve. Defense of the Fulda Gap might best have rested with a single command, but German and U.S. Army formations shared responsibility for that high-speed approach, which straddled the boundary between them. Such maldeployments were militarily unsound, but no adjustments of much consequence took place before the Cold War ended, because exchanges would have weakened defenses while in progress, diplomatic objections were discouraging, and moving costs would have been enormous.[10]

AOR PROBLEMS IN THE PACIFIC

Competition between the United States Army and the Navy over respective responsibilities and authority in the Pacific strained relationships during early stages of World War II and persisted until Japan capitulated. Jurisdictional disagreements that subsequently surfaced in Northeast Asia intensified after the Korean War erupted. Similar problems complicated military operations in Vietnam.

Disputes in the South Pacific. The Pacific area of responsibility that President Roosevelt and Prime Minister Churchill agreed upon in 1942 was for the most part a watery domain best suited for sea services, but armies and land-based air forces had prominent roles to play when U.S. holding actions ceased and offensive operations commenced against Japanese Armed Forces entrenched on an arc of island strongholds that constituted the first line of defense for their homeland. The U.S. Joint Chiefs of Staff (JCS), after carefully considering recommendations from political-military officials in Australia and New Zealand, consequently established a Southwest Pacific Area (SWPA) and installed General Douglas MacArthur as CINC, with purview over Australia, New Guinea, neighboring islands as far east as 160 degrees east longitude, all of the Dutch East Indies except Sumatra, and the Philippines. Admiral Chester W. Nimitz, simultaneously designated Commander in Chief Pacific Ocean Area (CINCPOA), retained New Zealand and the rest of the Pacific Ocean in

Map 52. *AFCENT Areas of Responsibility*



his area of responsibility, less a slice off Central and South America that remained within the Pacific Sector of Panama Sea Frontier (map 53).[11]

Competition between the two regional commanders in chief was keen from the start. The U.S. Joint Chiefs of Staff, after hearing all arguments, put Australia in the Southwest Pacific Area and New Zealand in the Pacific Ocean Area so the Navy could safeguard sea lines of communication between the United States and New Zealand, although the Army

repeatedly pointed out that similar lines led to Australia and lobbied to control terminals in both countries. The JCS moved General MacArthur's eastern boundary from the 160th to the 159th Meridian before ink dried on their original directive and thereby divided responsibility for the Solomon Islands so Admiral Nimitz could direct operations against Guadalcanal. The two CINCs, already engaged in fierce rivalry for scarce resources, thereafter proceeded along roughly parallel paths toward the Philippines, each firmly convinced that his AOR deserved top priority, but in May 1943 the JCS approved a dual drive that satisfied neither of them.[12]

Disputes in Northeast Asia. Far East Command (FECOM) reported directly to the JCS throughout the Korean War (June 1950- July 1953), but in 1956 most of the Joint Chiefs concluded that FECOM had outlived its usefulness in light of dwindling U.S. deployments in Northeast Asia and voted to transfer all functions to Pacific Command. Army Chief of Staff General Maxwell D. Taylor, the lone dissenter, advised enlargement to include Taiwan, the Philippines, Southeast Asia, and Indonesia where, in his opinion, the Army was better prepared than the Navy to block communist encroachment. FECOM disappeared on July 1, 1957, only after the Secretary of Defense broke the deadlock and approved in its place a pair of unified commands subordinate to CINCPAC: a four-star Army general became Commander in Chief of the U.N. Command and Commander, U.S. Forces Korea; a three-star Air Force general became Commander, U.S. Forces Japan. Questions concerning the efficacy of a Far East Command nevertheless resurface periodically, most recently during the roles and missions review in 1995.[13]

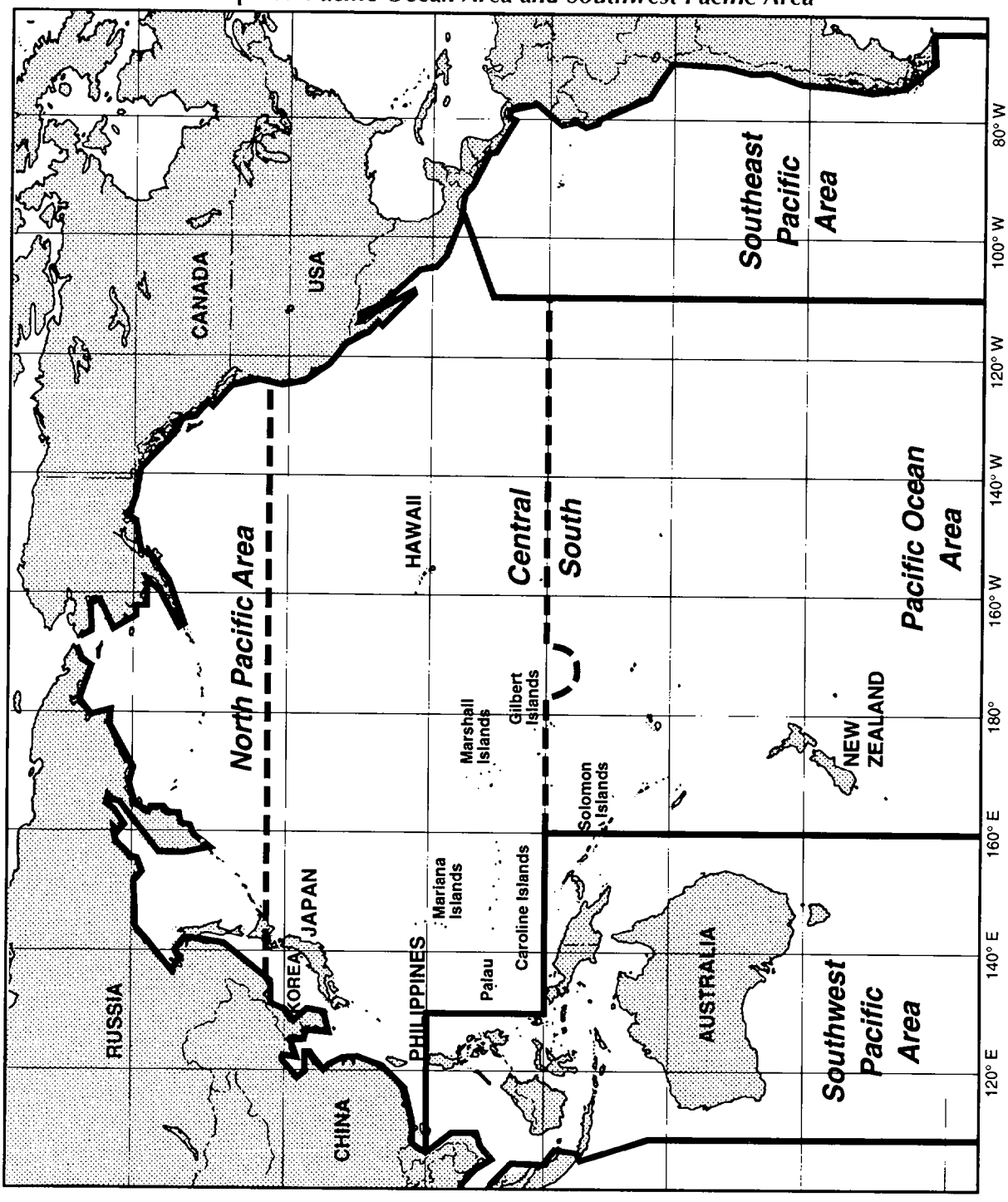
Disputes in Southeast Asia. The Joint Chiefs of Staff, well before U.S. Armed Forces became deeply involved, debated two basic command arrangements for operations in North and South Vietnam: Option A left both nations within Pacific Command's area of responsibility, where they had been since their establishment in 1954, and activated a unified command subordinate to CINCPAC; Option B envisaged an independent command on the same level as PACOM. The JCS recommended Option A, CINCPAC concurred, the Secretary of Defense approved, and U.S. Military Assistance Command Vietnam (MACV) emerged in 1962, but the new lashup never worked the way official "wiring diagrams" indicated. COMUSMACV often bypassed CINCPAC to deal directly with superiors in Washington, DC, including the President and Secretary of Defense, who played active parts in daily operations. CINCPAC conducted the air war and surface naval operations, while COMUSMACV took charge on the ground.[14]

General William C. Westmoreland, who was Commander, U.S. Military Assistance Command Vietnam from June 1964 until March 1968, observed in retrospect that an independent unified command for all of Southeast Asia would have clarified responsibilities and increased operational flexibility. "Instead of five 'commanders'—CINCPAC, COMUSMACV, and the American ambassadors to Thailand, Laos, and South Vietnam—there would have been one man directly responsible to the President on everything. . . . Such an arrangement would have eliminated the problem of coordination between the air and ground wars that was inevitable with CINCPAC managing one, MACV the other."[15]

AOR PROBLEMS IN THE MIDDLE EAST

A U.S. area of responsibility that formally embraced the Middle East and neighboring waters was unnecessary before the British Empire broke up in the late 1940s and British Armed

Map 53. *Pacific Ocean Area and Southwest Pacific Area*



Forces began to abandon outposts in that region. Secretary of Defense Thomas S. Gates, Jr., after heated JCS debates that pitted the Army and Air Force against the Navy and Marine Corps, in February 1960 officially put the Commander in Chief of U.S. Naval Forces Eastern Atlantic and Mediterranean (CINCNELM) in charge of plans and operations for an AOR that enclosed lands east of Libya and south of Turkey, the Red Sea, the Arabian Sea, and the Bay of Bengal. Secretary Gates concurrently enlarged Atlantic Command's AOR to include sub-Saharan Africa.[16]

Those arrangements proved unstable. The JCS Chairman in 1962, with active support from the Army and Air Force, accordingly proposed that the Commander in Chief of newly created Strike Command be assigned responsibility for the Middle East, sub-Saharan Africa, and southern Asia (MEAFSA). As it stood, they reasoned, CINCLANT and CINCNELM "are required to execute operations with forces they do not have, using force employment plans developed by other commands." The Chief of Naval Operations, backed by the Commandant of the Marine Corps, resisted change because CINCNELM was thoroughly familiar with Middle East problems and the likelihood of major U.S. military involvement anywhere in Black Africa seemed remote. The Secretary of Defense found the Chairman's arguments persuasive, added MEAFSA to CINCSTRIKE's responsibilities, and disbanded NELM on December 1, 1963.[17]

Disputes nevertheless persisted, expedient operations predominated, and continuity was elusive. The President and Secretary of Defense discontinued Strike Command and CINCMEAFSA in April 1971, tacked the eastern Mediterranean littoral, the Red Sea, the Persian Gulf, and Iran onto European Command, and left Africa south of the Sahara unassigned. Permanent improvements awaited the appearance of U.S. Central Command, which replaced an interim Rapid Deployment Joint Task Force on January 1, 1983. CENTCOM's geographic area of responsibility, which has endured since that date, consists of Egypt, Sudan, Djibouti, Ethiopia, Kenya, and Somalia, all in the Horn of Africa; Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Yemen, all on the Arabian peninsula; and Jordan, Iraq, Iran, Afghanistan, Pakistan, the Red Sea, and the Persian Gulf.[18]

AOR PROBLEMS IN THE CARIBBEAN

The Caribbean Basin and U.S. national security have been inseparable for more than 200 years, in peacetime as well as war.[19] Command arrangements for that crucial region, which had been within CINCLANT's area of responsibility since 1956, worked smoothly during the Cuban missile crisis of 1962 and U.S. operations in the Dominican Republic 3 years later, but heated debates about AORs began in October 1979 soon after President Carter deplored what he perceived to be ever greater Soviet encroachment and Cuban influence.[20]

CINCSOUTH and the Army Chief of Staff postulated that general war was a remote possibility, but if it did occur, LANTCOM would have to rivet attention on the Atlantic Ocean whereas Southern Command, armed with a wealth of Latin American experience, was ready, willing, and able to counter Communist activities that posed clear and present dangers to U.S. interests throughout the Caribbean. CINCLANT contended that it would be imprudent to pass responsibility for the Caribbean from his command to SOUTHCOM, given U.S. policies that encouraged greater vigilance and military capabilities in that volatile region. The Joint Chiefs found in favor of Atlantic Command, which they concluded was better able to safeguard vital sea lanes through the Caribbean to NATO Europe and from Venezuelan oil

fields to the United States under emergency conditions. Secretary of Defense Caspar Weinberger approved their recommendations on November 2, 1981.[21]

Different U.S. policies and priorities in response to different threats, however, appeared the following decade after possibilities of general war virtually disappeared for the foreseeable future. JCS Chairman General John M. Shalikashvili recommended, Defense Secretary William Perry concurred, and President Bill Clinton approved alterations that gave CINCSOUTH control over all U.S. military activities in the Caribbean basin as well as Central and South America effective June 1, 1997, primarily to remove troublesome seams that adversely affected counternarcotics operations. President Clinton on January 1, 1996, additionally transferred to SOUTHCOM responsibility for ocean waters around Central and South America from 30^0 West to 92^0 West to improve U.S. interactions with Latin American navies.[22]

USEFUL INSIGHTS

Members of the Strategic Plans and Policy Directorate (J-5) of the Joint Staff developed, and the JCS Chairman approved, six principles for use during the 1995 JCS review of the *Unified Command Plan*. All six still serve as yardsticks with which to measure how well assigned areas of responsibility suit each regionally oriented combatant command.[23] Each AOR must:

1. Support U.S. national security interests
2. Be consistent with the current U.S. national security strategy, national military strategy, and public law
3. Take international and interservice sensitivities into account
4. Facilitate unified military operations during peacetime as well as war
5. Be consistent with the CINC's span of control, so that reach does not exceed grasp
6. Be consistent with plans, programs, and force deployments that are realistic, affordable, and salable.

Thoughtful application of those principles might have ameliorated many AOR problems in the past and similarly could reduce the incidence of international and interservice discord in the future. Points 3 and 6 have special significance, because areas of responsibility almost invariably are unsatisfactory if statesmen, Service spokesmen, or holders of purse strings (Congress in the United States) strongly oppose.

THEATER AND TACTICAL AORS

Theater commanders in chief, who exercise operational control over land, sea, air, and amphibious forces within respective jurisdictions, as a rule delegate to major subordinate commands authority and accountability over parts of their AORs for operational, logistical, and administrative purposes. Tactical areas of responsibility (TAORs) facilitate control and coordination at lower levels. The boundaries that CINCs and other commanders draw are designed to facilitate freedom of action within assigned zones, ensure adequate coverage of objectives and target suites yet avoid undesirable duplication of effort, prevent confusion, and reduce risks of fratricide from so-called "friendly fire."

Theater and tactical AORs differ from global and regional subdivisions in several important respects: international sensitivities tend to diminish (but do not disappear), whereas interservice rivalries remain strong; areas of interest and influence tend to blur boundary lines; and TAORs are subject to frequent change during fluid operations.

BOUNDARIES ON EARTH'S SURFACE

Operation plans and orders employed by land and amphibious forces at every level commonly prescribe boundaries and other control lines to prevent gaps and forestall interference by combat and support forces with friendly formations on either flank, to the front, or toward the rear. Well drafted boundaries wherever possible follow ridges, rivers, roads, city streets, and other geographic features that are clearly recognizable on maps as well as on the ground. They neither divide responsibility for dominant terrain between two or more commands nor position forces from one command on both sides of formidable obstacles unless sensible alternatives seem unavailable.

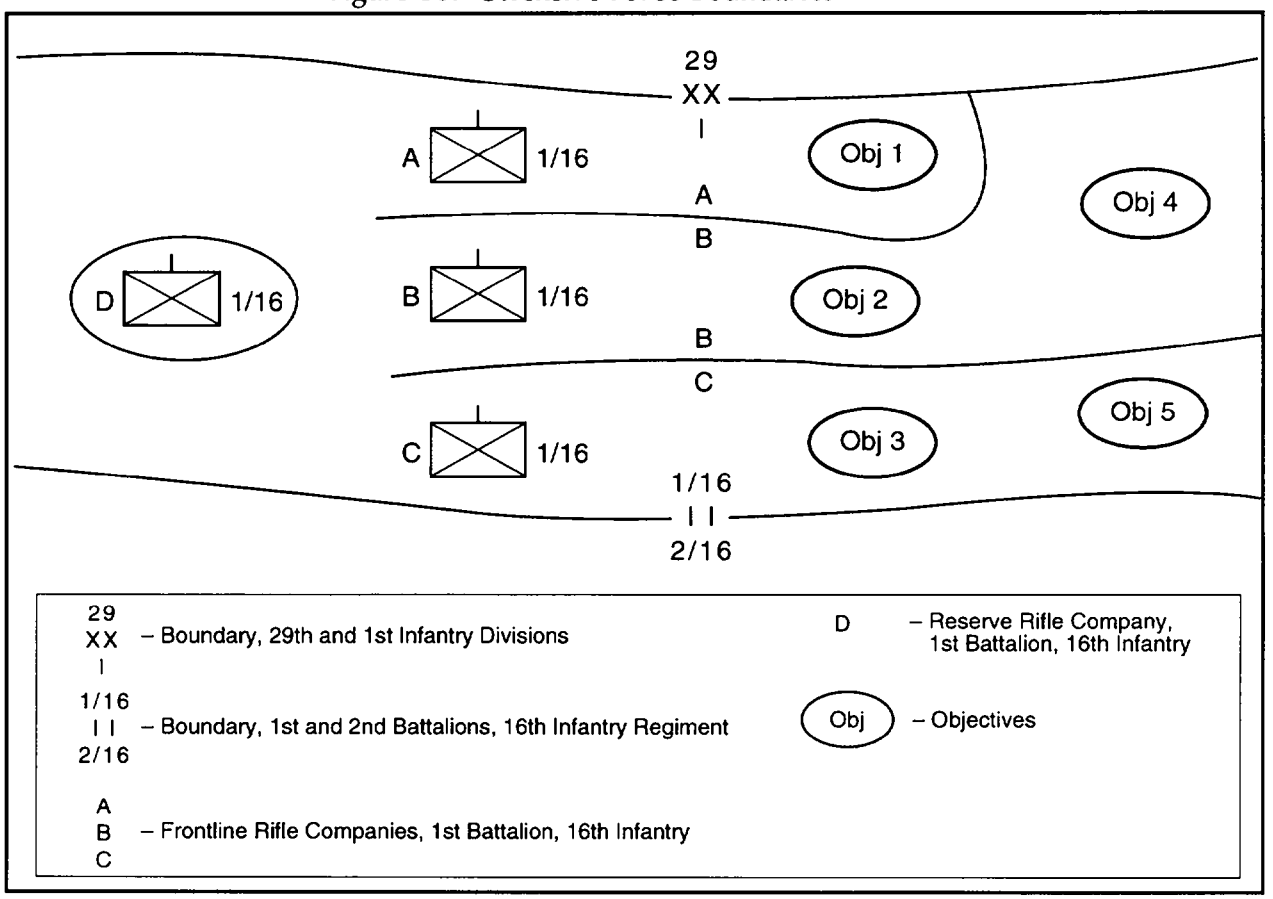
Boundaries During Offensive Operations. Overlays marked with lateral boundaries that extend beyond objectives help military commanders coordinate artillery and air strikes against enemies. Land boundaries moreover may "pinch out" elements, as shown in figure 38, to increase maneuver room for formations that are progressing toward objectives faster than adjacent units, to reconstitute reserves, or for other cogent reasons.

Boundaries During Defensive Operations. The linear frontage that any given size ground force can defend depends in large part on topography, vegetative cover, and soil conditions which, taken together, limit cover, concealment, observation, and high-speed avenues available for use by counterattacking forces as well as enemies. Abilities to overcome geographic adversities and capitalize on opportunities in turn hinge on states of technology. Frontages were invariably narrow when soldiers armed with muskets and short-range cannons stood shoulder to shoulder and the best control measures consisted of shouts, hand signals, semaphore flags, messengers, bugle calls, and pyrotechnics. Modern weapon systems, electronic communications, sophisticated sensors, and other technological innovations permit much greater dispersion, but defensive fronts still are (and probably will always be) severely restricted by rough terrain, forests, and manmade structures that afford poor fields of fire for flat trajectory weapons and attenuate radio waves. Bald flatlands conversely allow small forces with requisite mobility or long-range weaponry to cover relatively large areas.

Lateral boundaries for front line companies in defensive positions normally extend forward to the limit of observation from combat outposts, whereas divisional boundaries reach at least as far as the maximum effective range of organic or attached artillery. Division, corps, field army, and theater commanders also draw rear boundaries that identify areas of responsibility for forces with administrative, logistical, rear area security, and damage control missions.

Coalition Boundaries. National pride and political considerations other than military exigencies sometimes shape military areas of responsibility. The liberation of Paris was not one of General Eisenhower's immediate aims during the allied drive from beachheads in Normandy to the German border. But, after much bickering, the honor of first entry went to the 2d French Armored Division because the symbolic restoration of French freedom outweighed strictly military requirements.[74] Arab ground forces within the multinational

Figure 38. *Offensive Force Boundaries*



coalition that defeated Iraq in January-February 1991 for similar reasons were first to cross the border between Saudi Arabia and Kuwait, then were first to enter Kuwait City while U.S. Marines, as planned, assisted their passage.[25]

Linkup Boundaries. Military operations that proceed through hostile territory to link up with friendly armed forces on the far side require careful coordination. Associated problems are doubly touchy when both sides are in motion, which often is the case, and increase severalfold when converging forces come from two or more countries that find it difficult to communicate face-to-face, much less over air waves. Standard procedures designed to prevent mishaps require units to report when they cross mutually recognized phase lines and to display prearranged recognition signs when contacts become imminent.

General Eisenhower, to cite one real world case, noted that "the problem of liaison with the Russians grew constantly more important as we advanced across central Germany." Converging commanders, "anxious to have an easily identified geographical feature" serve as the junction line, selected the Elbe River, where troops of the U.S. 69th Infantry Division safely met Russian counterparts on the afternoon of April 25, 1945, just 2 weeks before Nazi Germany surrendered unconditionally.[26]

BOUNDARIES ON WATER

Sea services as a rule abhor boundaries that inhibit freedom of action. Command and control lines on open water, however, often are convenient and are unavoidable during amphibious assault operations.

Boundaries Between Naval Areas of Responsibility. Naval forces en route from one AOR to another commonly change operational control (CHOP) at predesignated times or places. Ships home-ported on the U.S. west coast or in Hawaii pass from Third Fleet control to Seventh Fleet when they cross the International Date Line headed for the Far East and reverse that process upon return. Seventh Fleet ships bound from PACOM to CENTCOM become subordinate to Fifth Fleet a specified number of steaming hours north or west of Diego Garcia, Second Fleet ships based on the U.S. east coast CHOP to Sixth Fleet west of Gibraltar before they enter the Mediterranean Sea, and so on. Each ship at CHOP time electronically transmits to the receiving command a status of resources and training report that summarizes its readiness to perform anticipated missions.

Amphibious Assault Boundaries. Boundaries drawn to coordinate amphibious forces before and during assaults on defended shores establish areas of responsibility (often over-the-horizon beyond the sight of observers on land) where troops transfer from ships to air cushion vehicles, helicopters, landing craft, or other conveyances. Boundaries on water also demark lanes from the line of departure to designated beaches, tell underwater demolition teams where to clear mines, and ensure that AORs ashore include adequate exits inland. Map 54 depicts such arrangements at Tarawa atoll in 1943.

BOUNDARIES IN THE AIR

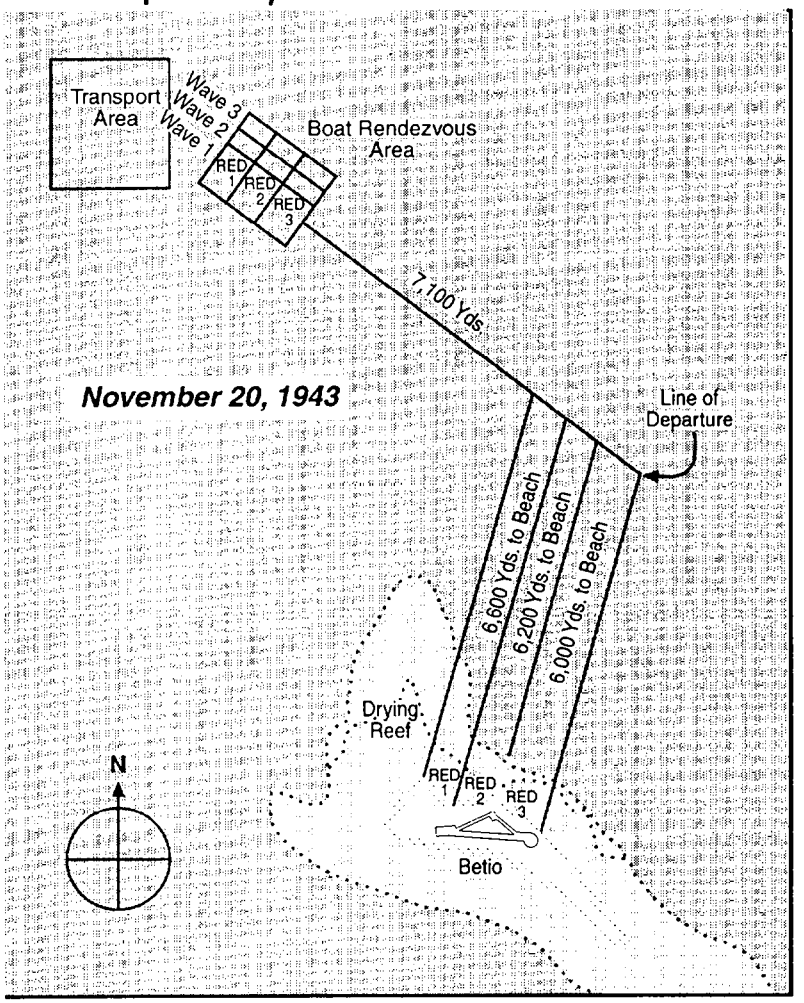
Air forces detest imaginary lines in the atmosphere as much as navies deplore boundaries drawn on the sea, but senior commanders sometimes assign sectors for reasons they rightly or wrongly believe promote the safest, most efficient use of airspace. Three instances, one related to airlift, a second to combat operations, and a third to peacekeeping, are illustrative.

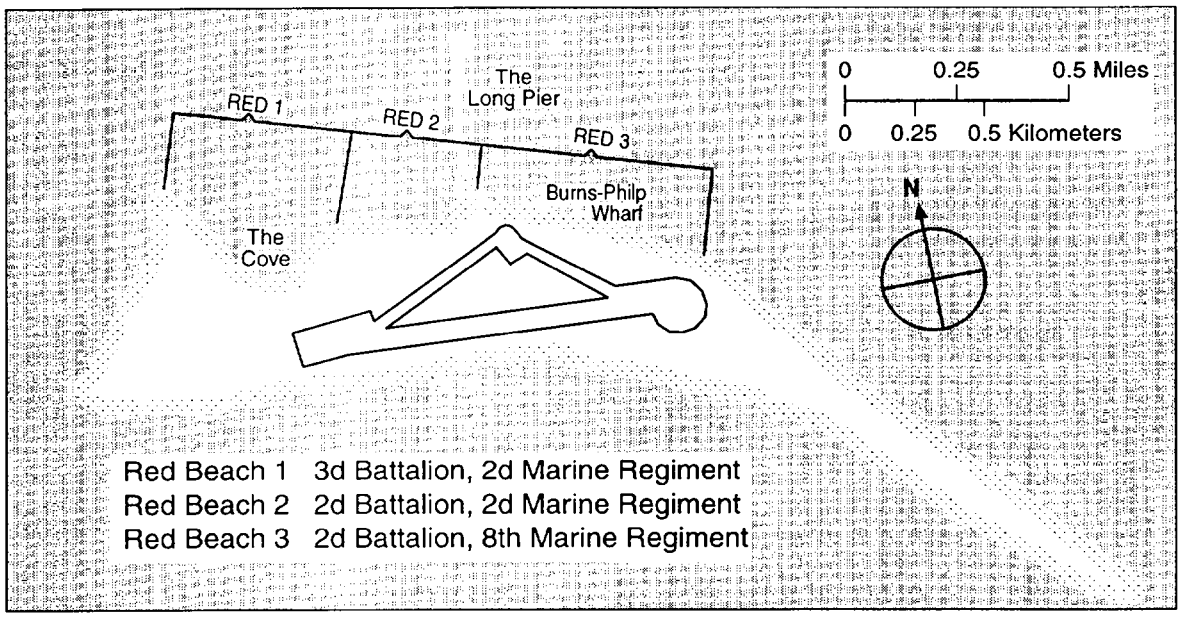
The Berlin Airlift. Technically, four roads, four rail lines, and one barge canal tied Allied occupation forces in West Berlin to West Germany during the period of the U.S., British, French, and Soviet occupation after World War II, but only one railway and the Autobahn to Helmstadt were actually open, and Soviet Armed Forces sealed both from June 22, 1948, until September 30, 1949. Food and fuel for West Berliners were at a low ebb when Allied air forces with civilian air line assistance launched Operation *Vittles* over three 20-mile-wide corridors from Hamburg, Hanover, and Frankfurt-am-Main (see map 6, page 23). Transport aircraft flying night and day on split-second schedules delivered more than 2.3 million tons of desperately needed supplies before the Soviet Politburo allowed trucks and trains to resume shipments.[27]

Air AORs Over North Vietnam. Control problems arose as soon as U.S. Air Force squadrons in South Vietnam and naval aircraft based on carriers in the Gulf of Tonkin began *Rolling Thunder* bombing campaigns against North Vietnam in March 1965. A joint USAF-Navy Coordinating Committee thereupon advanced three optional control plans, all of which were controversial.

Air Force members first proposed time-sharing arrangements that would reserve 3-hour periods within which one service, then the other, could attack approved targets. The Navy counterproposed responsibility on a north-south axis that reserved coastal targets for carrier

Map 54. *Amphibious Boundaries at Tarawa*





Adapted from Martin Russ, *Line of Departure: Tarawa* (Garden City, NY: Doubleday, 1975), 61, 67

aircraft, which lacked enough range to reach far inland without in-flight refueling, but some targets in that case would have received too little attention and others too much. The Coordinating Committee, despite Air Force objections, compromised with so-called "Route Packages," as follows (map 55):[28]

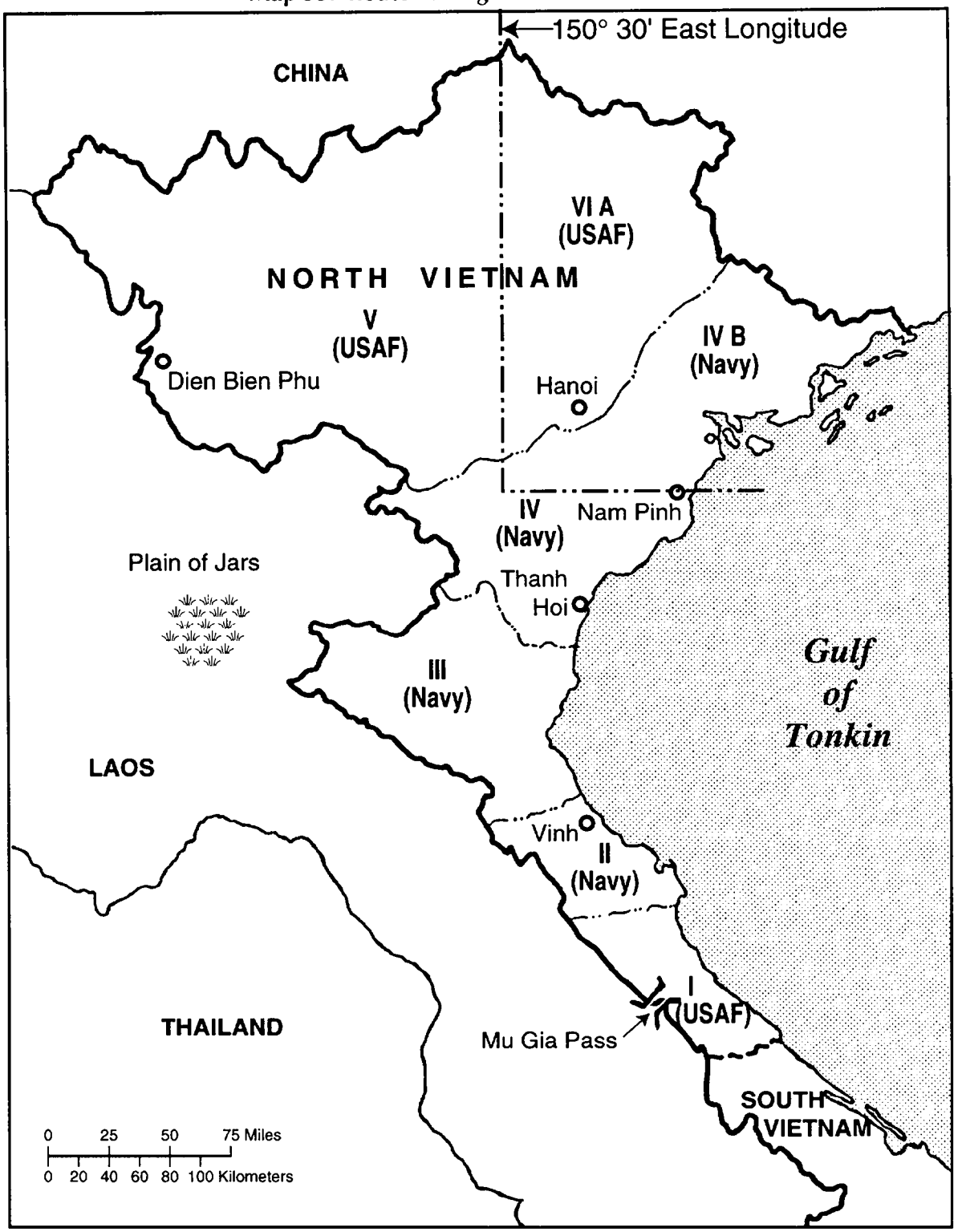
- Route Package I (Air Force) included enemy staging bases near the demilitarized zone and heavily-traveled Mu Gia Pass, which led into the Laotian panhandle.
- Route Package II (Navy) covered enemy logistical activities around Vinh, targets along the coastal highway, and littoral traffic.
- Route Package III (Navy) concentrated on supply lines that fed Pathet Lao and North Vietnamese forces on and near the Plain of Jars.
- Route Package IV (Navy) encompassed major marshaling yards, the Thanh Hoa bridge, and North Vietnam's only all-weather airfield south of Hanoi.
- Route Package V (Air Force), twice the size of and farther inland than any other parcel, embraced enemy bases between North Vietnam and northern Laos, including Dien Bien Phu.
- Route Package VI (divided between the Air Force and Navy along the highly-visible northeast railroad) was a heavily-defended, target-rich environment centered around Hanoi.

Those AORs remained in effect until October 1972 when, "to improve efficient use of resources and to attain mass application of force where indicated," Admiral Noel Gayler, in his capacity as Commander in Chief Pacific, designated Route Package VI around Hanoi as "an integrated strike zone" wherein USAF and Navy aircraft could "schedule strike missions into one another's geographical area."[29]

Not everyone was satisfied with that decision, which pertained to only one AOR in North Vietnam. Skeptics such as General William W. Momyer, who commanded U.S. Seventh Air Force at the time, soon thereafter wrote that "any arrangement arbitrarily assigning air forces to exclusive areas of operation will significantly reduce airpower's unique ability to quickly concentrate overwhelming firepower wherever it is most needed."[30] He concurrently cited the following words of British Air Marshal Tedder to buttress his case: "Air warfare cannot be separated into little packets; it knows no boundaries on land or sea other than those imposed by the radius of action of the aircraft; it is a unity and demands unity of command."[31]

"No Fly Zones" in Iraq. The United Nations Security Council in April 1991 passed Resolution 688, which directed Iraq to cease repressing Kurdish communities within its northern borders and Shi'ite Muslims in the far south. The United States and key allies shortly thereafter imposed two air exclusion zones to ensure compliance. U.S., British, and French aircraft that participate in Operation *Provide Comfort* from bases in Turkey have flown daily sorties since May 1991 to deny Iraq any use of its airspace north of the 36th Parallel. Patrols associated with Operation *Southern Watch* in August 1992 began to "sanitize" Iraqi airspace south of the 32d Parallel, mainly from Saudi Arabia, then expanded coverage to include the 33d Parallel in September 1996. Such flights, as a bonus, perhaps help deter rash moves by Saddam Hussein toward Kuwait and other countries on the Arabian Peninsula.[32]

Map 55. *Route Packages in North Vietnam*



"NO MAN'S LANDS"

Every U.S. military service seeks to stake out claims beyond tactical areas of responsibility in a "no man's land" where areas of interest, areas of influence, and the reach of long-range weapons overlap. Competition is intense, because the winners receive more money and a larger share of scarce resources with which to perform related roles, functions, and missions. Lack of mutual trust makes each supplicant loath to rely on others and prompts each, like the Prophet Isaiah, to plead, "Here am I; send me."

Land forces almost everywhere establish fire support coordination lines (FSCLs) or equivalents thereof designed to maximize freedom of action for air forces and long-range weapons yet simultaneously minimize interference with ground schemes of maneuver and forestall fratricide by aerial weapon systems that deliver munitions in direct support of front-line troops. Land- and carrier-based aircraft as a rule may strike surface targets on the friendly side of FSCLs only after consultation with and approval of appropriate land force commanders but, in most cases, are authorized to conduct air-to-surface and surface-to-surface attacks on the hostile side as they see fit.[33]

Those rules of engagement were reasonably satisfactory until land forces armed with missiles began to impinge on air force and naval preserves. The U.S. Army, for example, currently is armed and equipped to identify targets at 185 to 310 miles (300 to 500 kilometers) and engage targets regardless of weather conditions at ranges that exceed 60 miles (100 kilometers). Army spokesmen justify the use of such systems with quotations from U.S. joint doctrine, which prescribes areas of operation large enough for land commanders to protect their forces and fight at extended ranges.[34] Air Force rebutters contrarily contend that only USAF and naval airmen should fight high and deep, because Army interference fosters interservice coordination problems, invites disastrous collisions between aircraft and projectiles, promotes senseless redundancies, and incurs unconscionable costs. It would be equally "absurd," one critic said, for the U.S. Air Force to insist on its own tank battalions to defend air bases in event of enemy breakthroughs.[35] Deep battle disputes nevertheless will likely linger in the United States and elsewhere until senior decisionmakers determine how much (if any) overlap is advisable and prescribe crisply-demarked areas of responsibility for each military service.

BOUNDARIES IN AND THROUGH SPACE

Article IV of the Treaty on Outer Space, in force since October 10, 1967, states, "The moon and other celestial bodies shall be used by all [signatories] for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons, and the conduct of military maneuvers on celestial bodies shall be forbidden."

No treaty, however, forbids military activities in free space. U.S. Space Command wants the President to declare that void as a regional AOR.[36] Geosynchronous, geostationary, polar, lunar, and other prearranged orbit patterns probably would determine tactical areas of responsibility should he choose to do so, at least until technologists devise maneuverable spacecraft at some unpredictable future date. Military boundaries on the moon or other celestial bodies likely would share most attributes of those on Earth if any nation eventually deploys armed forces in such places.

KEY POINTS

- Strategic, operational, and tactical areas of responsibility constitute geographic entities within which one unified commander possesses the authority to plan and conduct operations that may involve more than one Military Service.
- Crisply-defined AOR boundaries foster unity of effort, ensure adequate territorial coverage, and avoid wasteful duplications.
- Traditional spheres of Service influence, threats, and available combat power as well as geographic circumstances commonly shape areas of responsibility
- The best laid global and regional boundaries take political sensitivities and cultural factors into account.
- The size and shape of coalition AORs often depends more on diplomatic demands than on strictly military considerations.
- Friction is probable when areas of interest and influence overlap areas of responsibility.
- Global and regional areas of responsibility require periodic reviews to ensure that they serve required purposes despite political, economic, military, technological, and other change
- Proposed AOR changes that initially seem simple almost always appear complex after investigation, partly because the elimination of any given seam almost inevitably creates other undesirable features.

NOTES

1. Maurice Matloff and Edwin M. Snell, *Strategic Planning for Coalition Warfare, 1941-1942, The United States Army in World War II* (Washington, DC: U.S. Army Center of Military History, 1990), 165-166.
2. Ibid., 166-168.
3. Walter S. Poole et al., *The History of the Unified Command Plan, 1946-1993* (Washington, DC: Joint History Office, Office of the Chairman, Joint Chiefs of Staff, February 1995).
4. Ibid., 12-13, 127-129.
5. Phillip E. Oates and Lawrence J. Stewart, *Unified Command in a Unipolar World*, National Security Program Discussion Paper (Cambridge, MA: Kennedy School of Government, Harvard University, June, 1991).
6. Poole et al., *The History of the Unified Command Plan*, 1-7.
7. Dwight D. Eisenhower, *First Annual Report of the Supreme Commander, Allied Powers Europe* (Paris: Public Information Division, SHAPE, April 1952), 14.
8. Stephen E. Ambrose with Morris Honick, "Eisenhower: Kindling the Spirit of the West," in *Generals in International Politics: NATO's Supreme Allied Commander, Europe* (Lexington, KY: University of Kentucky Press, 1987), 18-22.
9. See, for example, Congress, Senate, *NATO and the New Soviet Threat*, Report of Senator Sam Nunn and Senator Dewey Bartlett to the Committee on Armed Services, 95th Congress, 1st sess., 1977; *U.S. Air and Ground Conventional Forces for NATO: Overview* (Washington, DC: Congressional Budget Office, January 1978); Richard D. Lawrence and Jeffrey Record, *U.S. Force Structure in NATO: An Alternative* (Washington, DC: Brookings Institution, 1974).
10. Harold Brown, *Department of Defense Annual Report for FY 1979*, 237-238.

11. Matloff and Snell, *Strategic Planning for Coalition Warfare, 1941-1942*, 168-173; Rafael Steinberg, *Island Fighting* (New York: Time-Life Books, 1978), 20-23.

12. *Strategic Planning for Coalition Warfare, 1941-1942*, 258-265; Maurice Matloff, *Strategic Planning for Coalition Warfare, 1943-1944*, 1994, 91, 96-97, 137-138, 185-196, 453-459.

13. Poole, et al., *The History of the Unified Command Plan*, 20, 26-27.

14. Ibid., 36-37; *Report on the War in Vietnam*, Admiral U. S. G. Sharp, Commander in Chief Pacific Command, Section I, Report on Air and Naval Campaigns Against North Vietnam and Pacific-Wide Support of the War, June 1964-July 1968; and General William C. Westmoreland, Commander, U.S. Military Assistance Command Vietnam, Section II, Report on Operations in South Vietnam, January 1964-June 1968 (Washington, DC: Government Printing Office, 1968).

15. William C. Westmoreland, *A Soldier Reports* (Garden City, New York: Doubleday, 1976), 499-500.

16. Poole et al., *The History of the Unified Command Plan*, 16, 29-31.

17. Ibid., 32-34.

18. Ibid., 39-41, 64-70, 74-78.

19. See, for example, Alfred Thayer Mahan, "The Strategic Features of the Gulf of Mexico and Caribbean Sea," *Harper's New Monthly Magazine*, October 1887, 680-691; *The Caribbean—A Military Perspective*, Executive Summary and vol. I, Technical Report No. 83-2 (Washington, DC: Naval Sea Systems Command, December 1983).

20. *The History of the Unified Command Plan*, 26, 31-32, 70.

21. Ibid., 71-74.

22. *Unified Command Plan: Atlantic and Southern Command Participation in 1995 Review* (Washington, DC: U.S. General Accounting Office, December 1996).

23. Ibid., 13.

24. Martin Blumenson, *Breakout and Pursuit, U.S. Army in World War II, The European Theater of Operations* (Washington, DC: Government Printing Office,1961), chapter 29.

25. *Persian Gulf Conflict: Final Report to Congress* (Washington: Department of Defense, April 1992), 410; Prince Khaled Ibn Sultan, *Desert Warrior: A Personal View of the Gulf War by the Joint Forces Commander* (New York: Harper Collins, 1995), 391-419.

26. Dwight D. Eisenhower, *Crusade in Europe* (Garden City, New York: Doubleday, 1948), 410-411; Cornelius Ryan, *The Last Battle* (St. James Place, London: Collins, 1966), 371-372.

27. Ann and John Tusa, *The Berlin Airlift* (New York: Athenium, 1988).

28. William W. Momyer, *Air Power in Three Wars*, new imprint (Washington, DC: Government Printing Office, 1985), 89-94; Sharp, *Report on the War in Vietnam*, Section I, 16-48, 53-54.

29. Corona Harvest Report, *USAF Air Operations in Southeast Asia, 1 July 1972-15 August 1973*, vol. 2 (Hickam AFB, Hawaii: Dept. of the Air Force, Pacific Air Force, 1973), IV-34.

30. Momyer, *Air Power in Three Wars*, 94-99.

31. Marshal of the Royal Air Force the Lord Tedder, *Air Power in War*, the Lees Knowles Lectures (London: St. Paul's House: 1947), 91-92.

32. Kenneth Katzman, *Iraqi Compliance with Cease-Fire Agreements*, Issue Brief 92117 (Washington, DC: Congressional Research Service, March 1997), updated regularly; Alfred B. Prados, *The Kurds of Iraq: Status, Protection, and Prospects*, Report No. 94-423F (Washington, DC: Congressional Research Service, May 12, 1994).

33. Joint Pub 1-02: *Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: Office of the Chairman, Joint Chiefs of Staff, March 23, 1994), 146; FM 100-5: *Operations* (Washington, DC: Dept. of the Army, June 1993), 6-14; Air Force Doctrine Directive 1-1, vol. 2 (Washington DC: Dept. of the Air Force, March 1992), 161-164.

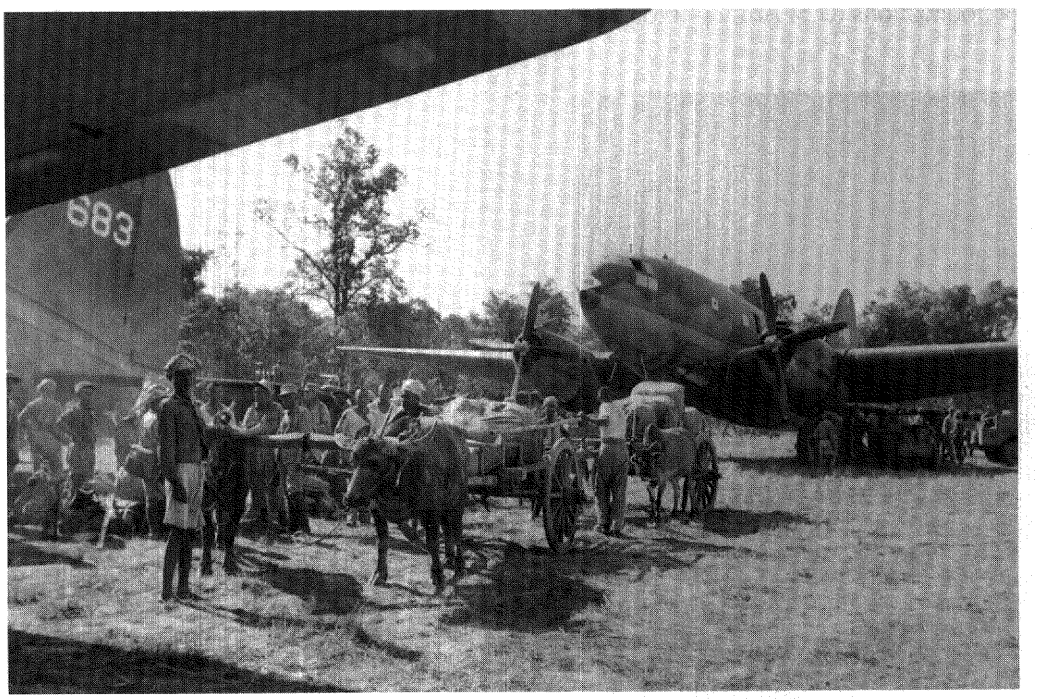
34. *Deep Battle* (Washington, DC: Dept. of the Army, Roles and Missions Directorate, November 15, 1994).

35. Merrill A. McPeak, *Presentation to the Committee on Roles and Missions of the Armed Forces*, revised (Washington, DC: Government Printing Office, September 14, 1994), 15-17, 34-35, 37, 39-40, 50-55; William W. Momyer. "An Organization for Theater Operations: From a Commander's Perspective," in Thomas A. Cardwell, III, *Command Structure for Theater Warfare: The Quest for Unity of Command* (Maxwell AFB, AL: Air University Press, September 1984), 131-134.

36. Douglas Berenson, "U.S. Space Command Wants Space Declared Its 'Regional' Area of Operations," *Inside the Pentagon*, February 20, 1997, 1.



A few of the 650 Kuwaiti oil wells that Iraqi President Saddam Hussein torched in February 1991 burn brightly and blacken the sky with acrid smoke. Unprecedented efforts were required to extinguish the flames, restore production, and cope with an ecological disaster of grand proportions (U.S. Air Force photograph).



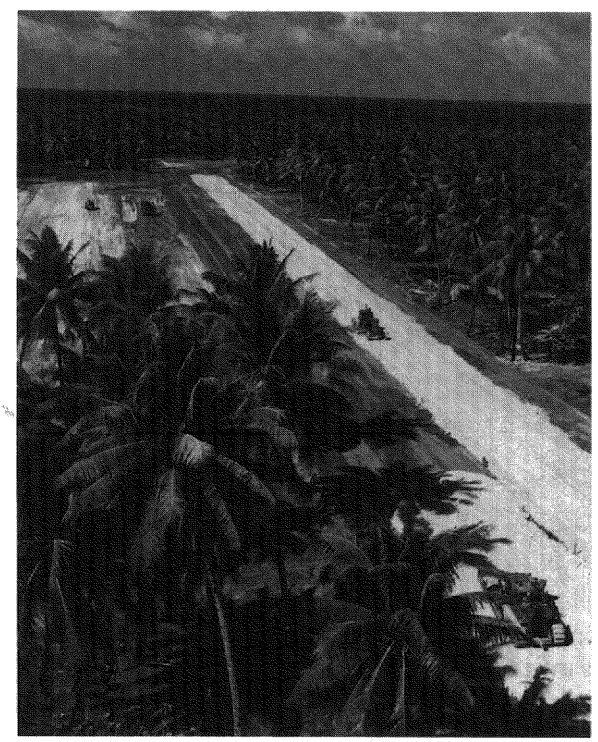
Local laborers in Assam and Burma routinely transferred supplies and equipment from ox carts to U.S. C-46 cargo aircraft bound for Kunming, China, via perilous routes over the Himalayan Hump. Nationalist Chinese divisions were the principal beneficiaries at that destination (U.S. Army photograph).



Allied and captured enemy quarries equipped with rock crushers come in handy when military requirements call for materials with which to construct, repair, or maintain roads, railways, airfields, and other military infrastructure that demand solid foundations (U.S. Army photograph).

The Berlin Airlift (Operation *Vittles*) supplied beleaguered West Berlin under trying circumstances during a protracted Soviet blockade that lasted from June 1948 until May 1949. Grateful citizens, who depended almost entirely on that aerial lifeline for food and fuel, lined high ground in good weather to cheer the arrival of precious shipments (U.S. Army photograph).





Expeditionary airfields, such as this one in the midst of a South Pacific palm grove, facilitate the rapid exploitation of land-based airpower for diverse purposes. Emergency strips may be operational within a day or two. Greater capabilities demand longer times that depend on local topography, land clearance requirements, soil stability, the availability of construction materials, and the early arrival of bare base kits (U.S. Navy photograph).

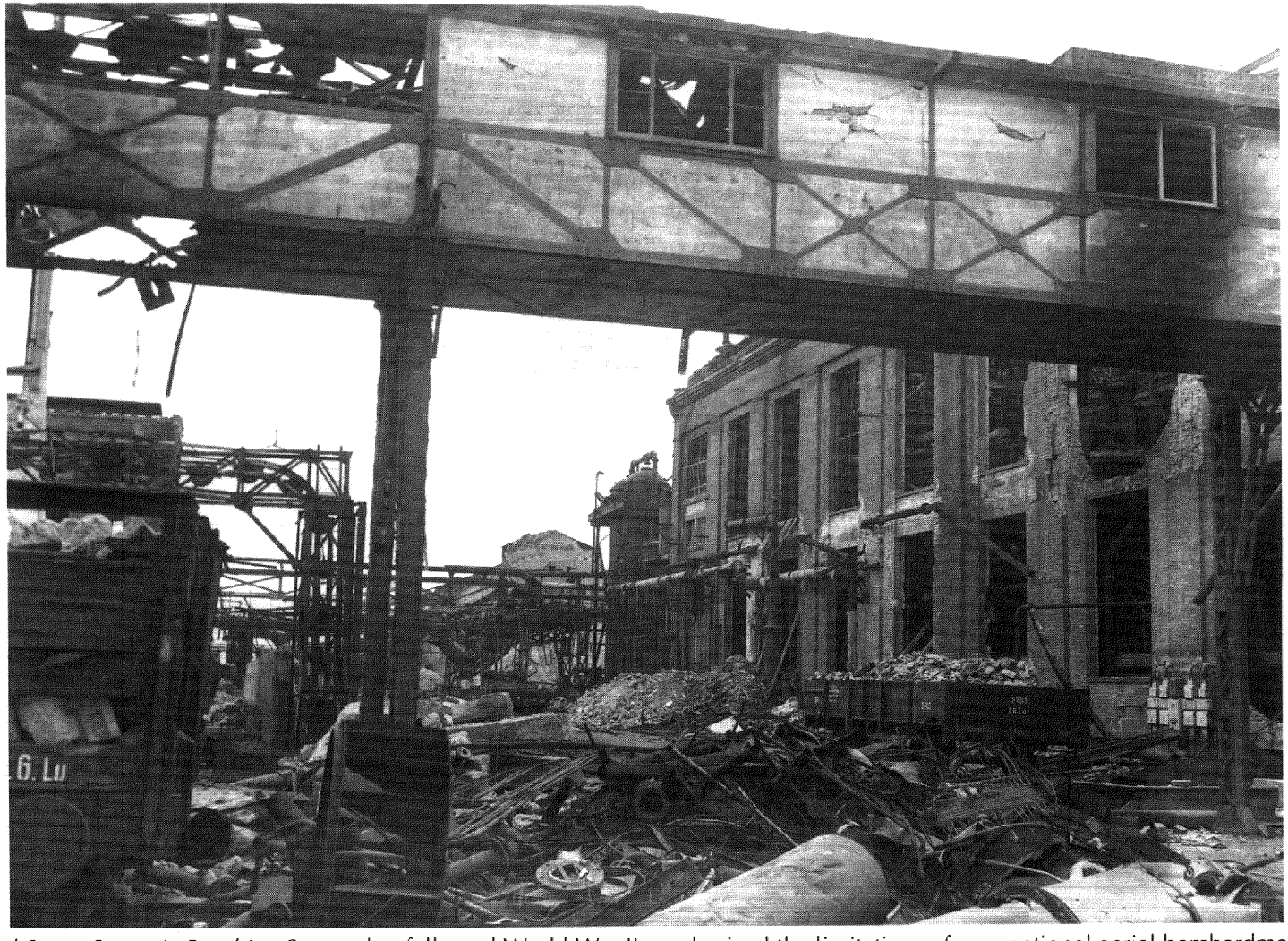




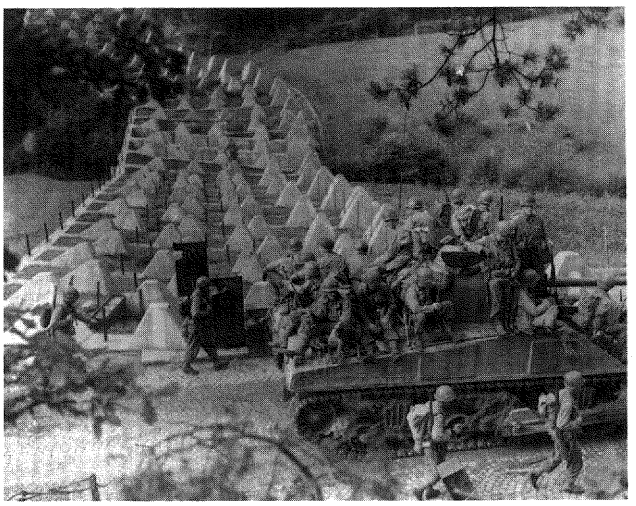
Hastily constructed helipads surrounded by triple canopy rain forests look like holes blasted in green blankets when viewed from above. Observers at ground level see a tangle of felled trees until chain saws complete the clearance process (U.S. Army photographs).



Urban combat often is more cruel to innocent bystanders than to belligerents. Foot troops beneath white flags (signs of surrender) indifferently file by this bewildered German grandmother who gazes in disbelief at the wreckage of her home that aerial bombs and artillery had reduced to rubble (U.S. Army photograph.)



The *United States Strategic Bombing Survey* that followed World War II emphasized the limitations of conventional aerial bombardment against industrial targets. The badly battered I.G. Farben plant at Ludwigshaven, Germany produced goods at almost 70 percent of capacity soon after this photo was taken (U.S. Army photograph).



Dragons' Teeth were merely the most visible defenses along the Siegfried Line that buttressed Germany's borders with France, Luxembourg, and Belgium during World War II. Some U.S. troops rolled through almost unopposed in September 1944 when the *Wehrmacht* was in disarray and those fortifications were lightly manned, but six more months elapsed before breakthoughs occurred on a broad front (U.S. Army photograph).

Cobblestones such as those on this stretch of Utah Beach in Normandy multiply the effects of artillery fire, because ricocheting rocks can be just as lethal as metal shards and high explosives (U.S. Army photograph).

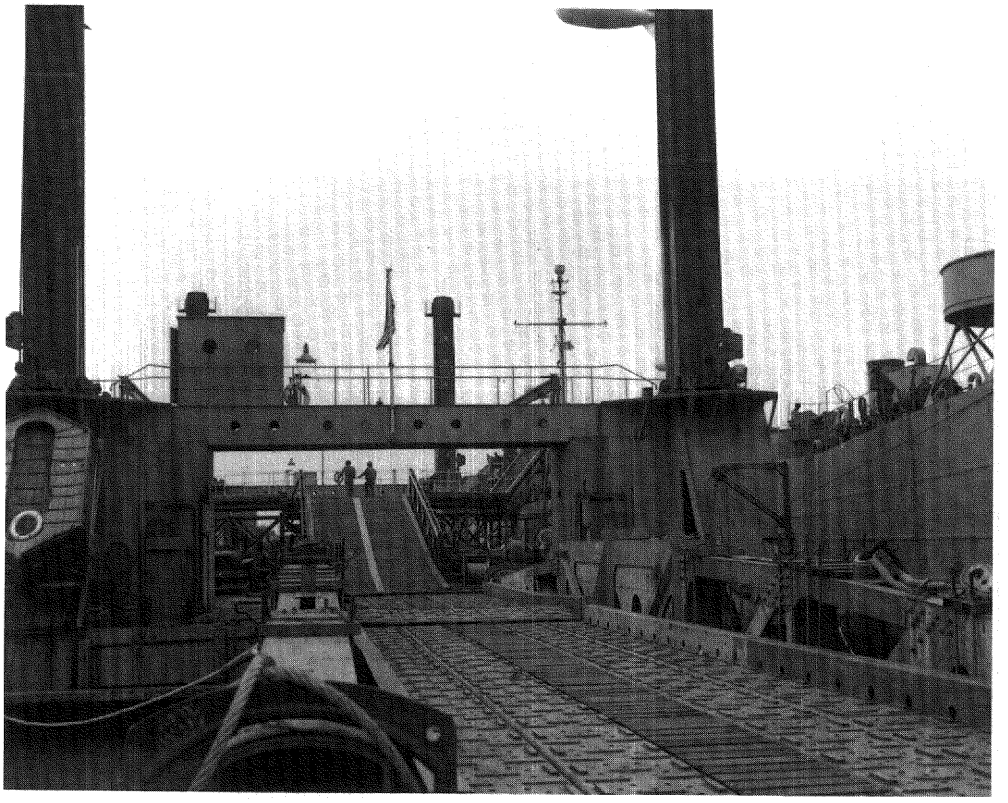


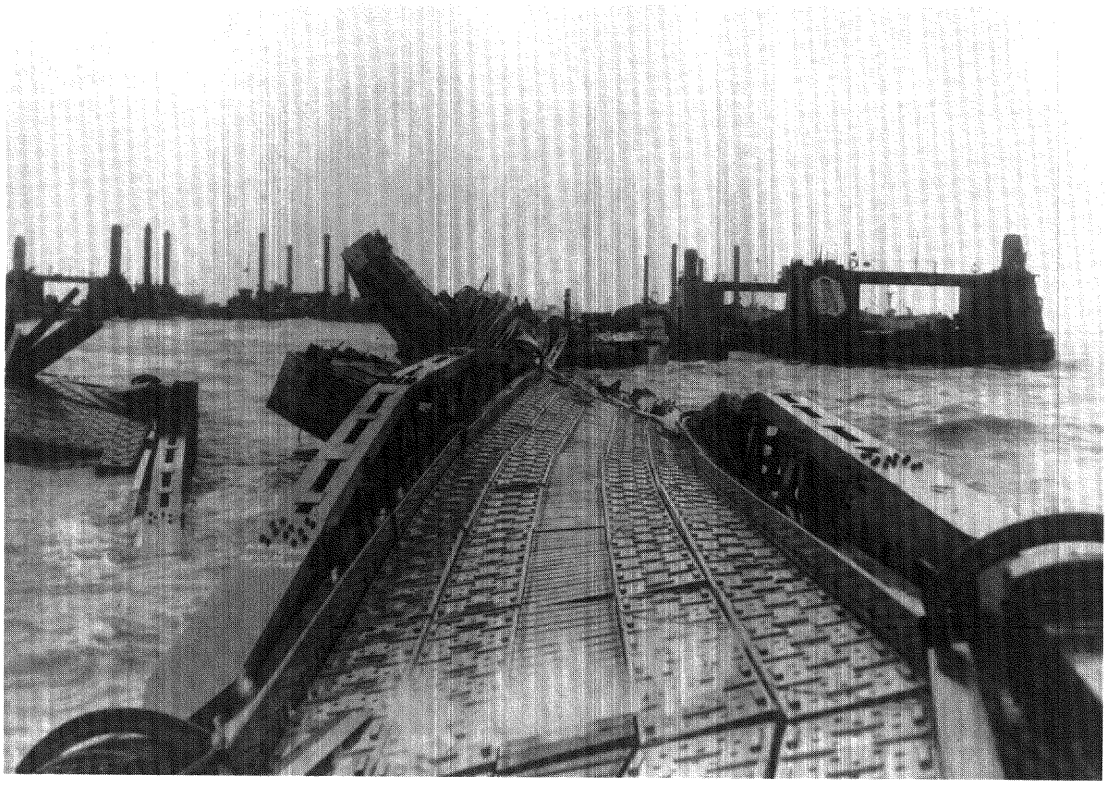


Armored vehicles trapped on narrow lanes between hedgerows atop steep earthen banks were easy targets for antitank gunners in Normandy, as the crew of this German Mark-5 tank discovered (U.S. Army photograph).



The Banghiang River crossing looked like a lunar landscape after U.S. aircraft repeatedly bombed and finally destroyed the triple span bridge near Tchepone in the Laotian panhandle. Truck traffic on that part of the Ho Ch Minh Trail thereafter ceased, because the river was unfordable, but barges ferried troops, weapons, equipment, and supplies to the south bank (U.S. Air Force photograph.).





Mulberry "A", an expedient port installed off Omaha Beach shortly after D-Day, was an engineering marvel. A devastating storm that struck on June 19, 1944 (D+13) reduced the primary structure to twisted wreckage, but not before thousands of troops, vehicles, and tons of supplies passed through its portals (U.S. Army photographs).





Top: This scene near the border between Laos and Vietnam illustrates a typical bypass and ford where Route 9 crossed a shallow stream in 1968. The rickety bridge that engineers installed when Laos was a French colony would no longer support even light vehicular traffic (U.S. Air Force photograph).
Bottom: A Marine Lance Corporal astride a baby bulldozer seeks to improve "Highway" 9 between Khe Sanh and the Laotian border. The badly eroded right of way, paralleling a shallow stream on one side and precipitous slopes on the other, was barely 6 feet (2 meters) wide in that locale (U.S. Marine Corps photograph).



Ban Houei Sane, just north of the Pon River on the outskirts of the tiny Laotian village from which it took its name (lower right), was the best airfield in the OPLAN *El Paso* objective area, even though it was abandoned and the runway of crushed stone and laterite was pocked with more than 20 bomb craters (U.S. Air Force photograph)

PART FOUR: AREA ANALYSES

17. FORMAT FOR AREA ANALYSIS

Eternal truths will be neither true nor eternal unless they have fresh meaning for every new . . . situation.

Franklin Delano Roosevelt
Address, University of Pennsylvania
September 20, 1940

PRESIDENT ROOSEVELT'S REMARK WAS WELL SAID WITH REGARD TO THE INFLUENCE OF PHYSICAL, CULTURAL, and political-military geography on military plans, programs, and operations at every level, because the significance of any given area fluctuates in response to seasonal, cyclical, and random changes that commanders and staffs must evaluate in consonance with missions, situations, forces available on both sides, and technological proficiencies. Computer-assisted intelligence collectors amass, sort, and disseminate much of the data needed for area analyses, but accurate interpretations and sound conclusions depend on incisive minds. Most professionals follow a format similar to the one briefly described below.

GEOGRAPHICAL DATA BASES

Data bases that deal with all pertinent geographic facts lay the foundation for each area in much the same way that Parts One and Two of this document underpin Parts Three and Four. Salient considerations such as spatial relationships, topography, oceanography, weather, climate, demography, urban patterns, transportation networks, and manmade structures indeed parallel the Table of Contents herein (see table 25).

Table 25. *Area Analysis Format*

GEOGRAPHICAL DATA BASES

Physical Geography			
Location Size Shape	Land Forms Drainage Geology Soils Vegetation	Sea Water Sea Ice Tides and Currents Waves and Surf Littorals	Weather Climate Light Data

Cultural Geography		
Population Patterns Races Ethnic Groups Tribes and Clans Religions Public Health	Cities Towns Military Bases Military Facilities Fortifications	Roads Railways Airports Seaports Canals Pipelines

MILITARY MISSIONS

Offensive Combat	Unconventional Warfare
Defensive Combat	Counterinsurgency
Peacekeeping	Counterterrorism
Reconnaissance	Civil Affairs
Logistical Support	Psychological Operations
Search and Rescue	Humanitarian Assistance

MILITARY IMPLICATIONS

Strategic Analyses	*Tactical Analyses*	*Logistical Analyses*
Geopolitics Core Areas Strategic Mobility Coalitions Infrastructure	Critical Terrain Observation Fields of Fire Cover and Concealment Obstacles Avenues of Approach	Supply Maintenance Transportation Construction Medical Care

EFFECTS ON COURSES OF ACTION

Effects on Friendly Courses of Action	Effects on Enemy Courses of Action

MILITARY MISSIONS

The full significance of basic geographic intelligence begins to emerge only when put into context with military missions. Distinctive requirements, for example, rippled down chains of command as soon as the U.S.-British Combined Chiefs of Staff on February 12, 1944, instructed General Eisenhower to "enter the continent of Europe and, in conjunction with other Allied nations, undertake operations aimed at the heart of Germany and the destruction of her armed forces." A U.S.-British-Canadian coalition thereupon prepared to land on the Normandy coast, consolidate five beachheads, then drive inland. The First U.S. Army prepared airborne and amphibious assaults to seize lodgments along its stretch of invasion coast, U.S. V Corps prepared to land on Omaha Beach, the 1st and 29th U.S. Infantry Divisions prepared to hit respective subsections at H-Hour on D-Day. Battalions, companies, platoons, and squads prepared to accomplish ever more detailed missions within ever smaller AORs.[1] Each organization required a formal or informal area analysis slanted specifically to meet its unique needs.

Land, sea, and air force commanders in this day and age additionally must prepare to accomplish such diversified missions as peacekeeping, humanitarian assistance, disaster relief, nation building, hostage rescue, counterterrorism, drug interdiction, and other operations short of war. Mission-oriented area analyses in each instance are essential.

MILITARY IMPLICATIONS

Detailed diagnoses occupy strategic, tactical, and logistical categories that respectively serve national policymakers and planners, combatant commanders, and support forces that specialize in supply, maintenance, transportation, construction, and medical care.

STRATEGIC AREA ANALYSES

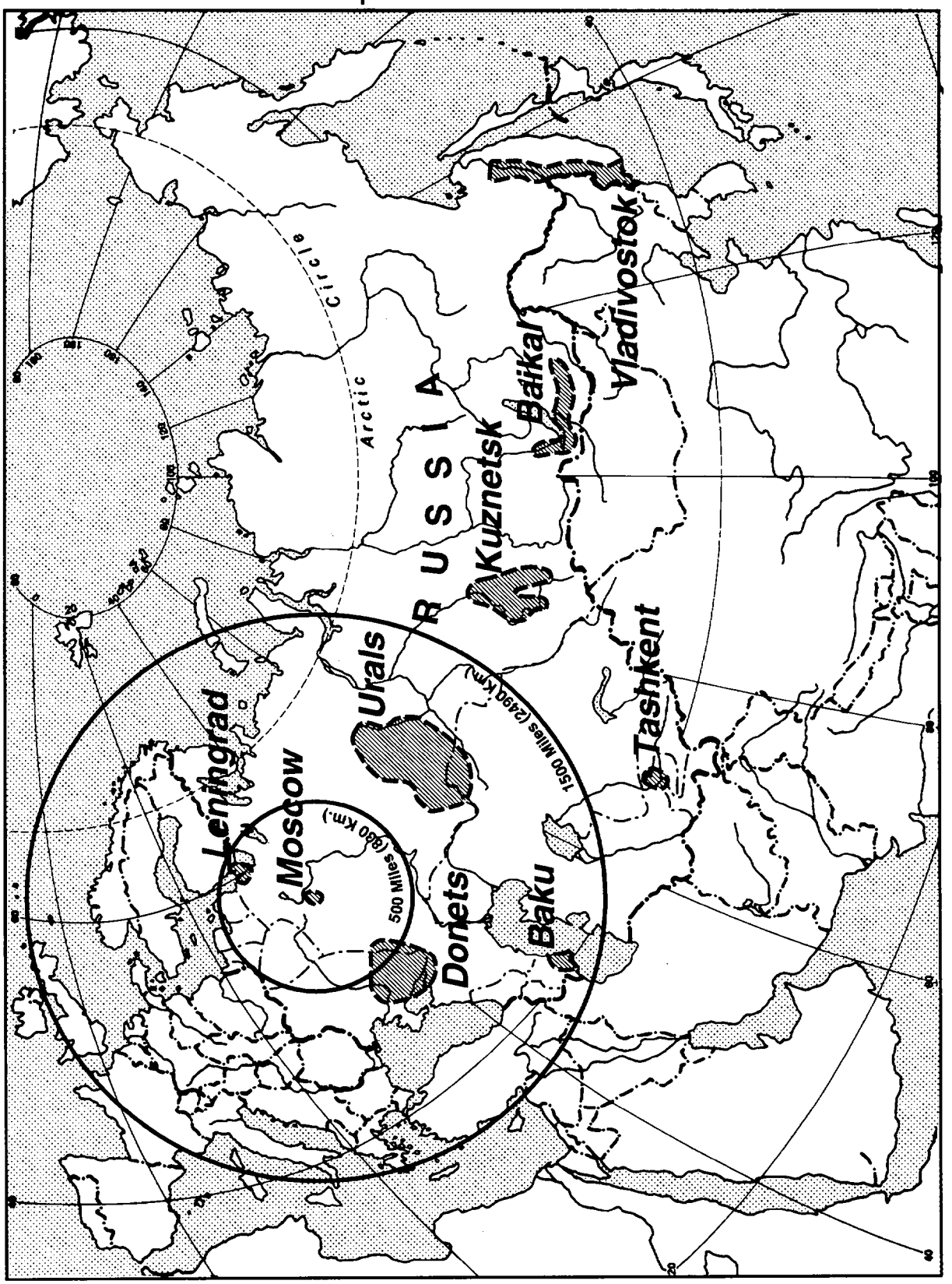
Area analyses at the national level concentrate on political-military matters much like those that Part Three of this document addresses, together with lines of communication needed to reach distant areas of responsibility, abilities to form coalitions after arrival, and the availability of militarily useful infrastructures.

Strategic analyses also assess enemy core areas that contain targets of great political, economic, military, or cultural value, the seizure, retention, destruction, or control of which would afford marked advantage. U.S. analysts during the Cold War identified several agglomerations in European Russia that would have been vitally important to Soviet national security in the event of a general nuclear war: Moscow, Leningrad, heavy industries in the Donets Basin and Ural Mountain complex, oil fields and refineries around Baku. Subsidiary cores centered around Tashkent, the Kuznetsk Basin, Lake Baikal, and Vladivostok were regionally important, but the Soviet Union could have survived as a strong state without them (map 56).[2]

TACTICAL AREA ANALYSES

Area analyses developed for combat forces emphasize critical terrain, avenues of approach, natural and manmade obstacles, cover, concealment, observation, and fields of fire. A few words about each suffice.

Map 56. *Soviet Core Areas*



Critical Terrain. Marked advantages accrue to armed forces that hold, control, or destroy critical (sometimes decisive) terrain, which is a lower level analog of strategically crucial core areas. Typical examples range from commanding heights and military headquarters to geographic choke points, telecommunication centers, logistical installations, power plants, dams, locks, airfields, seaports, railway marshaling yards, and road junctions. Features that qualify differ at each echelon, because senior commanders and their subordinates have different perspectives. Three- and four-star officers, for example, might see an entire peninsula as critical terrain while successively lower levels focus first on one coastal city, then on the naval shipyard therein, the next layer down on harbor facilities, and finally on pierside warehouses.

Avenues of Approach. The value of avenues on land, at sea, and in the air also varies with levels of command. Field Marshal Graf von Schlieffen, who was Chief of the German General Staff at the turn of the 20th century, visualized a single high-speed corridor between Saxony and France, adequate for 34 divisions abreast if "the last man on the right brushed the English Channel with his sleeve,"[3] whereas haggard platoon leaders at the bottom of his heap felt lucky when they found a suitable stretch 1,000 meters long. Approaches that are attractive to friendly armed forces seldom suit enemy schemes of maneuver and vice versa, but useful avenues in neither event need follow the most obvious paths—on the contrary, savvy commanders occasionally pick inauspicious routes precisely because they facilitate surprise.

Obstacles. Representative obstacles along land avenues of approach include mountains, unfordable streams, swamps, steep slopes, deep snow, dense forests, flooded lowlands, reefs, shoals, urban centers, minefields, antitank ditches, roadblocks, blown bridges, cratered airport runways, and "dragons' teeth." Distance and overland accessibility don't always correlate closely, as evidenced by Tibet, which is reached more easily from Chongqiang, China, north of the Himalayas than from Calcutta south of that awesome wall. Impediments perpendicular to avenues of attack cause offensive ground forces to lose forward momentum and temporarily bunch up, which increases vulnerabilities. Polisario guerrillas in Western Sahara, for example, never were able to mount large-scale assaults across the huge berm that Moroccan troops built as a defensive barrier.[4]

Solid obstructions are absent in the air and uncommon on sea surfaces (ice, islands, reefs, and shoals are important exceptions), but underwater topography inhibits submarines, bad weather commonly interferes with operations aloft and afloat, rugged terrain limits flight paths, and intangible obstacles such as the denial of overflight rights for political reasons may impede the use of airspace.

Observation and Fields of Fire. Ground forces for millenia have spilled countless buckets of blood in efforts to seize, hold, or destroy observation posts in church steeples, on water towers, or atop dominant peaks such as Monte Cassino (Italy) and Mount Surabachi (Iwo Jima). The loftiest perches, however, provide the best visibility only if lines-of-sight are unobstructed by terrain masks, dense vegetation, rain, drizzle, swirling snow, dust, fog, smoke, smog, mirages, or other obscurants that also limit aerial surveillance. Darkness reduces visibility for land, sea, and air forces alike unless they possess night vision devices.

Topographic features, vegetative cover, and buildings commonly restrict air-to-ground as well as surface-to-surface weapon systems. North Korea is a cogent case in point, because low-hanging clouds often cover mountain tops, valley winds blow strongly, and many

lucrative targets are deeply buried in tunnels at the bottom of shadowy, steep-sided ravines that face north. Contour-flying aircraft, "smart bombs," and terminally-guided missiles assuredly would be hard-pressed to make sharp, high-speed turns in such close quarters.[5]

Cover and Concealment. Military personnel, command posts, weapon systems, and installations benefit more from cover, which connotes protection, than from concealment, which merely prevents observation. Camouflage nets and lilac bushes, for example, may frustrate prying eyes, but provide no better shields that buttons on battle jackets. Foxholes and folds in the ground that stop bullets and flying shards afford scant security against chemical warfare agents that seek the lowest levels.

LOGISTICAL AREA ANALYSES

Logisticians get little satisfaction from area analyses that emphasize critical terrain, avenues of approach, obstacles, observation, fields of fire, cover, and concealment. Their interests in supply, maintenance, transportation, construction, and medical care instead demand up-to-date data concerning such diversified subjects as the effects of weather and terrain on needs for specialized food, clothing, and shelter; the availability of stone quarries and lumber yards needed to construct or maintain roads, airfields, seaports, cantonments, depots, and other military installations; bottlenecks along, and throughput capacities of, potential main supply routes; the presence or absence of plentiful water supplies and the location of alternative sources; indigenous sanitation problems and endemic diseases; quantitative and qualitative characteristics of local labor forces. Civil affairs and psychological operations forces similarly require area analyses prepared expressly for their purposes.

EFFECTS ON COURSES OF ACTION

The culmination of each area analysis evaluates and compares geographic influences on friendly and enemy courses of action. Results give the clearest possible views of advantages versus disadvantages before staff officers make recommendations and commanders make decisions. Chapters 18 and 19 present two dissimilar area studies that show effects on U.S. and enemy courses of action in the relatively recent past. Case 1 investigates influences on airborne and amphibious assaults that opened a second front in Western Europe during World War II. Case 2 explores the geographical antecedents of logistical problems that plagued plans to block the Ho Chi Minh Trail in Laos during President Lyndon Johnson's administration. Key findings are instructive, because geographical facts of life will similarly confront future statesmen, who must determine whether armed force is the most appropriate instrument in any given instance, and military commanders at every level, who must decide where, when, how, and in what strength to apply power most effectively given assigned missions.

KEY POINTS

- Data bases normally lay solid foundations for area analyses only if they address cultural and political as well as physical geography.
- Skilled analysts consistently reach sound conclusions only if they apply time-tested techniques to ensure that all relevant considerations receive adequate attention.
- Land, sea, air, and space forces individually prepare area analyses to fulfill specialized needs of combatant and support commands at every echelon.
- Area analysts tailor each assessment to satisfy specific military missions, each of which requires unique interpretations.
- Geographical influences over friendly and enemy courses of action generally are of equal importance.
- Area analyses are perishable, because the military significance of any given plot fluctuates in response to seasonal, cyclical, and random changes as well as missions assignments.

NOTES

1. Forrest C. Pogue, *The Supreme Command* (1954), 53, and Gordon A. Harrison, *Cross Channel Attack*, chapter 8, "The Sixth of June" (1951), 269-335, both in a series entitled *United States Army in World War II, The European Theater of Operations* (Washington, DC: Government Printing Office, 1947-).

2. John M. Collins, *U.S.-Soviet Military Balance, 1960-1980* (Washington, DC: McGraw-Hill Publications, 1980), 130-133.

3. Trevor N. Dupuy, *A Genius for War: The German Army and General Staff, 1807-1945* (Englewood Cliffs, NJ: Prentice-Hall, 1977), 130-147.

4. Patrick O'Sullivan, "The Geography of Wars in the Third World," 40, and William H. Lewis, "War in the Western Sahara," 117-137, in *The Lessons of Recent Wars in the Third World: Approaches and Case Studies*, eds. Robert E. Harkavy and Stephanie G. Neuman (Lexington, MA: D. C. Heath, 1985).

5. Mark Hibbs and Margaret Ryan, "Experts Say U.S. Weapons Can't Destroy DPRK Nuclear Facilities," *Nucleonics Week*, April 7, 1994, 15.

18. OPERATION *NEPTUNE*

The landing beaches were just one x in an algebraic equation that contained half the alphabet. What we wanted was a lodgment area into which we could blast ourselves and from which our main bodies, having suitably concentrated themselves within it, could erupt to develop the campaign eastward.

Lieutenant General Sir Frederick Morgan
Chief of Staff to the Supreme Allied Commander
Overture to Overlord

A SECOND FRONT IN WESTERN EUROPE BECAME AN URGENT PRIORITY OF THE GRAND ALLIANCE EARLY in 1942, by which time the Nazi German juggernaut had overrun western Russia, Ukraine, and was well on its way toward the oil-rich Caucasus.[1] Operation *Overlord*, which took shape over the next 2 years, planned to land in Normandy, battle across France and Belgium, destroy enemy armed forces west of the Rhine, then "clean out the remainder of Germany."[2] This case study concentrates on Operation *Neptune*, the cross-channel assault.[3]

Geographic factors influenced plans and operations from selection of the lodgment area through the D-Day landings to the breakout from consolidated beachheads on July 25, 1944 (D+50). Time, distance, light data, coastal topography, tides, drainage patterns, weather, climate, land use, settlements, and transportation networks all affected courses of action on both sides. Enemy fortifications caused additional Allied concerns.

SELECTION OF THE LODGMENT AREA

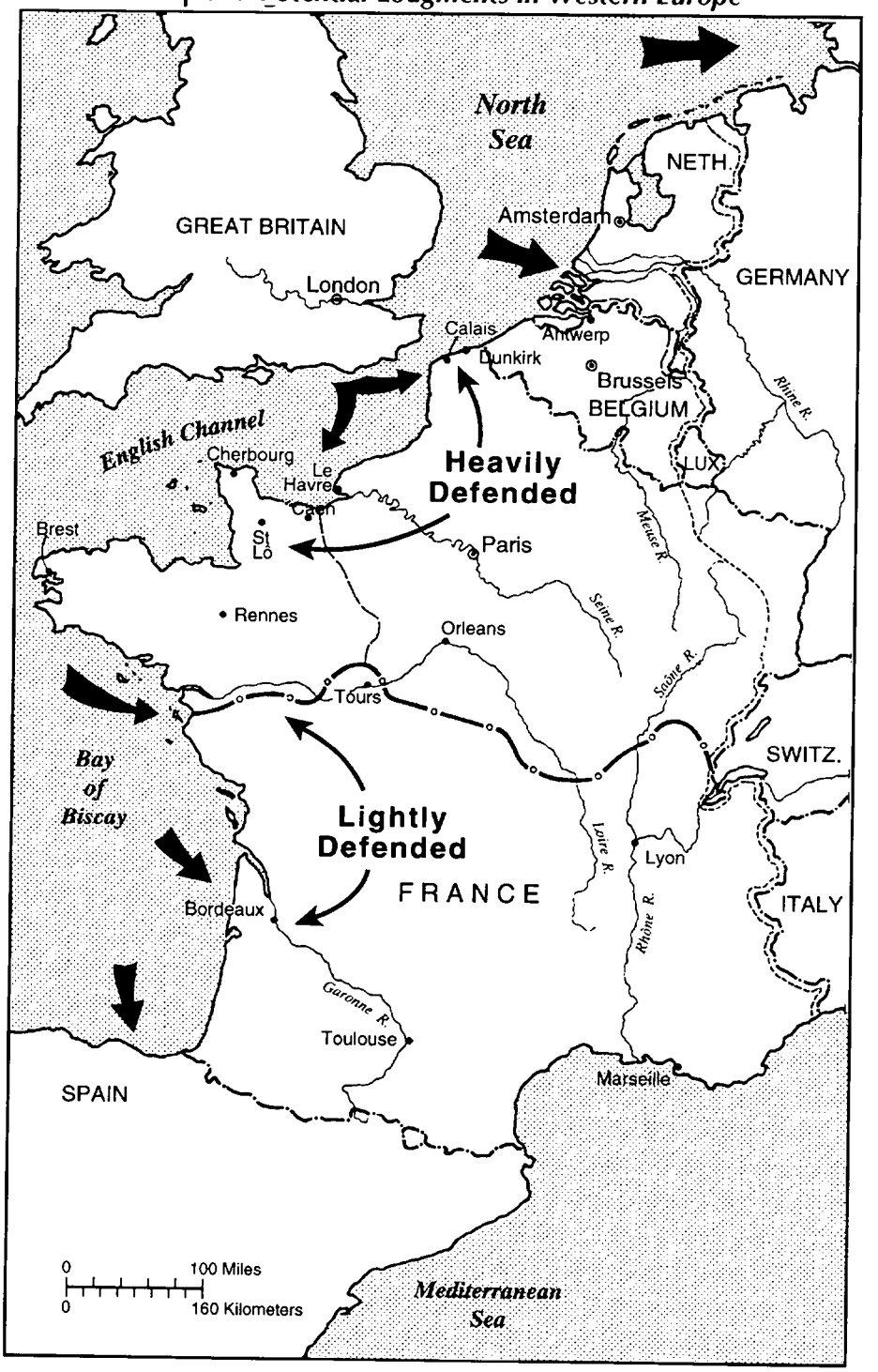
Campaigns in North Africa (September 1940-May 1943) and thereafter in Italy simulated Second Fronts,[4] but neither of those "sideshows" satisfied Stalin who needed massive help of a more direct nature, nor would much-debated Anglo-American operations in the Balkans threaten Hitler's primary sources of military power.[5] The key question therefore became, "Where should Allied armed forces enter Western Europe on their way to the Third Reich?"

WHY NORTHERN FRANCE?

British Lieutenant General Sir Frederick Morgan, as Chief of Staff to the Supreme Allied Commander (COSSAC), began to search for a satisfactory lodgment area well before General Dwight D. Eisenhower arrived on scene (map 57). He quickly discarded Norway because "to debouch therefrom southward in battle array would be quite something." Denmark's narrow Jutland Peninsula was likewise unappealing. Prevailing winds off the North Sea

whipped beaches in Belgium and Holland, which lacked convenient outlets through waterlogged lands that not only were criss-crossed with canals but, being below sea level, were subject to widespread inundation. Portugal and Spain south of the Pyrennes Mountains were far from objectives inside Germany.[6]

Map 57. *Potential Lodgments in Western Europe*



WHY NORTHWESTERN NORMANDY?

The focus on northern France sharpened swiftly. COSSAC's staff believed that beaches at Dunkirk and in Brittany were much too small to support amphibious assaults followed by rapid buildups on envisaged scales. Field Marshal Gerd von Runstedt, who then was German Supreme Commander in the West, later acknowledged that Allied landings near the thinly held Loire valley would have been ideal in most respects—Major General Günter Blumentritt, his Chief of Staff, confided that a company commander on that coast had to cycle all day to inspect his sector—but both breathed easily because they knew that the Loire Valley was well beyond the reach of "short-legged" fighter bombers based in England. Serious considerations, according to COSSAC, thus "whittled themselves down to two: direction Pas de Calais or direction western Normandy."[7]

Calais at first seemed attractive, because the 22-mile (35-kilometer) cross-channel trip was short enough to maximize loiter times for fighter-bombers, minimize shipping requirements, and limit losses due to anticipated enemy U-boat attacks. Straight-line routes to the German border moreover measured barely 150 miles (240 kilometers). Debits, however, outweighed credits. COSSAC wryly noted that defenders who could read maps as well as he had made Calais the pivot point of Atlantic Wall fortifications. Nearby beaches were small, widely spaced, and exposed to storms, seaports along that stretch of coast were hopelessly inadequate even in perfect condition, and actions to seize Antwerp or Le Havre would necessarily parallel German dispositions for the full distance and thus be subject to flank attacks.[8]

The Baie de la Seine between Caen and the Cotentin Peninsula in contrast was much better sheltered than littorals east or west, beach capacities coupled with port facilities at Cherbourg seemed adequate to satisfy initial needs, COSSAC planners found no serious fault with distances from England, and air power could delay German reinforcements by blowing bridges over the Seine and Loire Rivers, which respectively bounded prospective objective areas on the north and south. Northwestern Normandy thus seemed to be the best possible compromise.[9]

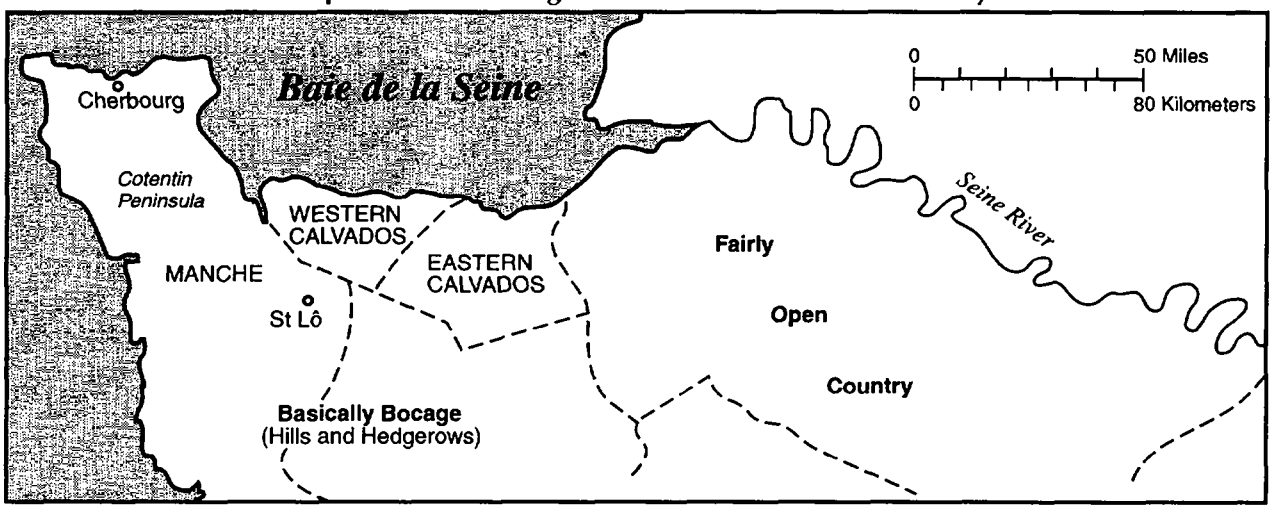
DESCRIPTION OF THE LODGMENT AREA

The lodgment area that COSSAC selected in Normandy occupied the Departments of Manche and Calvados (the equivalent of U.S. counties), both bounded on the north by the Baie de la Seine and on the south by rough, wooded terrain that the locals call "bocage." Geographical data bases in support of Operation *Neptune* addressed relevant factors in four distinctive regions, along with overlapping phenomena.[10]

LAND FORMS AND LAND USE

Land forms and land use on Manche's Cotentin Peninsula, in western Calvados, eastern Calvados, and in the hilly hinterland are dissimilar in many important respects, but cross-compartments are common, wide open spaces are conspicuously absent, and most terrestrial corridors that connect northwestern Normandy with the rest of France parallel the coast. All four regions encourage close combat rather than fluid warfare (map 58).

Map 58. *Natural Regions in Northwestern Normandy*

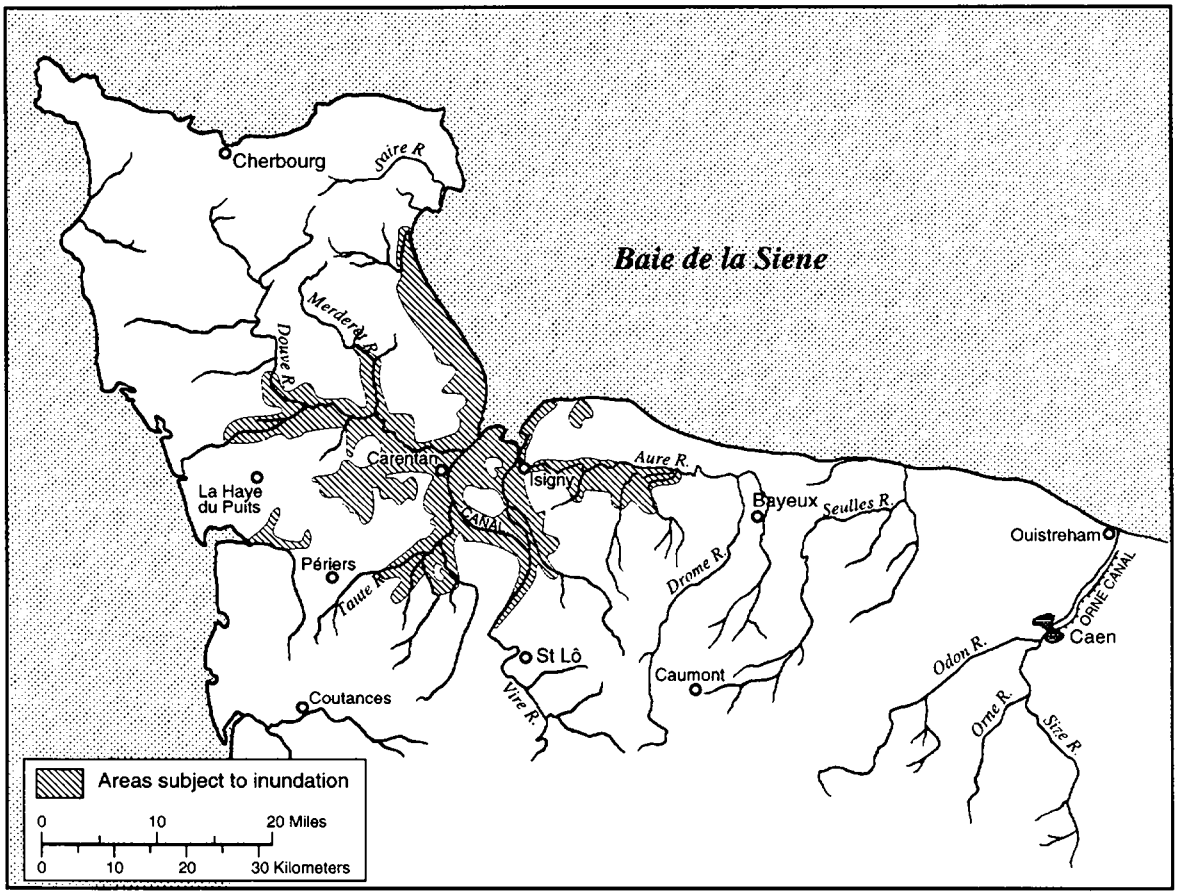


The Cotentin Peninsula. The Cotentin Peninsula, which comprises the northernmost part of Manche, projects into the English Channel like a stubby finger. Topography at the tip, which is devoid of hospitable beaches, features bare granite rocks that stone cutters quarry on the back slopes of a semi-circular escarpment around Cherbourg. Thin, infertile soils are the rule in that rough terrain, which slopes gently toward the south and east where forests give way to orchards, then to checkerboards of thick, high hedges that enclose small fields. Marshy meadowlands and mud flats called *"Prairies Marécageuses"* follow river valleys in the extreme southeast and thrust long fingers into hills farther west (map 59). Dikes, drainage ditches, and locks along inland waterways plus scattered farmsteads are the only manmade structures in that desolate land. A few narrow causeways cross swamps that separate flat beaches from the first firm ground about a half mile inland (somewhat less than one kilometer).

Western and Eastern Calvados. Bluffs incised by shallow draws back discontinuous beaches that nestle between limestone cliffs where western Calvados meets the Cotentin Peninsula. Tablelands beyond the crest gradually rise southward for about 2,000 yards (1,825 meters) until they overlook the lower Aure River, which is more than 60 feet wide and 12 feet deep (18 by 3.6 meters) at Isigny-sur-Mer. Landscapes in Eastern Calvados, which are less formidable, consist primarily of a low, undulating plain that fronts on sandy beaches. Cultivated fields that begin to displace hedgerows beyond Bayeux become increasingly widespread southeast of Caen. The Orne River valley and the canal that connects Caen with its outport at Ouistreham are among the most prominent terrain features.[11]

Basically Bocage. Thick blackthorn hedgerows and stone walls, many of them buttressed by large trees and high earthen embankments that follow no consistent alignment, serve as fences in parts of the Cotentin Peninsula and coastal Calvados, but bocage is most prevalent in hilly country farther south, where some fertile valleys and lower slopes sport 300-400 oddly shaped fields per square mile. Easy access from one enclosure to another normally is available only at corners where two or more join. Heath or oak, beach, chestnut, and hornbeam forests, plus stands of planted pines, cover heights that are unsuitable for orchards or pasture. High-speed corridors that cut clear through the bocage from north to south are widely-spaced.[12]

Map 59. *Drainage Patterns in Northwestern Normandy*

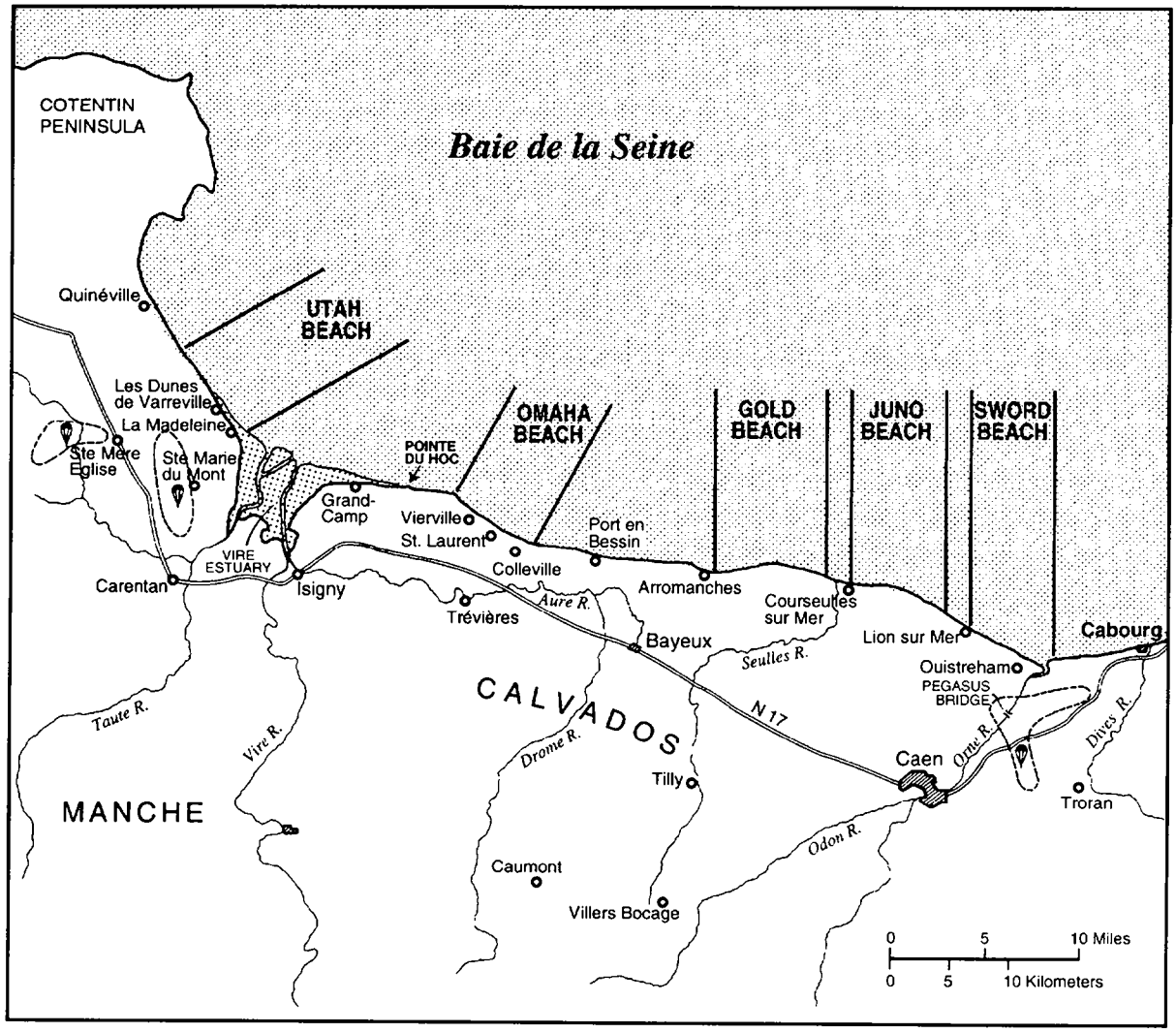


SEACOASTS

Successful amphibious assaults against the seacoasts of northwestern Normandy initially depended on intimate knowledge of treacherous currents and tides in the English Channel as well as geographic information about the Baie de la Seine, a comparatively shallow, trough-like depression. Intelligence collectors therefore turned attention to water depths, the location of reefs, rocky ledges, other obstructions, beach gradients, shoreline characteristics, and avenues inland. Operation *Neptune* planners soon narrowed the search to a stretch between Quineville on the southeastern Cotentin coast and the mouth of the Orne River in eastern Calvados (map 60).[13]

Utah Beach. The most favorable Cotentin site, destined to become Utah Beach, centered on Les Dunes de Varville just north of the Vire Estuary where 4 miles of level, firm sand 700 yards wide (640 meters) terminate against low dunes and a masonry sea wall. Gradients above low water average 1:130 for the first 500 yards, then steepen somewhat, but approaches are clear, surf normally is negligible, landings are feasible at any stage of the tide, and a sheltered anchorage for transport ships lies 2.5 miles (3.6 kilometers) offshore. Motor vehicle exits unfortunately are confined to a few tracks that lead through marshy meadows to a coastal road. The best of them in June 1944 was an unsurfaced causeway, scarcely 12 feet wide (4 meters) and barely above the muck during dry weather.

Map 60. *Utah, Omaha, Gold, Juno, and Sword Beaches*



Omaha Beach. The outlook in western Calvados was less attractive. Swamps and rocky outcroppings offshore, succeeded by sheer walls that sometimes exceed 100 feet (30 meters), characterize the coast for more than three miles east of the Vire River until a crescent-shaped strand appears beneath steep bluffs below Vierville-sur-Mer and Colleville-sur-Mer. That site, which *Neptune's* planners designated Omaha Beach, occupies the next 7,000 yards or so before palisades reemerge.

Waters off Omaha Beach, unlike those at Utah, not only experience tricky rip tides, eddies, and moderately strong offshore currents, but are open to northerly and easterly winds. Vehicles and waders find traction uncertain in the shallows, even though low tides expose about 300 yards of gently sloping (1:188), well-compacted sand, because submerged bars and runnels run at right angles to the beach. Gradients increase sharply to 1:47 during the final 250 yards below high water, then to 1:8 before tidal flats terminate in a low, wave-cut embankment that large, loose shingle stones and a solidly-constructed wall supplement in some places. A level, marshy shelf thereafter connects beaches to bluffs that before D-Day

were broken by five wooded draws just wide enough to accommodate one narrow road, cart track, or trail apiece. No other exits were available for vehicular traffic.

Gold, Juno, and Sword Beaches. More than 15 miles (24 kilometers) of chalky cliffs and rocky flats separated U.S. Omaha Beach from British Gold Beach, which is narrowest near Arromanches-les-Bains and widens toward the east. Low tide uncovers 800 yards of solid sand and the so-called "Plateau de Calvados" reaches seaward another three-quarters of a mile (1 kilometer) at depths no greater than 2 or 3 feet, after which the bottom drops off rapidly enough to allow good anchorages. Gold Beach above the high water mark is almost level, but a massive stone sea wall bridged only by two ramps inhibits vehicular access to heavily traveled roads that link Courseulles with Bayeux and Caen.

Nearly contiguous Juno Beach, reserved for Canadian troops during Operation *Neptune*, straddles rocky approaches that mar tidal flats for almost a mile (1.7 kilometers). Juno ashore is similar to Gold, except for a line of low, unconsolidated dunes along the waterfront. Seaside resorts, which are almost absent behind Utah and Omaha Beaches, dot the coast all the way from Arromanches past the mouth of the Orne River. Ramps and stairways on Juno Beach help personnel and motor vehicles cross a promenade that otherwise comprises a formidable barrier, village streets thereafter accommodate two-way traffic, and two macadamized roads lead to Caen.

British amphibious forces that landed at Lion-sur-Mer on the westernmost part of Sword Beach found about half a mile of solid sand between high and low water, whereas flats on the eastern flank at Ouistreham are well over twice that wide and gradual gradients approximate 1:300. Views from the water see soft sand and loose dunes ashore, plus a formidable wall with few ramps or stairs, but the going is easier on hard-surfaced roads beyond those barriers.

WEATHER AND CLIMATE

Northwestern Normandy, adjacent to the English Channel, enjoys moderating climatic influences in every season (the Cotentin Peninsula is almost insular). Mild winters, cool summers, humid conditions, and brisk breezes predominate (table 26).[14]

The Department of Manche is the rainiest in all of northern France, with Calvados a bit farther east and Brittany a bit farther west as close contenders. Maximum precipitation, mainly in the form of drizzle or showers, falls most frequently in October, although some weather stations along the littoral show a secondary peak in June or July and downpours occasionally deliver more than two inches (60 millimeters) in a single day. Persistent rains adversely effect the trafficability of poorly-drained soils like those behind Utah Beach and along lower reaches of the Taute, Vire, Aure, Seulles, and Orne Rivers where water tables habitually are close to the surface.

Fog and low clouds are most evident in winter, but poor visibility coupled with ceilings below 2,000 feet (610 meters) often limit air operations during early morning hours in summertime. May, June, and July offer the best chances for 5 or more consecutive days of fine flying weather. The phenomenon of very long days and very short nights at 50 degrees North Latitude during those months not only maximized daylight available to Allied aviators, but allowed German ground forces minimum time to move troops and supplies under cover of darkness.

Table 26. *Selected Climatic Statistics for Manche and Calvados*

AVERAGE MONTHLY PRECIPITATION

	Cherbourg		*St Lô*		*Caen*	
	Inches	*Millimeters*	*Inches*	*Millimeters*	*Inches*	*Millimeters*
May	2.0	51	2.9	72	2.2	56
June	1.8	45	2.3	57	2.0	49
July	1.8	46	2.5	62	2.3	58
August	3.0	75	2.3	58	2.5	62

AVERAGE NUMBER OF RAINY DAYS

	Cherbourg	*St. Lô*	*Caen*
May	16	9	11
June	11	11	9
July	15	11	11
August	16	8	14

AVERAGE MEAN MONTHLY TEMPERATURES

	Cherbourg		*St. Lô*		*Caen*	
	°F	°C	°F	°C	°F	°C
May	52	11.1	52	12.1	55	12.5
June	57	14.1	59	15.0	61	16.1
July	62	16.4	64	17.1	62	17.4
August	62	16.5	62	16.9	62	17.4

AVERAGE CLOUD COVER AT CHERBOURG

Percentage	May	June	July	August
<3/10	16	21	19	16
>8/10	59	53	53	57

SETTLEMENT PATTERNS

Rural residents of northwestern Normandy were widely dispersed among hundreds of hamlets and isolated farmsteads, although territories within 5 to 15 miles of the coast (8 to 24 kilometers) generally were "off limits" to all but professional fishermen in 1944. The last pre-war census statistics for cities, towns, and villages, compiled in 1936, indicate that regional centers such as Cherbourg, St. Lô, and Caen were relatively small (table 27), but even those figures were inflated, because German occupation forces moved about 100,000 French civilians inland well before D-Day.[15]

Table 27. *Populated Places in Manche and Calvados*
(1936 census)

	Urban	*Rural*	*Total*	*Density (per square mile)*
Manche	114,380	324,160	438,540	177.1
Calvados	149,540	255,360	404,900	184.2

Arromanches-les-Bains	260
Bayeux	7,245
Caen	61,335
Carentan	3,875
Cherbourg	39,140
Colleville-sur-Mer	240
Courseulles-sur-Mer	1,190
Isigny-sur-Mer	2,835
Lion-sur-Mer	1,050
Quineville	335
St. Laurent-sur-Mer	215
St. Lô	11,815
Ste. Marie-du-Mont	920
Ste. Mère Église	1,175
Tilly-sur-Seulles	685
Trévières	820
Vierville-sur-Mer	335
Villiers Bocage	1,095

ROAD NETS

Roads within *Neptune's* lodgment area never were designed for sustained heavy traffic. Even the arterial Cherbourg-to-Paris highway carried more tourist trade than commerce, while most other routes served strictly local needs. The lattice in Manche and Western Calvados lacked first-rate north-south roads. The *Prairies Marécageuses* moreover restricted vehicular traffic near the base of the narrow Cotentin Peninsula to a pair of vulnerable avenues on relatively high ground, both of which, like routes from Omaha Beach inland, thereafter threaded through an untold number of defiles and bridged many streams. Attractive exits to the south and east consequently emanated mainly from Caen on *Neptune's* left flank.[16]

ASSESSMENTS OF THE LODGMENT AREA

First COSSAC, then General Eisenhower and subordinates in every U.S., British, and Canadian armed service at every level, assessed mountains of information concerning the lodgment area to ascertain the influence of geographic factors on plans and programs for Operation *Neptune*. Appraisals below emphasize "big pictures."[17]

CORE AREAS

Three urban centers within the lodgment area constituted core areas of great political, economic, and military significance:[16]

- Cherbourg, the second largest city in the lodgment area, clearly was indispensable. Its main harbor was the premiere transatlantic passenger terminal in France during the 1930s, the inner roadstead could accept transoceanic cargo ships except when neap tides lowered water levels, the *Gare Maritime* could discharge cargoes directly into trucks, and no other port between Rotterdam and Bordeaux possessed greater capacities, according to pre-invasion studies.
- Caen, the capital of Calvados and the principal transportation node in northwestern Normandy, radiated major roads and railways. Control over that city first could block enemy reinforcements and supplies headed west, then facilitate breakouts from Gold, Juno, and Sword Beaches toward relatively open ground south and east.
- St. Lô, the capital of Manche, was another transportation hub from which routes reached in all directions. Allied ground forces on the Cotentin Peninsula and in western Calvados could not strike far south through bocage country without ousting adversaries from that pivot point.

KEY TERRAIN

Key terrain viewed by Allied strategists and tacticians stretched from just beyond the water's edge to targets deep in enemy territory:

- Beach exits were high on all planners' lists because, as COSSAC put it, "If an invasion battle takes place on the beach, one is already defeated. There must be as little delay as possible in getting the troops and their multifarious goods inland."[18]
- The dam and lock at la Barquette just north of Carentan, which regulated water depths along the lower Douve, Merderet, Taute, and Vire Rivers, were early D-Day objectives, because overflows would create a lagoon from Carentan to Quineville, impede progress inland from Utah Beach, and complicate efforts to consolidate Utah with Omaha.
- Bridges over the unfordable Orne River and Orne Canal, which followed parallel paths between Caen and Ostreham, likewise were worthy D-Day objectives because early capture could help secure the lodgment's east flank until assault troops and follow-on forces were firmly ashore.
- *Neptune's* planners never lost interest in enemy coastal fortifications or the artillery atop cliffs at Pointe du Hoc, which reportedly could bring withering fire to bear on Utah as well as Omaha Beach.
- Allied air forces in spring 1944 intensified strikes against road and railway bridges over the lower Seine and Loire Rivers to isolate the battlefield well before combat began on the beaches.[19]

AVENUES OF APPROACH

COSSAC and his staff concluded, and General Eisenhower later concurred, "It was out of the question to make the whole assault north of the Vire estuary." The beaches were inadequate, exits inland crossed an easily flooded morass, and enemy armed forces might seal off the Cotentin Peninsula at its base and thereby bottle up the entire Allied expedition indefinitely.

Divisions put ashore exclusively along the Calvados coast conversely would be hard pressed to seize essential port facilities at Cherbourg in anything like acceptable time. Beaches on both sides of the Vire therefore were required to establish a strong presence ashore and build strength rapidly.[20]

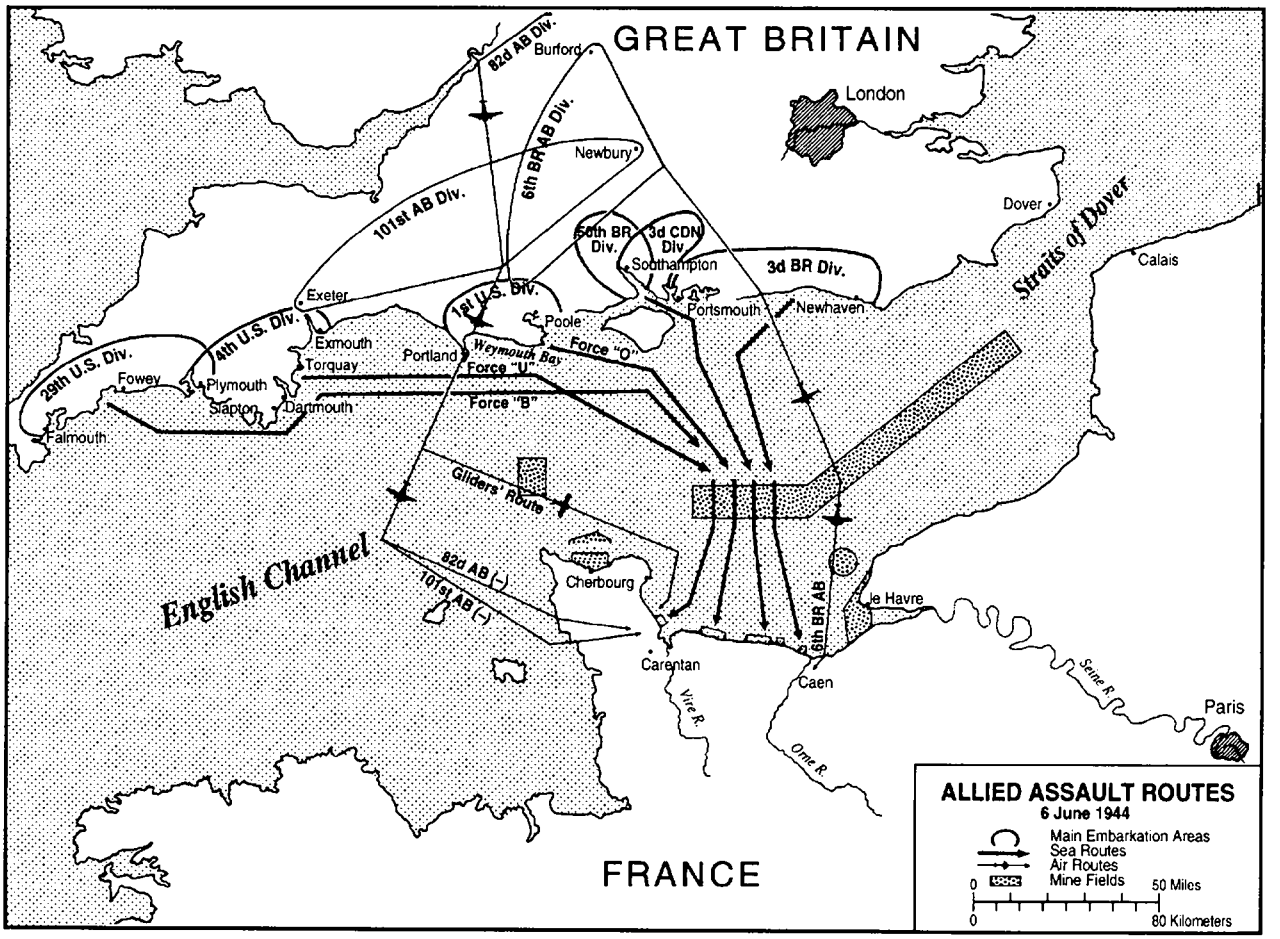
Allied armed forces followed cross-channel avenues from marshaling areas in England to drop zones, glider landing zones, and beaches in Normandy. Amphibious assault and successive waves took a second set of approaches from ships to shore, whereafter all fanned out along land lines that led through, then out of, *Neptune's* initial lodgments.

Cross-Channel Avenues. Men and equipment destined to implement Operation *Neptune* reported to sausage-shaped staging areas from Cornwall to East Sussex beginning the second week in May 1944, where they were quarantined pending cross-channel trips that look deceptively simple as plotted on map 61, but in fact were incredibly complex. U.S. and Royal Navy planners would have faced formidable problems if *one* naval task force had been sufficient, but in fact there were *five* filled with military ships and craft of every description, all scheduled to arrive at designated spots in the Baie de la Seine at about the same time. Plans called for all five to rendezvous near the Isle of Wight, which minimized air cover and minesweeping requirements, then begin the run south through treacherous waters where flood tides athwart the north-south course from England to France flow from west to east while ebb tides reverse direction. Each avenue at the half way point divided into fast and slow lanes so lumbering amphibious ships could steer clear of battleships, cruisers, other surface combatants, and troop transports.

Task Force U, which numbered 865 convoy escorts,[21] fire-support ships, troop carriers, landing ships tank (LSTs), smaller craft, and auxiliaries, loaded 12 separate convoys at nine widely separated locations. Minesweepers cleared lanes through Cardonnet Bank, after which flotillas set sail for the transport area 22,500 yards (20,575 meters) off Utah Beach, where ship captains dropped anchor shortly before 0300 on D-Day. Task Forces O and B en route to Omaha Beach followed similar procedures, as did British and Canadian contingents on their way to Gold, Juno, and Sword. Airborne divisions dog-legged from distant departure airfields.[21]

Ship-to-Shore Approaches. Low tide landings would have simplified tasks for underwater demolition specialists whose job was to blow gaps between obstacles that were concealed only at high tide, but heavily-laden assault forces wading through shallow water for half a mile or more would have taken terrible casualties long before they reached shore. *Neptune's* planners therefore scheduled landings to start three hours before rising tides reached their peak, so amphibious craft that beached early could later float off (a one-foot tidal rise, for example, inundates nearly 200 feet of flat sand off Omaha Beach, where gradients generally average 1:188). Ideal conditions, however, were not simultaneously obtainable at all five beaches, because high water reaches Cotentin coasts about 40 minutes earlier than it does in Eastern Calvados and the sites selected were neither equally level nor equally obstructed. H-Hour on D-Day consequently occurred at 0630 on Utah Beach, 15 minutes later at Omaha Beach, and 0745 on Gold.

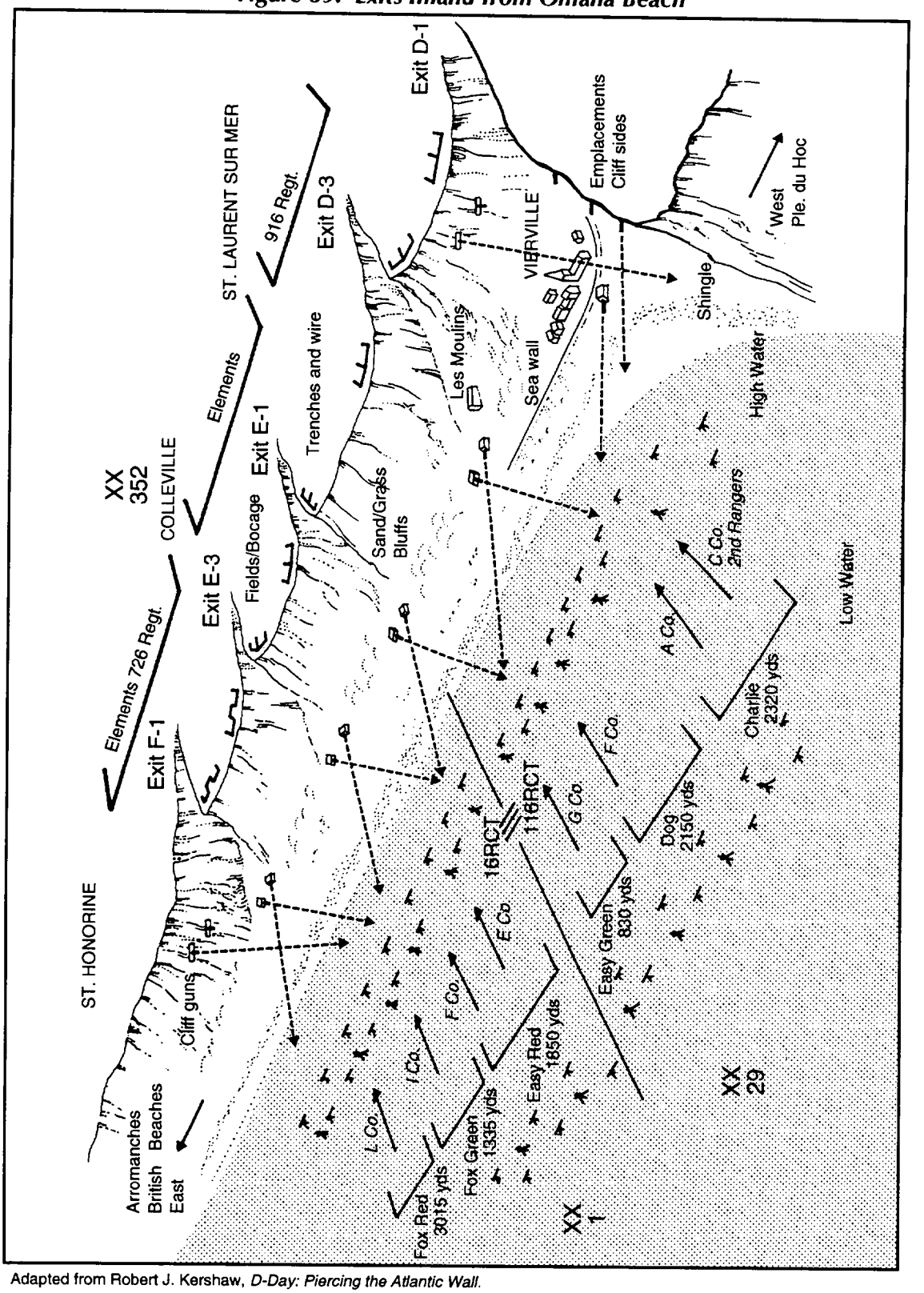
Map 61. ***Cross-channel Routes from England to Normandy***



Causeways over marshlands between Utah Beach and the nearest coastal road were crucially important, but five draws that climbed the bluffs behind Omaha Beach were more so, because that steep terrain otherwise blocked tracked as well as wheeled vehicles (figure 39). A rough trail at Exit F-1 on the left flank scrambled up a narrow valley where slopes exceeded 10 percent; an eight-foot-wide cart track at neighboring E-3 led to Colleville, 2,000 yards inland; Exit E-1, which tilted 100 feet in 500 yards, and the D-3 Exit at les Moulins both headed for St.Laurent-sur-Mer as soon as they cleared the crest. Grades were less demanding at Exit D-3 on the right flank and the road was graveled past Vierville until it met macadam. Assault troops that reached the top were much better off than on the beach, because German defenses-in-depth were nearly nonexistent.

Land Avenues Inland. Avenues inland from *Neptune's* drop zones and beaches were geographically inviting only to the east and southeast, because the Aure River valley and bocage-covered hills separated landing sites in coastal Calvados from tank country due south. Narrow necks of dry ground that form the watershed between the Vire and Taute Rivers channelized movement from the Cotentin Peninsula and Carentan toward St. Lô, severely limited maneuverability in lower Manche even for foot soldiers, and confined vehicular traffic to roads. Pre-invasion phase lines that anticipated fairly rapid headway despite adverse

Figure 39. *Exits Inland from Omaha Beach*



Adapted from Robert J. Kershaw, *D-Day: Piercing the Atlantic Wall.*

terrain accordingly proved optimistic, whereas progress after Allied forces broke into the open was faster than predicted.[23]

OBSTACLES

Natural and manmade obstacles astride the avenues just described blocked all beaches to some degree and impeded progress inland, then helped German defenders pen Allied armed forces inside the lodgment area from June 6, 1944, until late July. Formations able to bypass one set of obstructions often ran head-on into others as bad or worse.

Beach Fortifications. The objective of German Field Marshal Erwin Rommel obviously was to stop invaders before they reached the water's edge, then annihilate them with interlocking, overlapping cones of fire,[24] but beach defenses on D-Day varied considerably because preparations were incomplete. Only two artillery positions along Juno Beach, for example, were under concrete, while the rest occupied roofless bunkers or bare earthen pits.[25] The aggregate nonetheless could best be described as awesome.

Defensive bands studded tidal flats with twisted steel girders called "hedgehogs," pilings driven deeply into firm sand at angles calculated to gut incoming landing craft, other diabolical devices, and millions of water-proofed mines. Tetrahedral antitank barriers, caltrops, ditches, concrete blocks, more mines, and concertina wire littered beach shelves and coastal dunes, while immobile roadblocks and "Belgian Gates" mounted on rollers guarded every exit. Fortified beach-front villas, promenades, and sea walls were especially prominent in eastern Calvados—the highest bastion, at Arromanches-les-Bains, measured 15 vertical feet (almost 5 meters). Automatic weapons and artillery housed in cleverly-concealed, well-camouflaged concrete pillboxes and casements were well-sited to cover Allied approaches from maximum to point-blank ranges.[25]

Obstacles Inland. Fears about floods along the lower Aure Valley and behind Utah Beach were well founded. Amphibious forces slogged their way inland without excessive difficulty, but many heavily loaded paratroopers drowned when 12 air transports overshot designated drop zones and dumped them in swamps astride the Merderet River. Defenders who sought to discourage parachute assaults and glider landings also seeded the few open spaces with several hundred thousand sturdy stakes known as "Rommel's asparagus," mined the tops, and interlaced the lot with tripwires.[27]

Sturdily constructed villages and farmsteads, often ringed with stone walls, became impromptu German strongpoints across Manche and Calvados, especially those located on dominant ground or at bitterly contested road junctions. Fort du Roule atop a steep granite promentory above Cherbourg fell on June 25th after fierce fighting, but some hardened sites nearby held out for another week.[28]

"The Normandy Campaign" above all became almost synonymous with "The Battle of the Hedgerows" in summer 1944. Fields of fire for flat trajectory weapons were exceedingly short in the bocage, where poor observation severely limited the effectiveness of mortars, artillery, and close air support. Land combat consequently was risky business. Front-line infantrymen in broad daylight often lost contact with friends a few yards away and could hear but seldom saw enemies except for bodies left behind during hasty withdrawals. Allied tanks went belly up against shoulder-high embankments topped by vegetative ramparts several feet thick until innovative Master Sergeant Curtis E. Culin converted German hedgehogs and

tetrahedons into hedgerow cutters that let tanks plow through without losing speed appreciably.[29]

EFFECTS ON ALLIED COURSES OF ACTION

Four additional geographic effects on Allied courses of action merit brief explanations, because they determined the day and hour that Operation *Neptune* commenced and strongly influenced staying power. Coastal hydrography and weather conditions were primarily important.

H-HOUR DETERMINATION

Light data and tides determined H-Hour, the time the first wave of landing craft was scheduled to drop ramps and discharge assault troops ashore. Darkness was undesirable, because control would be difficult in the absence of night vision devices which had not yet been invented. *Neptune* planners, who preferred a time soon after dawn, picked the Beginning of Morning Nautical Twilight (BMNT) plus 40 minutes, which they deemed ample time for Allied aircraft and fire-support ships with aerial spotters to "soften" targets ashore before battles began on the beaches, while enemy observers still in relative darkness on the ground would lack clear lines-of-sight seaward. Unloadings moreover had to commence not earlier than 3 hours before high tide and terminate not later than three hours thereafter or assault troops would be stranded far from shore. Similar tidal conditions in late afternoon allowed follow-on echelons to land before dark.

Airborne assaults behind Utah Beach and near Caen were timed for 0200 on D-Day, well before H-Hour, to take full advantage of a late-rising moon that would allow transport pilots to approach in darkness but easily discern drop and landing zones (bad weather made that impossible). Captain Frank L. Lillyman, whose 101st Airborne Division pathfinder team leaped at 0015 local time (12:15 A.M.), was first to set foot on French soil.[30]

D-DAY DETERMINATION

Ideal conditions for amphibious operations in northwestern Normandy combined spring tides with a full moon, a coincidence that normally occurs three days each month. June 5, 1944, the first day that satisfied those specifications during the most favorable month, thus became top choice. Prognoses, however, were poor when the final conference to approve or reject that date convened at 0400 on June 4th, because the worst June storm in 20 years had begun to punish the English Channel with low clouds, high winds, and white-capped water. Air support would be impossible, naval gunfire ineffective, and small boats subject to capsize, according to authorities at the table. General Eisenhower reluctantly ordered a 24-hour weather delay, even though so doing disrupted time-sensitive schedules. Convoys already at sea turned back to refuel while ships fully loaded with seasick soldiers fretted in port. Meteorologists the following day fortunately foresaw a small "hole" in the weather though which *Neptune's* naval task forces might pass before a second storm stuck. Further postponement would create monumental logistical muddles, troop morale would plummet, and secrecy would be hard to ensure. The Supreme Allied Commander mulled a moment, then said, "I don't like it, but we'll go." Signals flashed to the fleets and forces on shore: PROCEED WITH OPERATION *NEPTUNE*.[31]

PORT PREFABRICATION

Neptune's planners from the onset knew that Cherbourg port never could satisfy all early needs even with assistance from logistical operations over open beaches.[32] They therefore issued prescriptions for two artificial harbors code-named Mulberry A and Mulberry B, each with throughput capacities about equal to that of Dover. Preliminary construction, which began in 1943 at scattered locations in Britain, produced 10 miles of piers, 23 pierheads, 93 floating breakwaters called "Bombardons," and more than 100 gigantic concrete caissons that looked like six-story buildings lying on their sides. A motley fleet of seagoing tugboats towed that cantankerous armada to Normandy beginning just before D-Day, accompanied by 80-some aging blockships loaded with sand ballast and enough high explosives to tear their bottoms out when properly positioned off Omaha and Gold Beaches (see expedient port operations in chapter 11 for additional details).

Performance exceeded expectations until D+13, June 19, 1944, which dawned cold and gray with gale force winds by mid-afternoon. Meteorologists even so predicted good weather and anxious beachmasters found further reassurance in their "Bible," the *Channel Pilot,* because the column that counted the average number of stormy June days in the Baie de la Seine contained a great round "O". Long- and short-range forecasts unfortunately were both wrong. Wild winds and surf pounded Mulberry A so severely that little was left except salvage parts with which to rebuild Mulberry B at Arromanches-les-Bains. Good news nonetheless was mixed with bad: Allied forces in midchannel would have been unable to reinforce or resupply assault forces ashore if General Eisenhower had postponed D-Day from the original June 5th to June 19th, the earliest acceptable alternative date.[33]

AIRFIELD CONSTRUCTION

The first emergency landing strip in Normandy appeared at Pouppeville near the southern edge of Utah Beach on D-Day, followed by second one at St. Laurent-sur-Mer on D+2, but Allied fighter-bombers based in Britain urgently required forward facilities that allowed faster turn-around times and used less fuel. Responsive engineers in the U.S. sector hastily constructed 20 fully serviceable expeditionary airfields suitable for daylight operations (seven of them by D+20), despite enemy action and geographic conditions that confined all installations to islands of solid ground where bocage was least obtrusive (map 62 and table 28). Runways, taxistrips, and "hardstands" were surfaced with huge rolls of tar paper or "chicken wire" mesh firmly pegged down after bulldozers and scrapers cleared proper spots.

Those primitive airfields were designed to last 2 or 3 months under "normal" conditions, which did not pertain because deep ruts appeared as soon as the wheels of bomb-laden aircraft crushed pliable tar paper into soggy earth and billowing clouds of powdery dust trailed pilots down wire mesh runways on dry days. Air base engineer battalions struggled manfully around the clock, but many strips were fast becoming unserviceable by early August and were abandoned as soon as more favorable sites became available outside *Neptune's* lodgment area.

Map 62. *U.S. Expeditionary Airfields in Manche and Calvados*

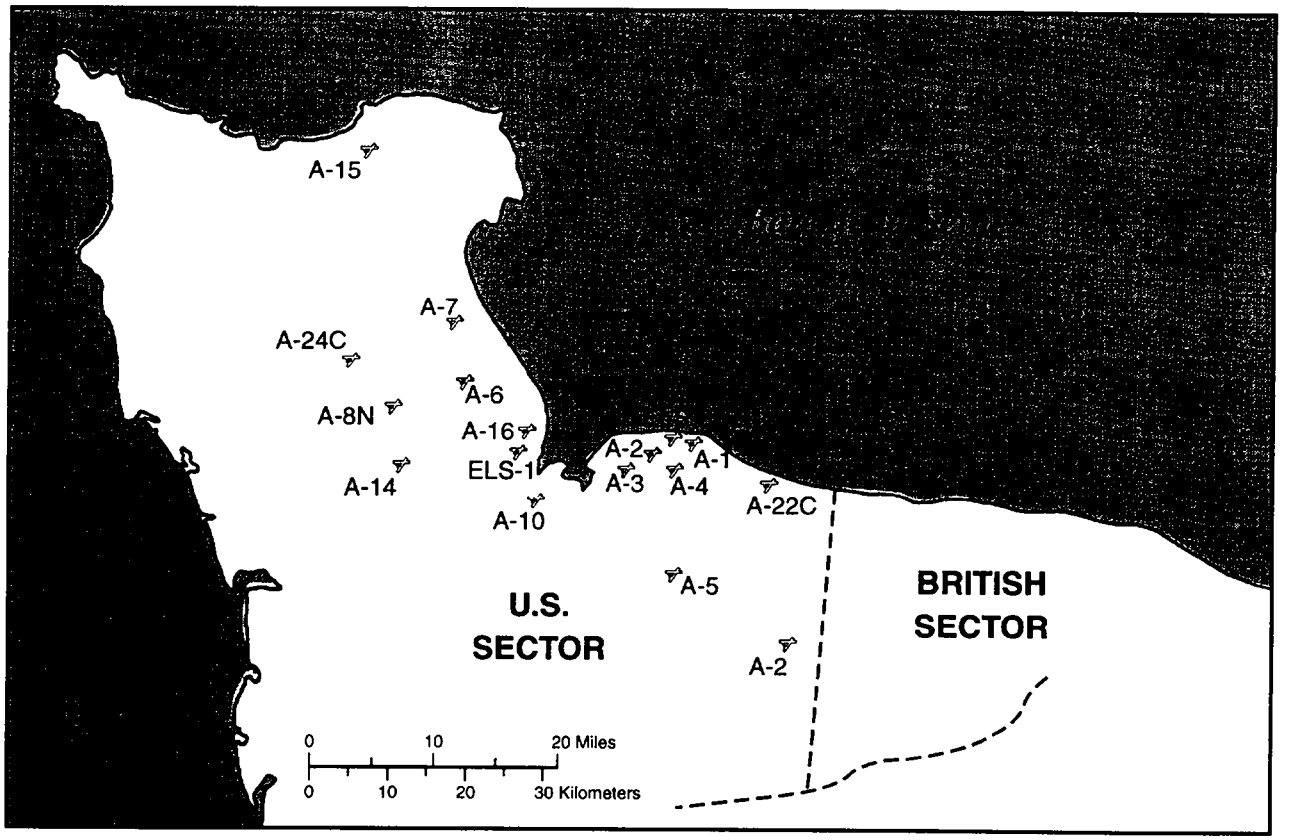


Table 28. *U.S. Expeditionary Airfields in Manche and Calvados*

Airfield	*Location*	*Operational Date*
Emergency Landing Strip (ELS-1)	Pouppeville (Utah Beach)	D-Day
Emergency Landing Strip (ELS-2)	St. Laurent (Omaha Beach)	D+2
A-1	Cardonville	D+8
A-3	St. Pierre-du-Mont	D+8
A-6	Beuzeville	D+9
A-2	Cricqueville	D+11
A-7	Azeville	D+16
A-10	Carentan	D+19
A-4	Deux Jumeaux	D+20
A15	Cherbourg-Maupertus	D+28
A-9D	le Molay	D+29
A-5	Chipelle	D+33
A-8	Picauville	D+35
A-22C	Colleville-sur-Mer	D+37
A-14	Cretteville	D+42
A-24C	Biniville	D+44
A-12	Lignerolles	D+45
A-13	Tour-en-Bessin	D+52
A-23C	Querqueville	D+53
A-20	Lessay	D+58
A-26	Gorges	D+58
A-16	Brugheville	D+60

WRAP-UP

Geographical information concerning northwestern Normandy was incomplete and often inaccurate on D-Day, even though that region had been prominent in European history for more than 1,000 years. Obsolete charts of coastal waters, misleading climatic mean statistics, and belated appreciation of the bocage are just a few among many problems that plagued U.S., British, and Canadian forces during the June 1944 landings and buildup.

Operation *Neptune* nonetheless was an astounding success. Allied assault forces "entered the continent of Europe" despite perverse weather and terrain, consolidated footholds, and linked all five beachheads during the first week. Allied expeditionary forces by July 2nd had deposited ashore 1,000,000 men, 24 divisions (13 U.S.,11 British, 1 Canadian), 566,000 tons of supplies, and 171,000 vehicles at a cost of 60,770 casualties, of whom 8,975 were killed.[34] The sacrifices of those valiants initiated the long-awaited Second Front and, in accordance with General Eisenhower's orders, began "operations aimed at the heart of Germany and the destruction of her Armed Forces."

KEY POINTS

- Geographical constraints make amphibious and airborne forcible entries among the most complex of all military operations.
- The presence, capacities, and locations of staging bases strongly affect avenues of approach to selected lodgment areas.
- The presence or absence of suitable ports and airfields in lodgment areas strongly affects military missions and the assignment of objectives.
- Far-sighted planners anticipate and prepare for disruptions caused by adverse weather conditions, which strongly affect assault and support forces en route to lodgment areas.
- Tides and light data determine the most favorable dates and times for amphibious assaults.
- Topographical features that narrow the number of suitable drop zones, landing zones, and amphibious landing sites generally favor defenders who can concentrate power at probable points of decision.
- Commanders who prepare alternative breakout plans that take advantage of assorted avenues are best prepared to exploit unexpected opportunities.

NOTES

1. Don A. Harrison, "Cross-Channel Attack," *United States Army in World War II, European Theater of Operations* (Washington, DC: Government Printing Office), 73-74, 423-426; Douglas Botting, *The Second Front* (New York: Time-Life Books,1978), 4; John Keegan, *Six Armies in Normandy* (New York: Viking Press, 1982), chapter 1.

2. Dwight D. Eisenhower, *Crusade in Europe* (Garden City, New York: Doubleday, 1948), 228-229.

3. For many pertinent maps and diagrams, see John Man, *Facts on File D-Day Atlas* (New York: Facts on File, 1994). Refer also to Colin F. Baxter, *The Normandy Campaign, 1944: A Selected Bibliography* (New York: Greenwood Press, 1992).

4. Richard Collier, *The War in the Desert* (New York: Time-Life Books, 1977), and Robert Wallace, *The Italian Campaign* (New York: Time-Life Books, 1978).

5. Richard M. Leighton, "Overlord Versus the Mediterranean at the Cairo-Tehran Conferences," in *Command Decisions*, ed. Kent Roberts Greenfield (Washington, DC: Government Printing Office,1960), 255-285.

6. Sir Frederick Morgan, *Overture to Overlord* (Garden City, New York: Doubleday, 1950), 132-133; *Report on Operation Overlord, 15 July 1943-26 March 1944*, Chief of Staff to the Supreme Allied Commander (COSSAC).

7. Ibid.; Basil H. Liddell Hart, *The German Generals Talk* (New York: William Morrow, 1948), 228, 238.

8. Morgan, *Overture to Overlord*, 134, 141,142; *Report on Operation Overlord* (COSSAC).

9. Ibid., 139-141, 142.

10. Descriptions of the lodgment area, unless otherwise cited, were drawn from John Collins, *Military Geography of the Normandy Campaign* (Master's thesis, Clark University, Worcester, MA, 1951). Sources included many Secret and Top Secret documents declassified after World War II.

11. Jean Gottman, *A Geography of Europe*, 4th ed. (New York: Holt, Rinehart and Winston, 1969), 329-331.

12. *St. Lô*, American Forces in Action Series (Washington, DC: Government Printing Office, August 21, 1946), 2-4, 6.

13. *Normandy West of the Seine*, Interservice Information Series, Report on France, CB 4096j (15), vol. 2, part 5 (A), Coasts, Beaches, and Exits, January 1943, 18-22, 30-33; *Utah Beach to Cherbourg*, American Forces in Action Series (Washington, DC: Government Printing Office, October 1, 1947), 3-4; *Omaha Beachhead*, American Forces in Action Series (Washington, DC: Government Printing Office, September 20, 1945), 10-16.

14. *Meteorological and Oceanographic Conditions for June 1944 in the Neptune Area, Detachment "M,"* 21st Weather Squadron, Ninth Air Force, May 3, 1944; *Weather & Climate As Related to Military Operations in France*, Report 644, Weather Division, Army Air Forces, April 1944.

15. *First U.S. Army Report of Operations, 20 October 1943-1 August 1944*, annex 1, 111-115, annex 2, 204-206.

16. Ibid., annex 1, 101-105; annex 12, 18; *Normandy West of the Seine*, vol. 2, part 3 (B), Roads, May 1943.

17. For assessments of the lodgment area, see note 10.

18. Morgan, *Overture to Overlord*, 140.

19. Humphrey Wynn, *Prelude to Overlord: An Account of the Air Operations Which Preceded and Supported . . . the Allied Landings in Normandy* (Novato, CA: Presidio Press, 1984).

20. Viscount Montgomery of Alamein, *Normandy to the Baltic* (Boston, MA: Houghton Mifflin, 1948), 20-50; Morgan, *Prelude to Overlord*, vi-vii, 143-150; Eisenhower, *Crusade in Europe*, 230

21. James F. Tent, *E-Boat Alert: Defending the Normandy Invasion Fleet* (Annapolis, MD: U.S. Naval Institute Press, 1996).

22. *Utah Beach to Cherbourg*, 12-13; *Omaha Beachhead*, 8-9.

23. Eisenhower, *Crusade in Europe*, 244 and the Overlord Forecast Map between 224-225.

24. Hans Speidel, *Invasion 1944: Rommel and the Normandy Campaign*, trans. Theo W. Crevenna (Chicago, IL: Regnery, 1950); Samuel W, Mitcham, *Rommel's Last Battle: The Desert Fox and the Normandy Campaign* (New York: Stein and Day, 1983).

25. Keegan, *Six Armies in Normandy*, 130.

26. James H. Herzog, *Breaching Fortress Europe: The Story of U.S. Engineers in Normandy on D-Day* (New York: Kendall/Hunt, 1944); *Omaha Beachhead*, 20-25; *Utah Beach to Cherbourg*, 4-8; Botting, *The Second Front*, 12-20.

27. M. Devlin, *Paratrooper* (New York: St. Martin's Press, 1979), 387.

28. Utah Beach to Cherbourg, 183-208.

29. *St. Lô* (7 July-19 July 1944), American Forces in Action Series (Washington, DC: Government Printing Office, August 21, 1946); Eisenhower, *Crusade in Europe*, 268-269.

30. Devlin, *Paratrooper!* 280-281. See also S. L. A. Marshall, *Night Drop: The American Airborne Invasion of Normandy* (Boston, MA: Little, Brown, 1962); Richard N. Gale, *With the 6th Airborne Division in Normandy* (London: S. Low, Marston, 1948).

31. Walter Bedell Smith, *Eisenhower's Six Great Decisions* (New York: Longmans, Green, 1956), 50-55; Eisenhower, *Crusade in Europe*, 249-250; Botting, *The Second Front*, 60-63.

32. Morgan, *Overture to Overlord*, 144, 148.

33. Kenneth Edwards, *Operation* Neptune (London: Collins, 1946), 228-232; 200-201.

34. Eisenhower, *Crusade in Europe*, 270.

19. OPERATION PLAN *EL PASO*

I'd like to go to Tchepone, but I haven't got the tickets.

General William C. Westmoreland
to General Creighton W. Abrams
Saigon, Vietnam, March, 1968

THE HO CHI MINH TRAIL, WHICH LINKED NORTH VIETNAM'S RED RIVER DELTA WITH SOUTH VIETNAM VIA THE Laotian panhandle in the 1960s and early 1970s, was an indispensable source of supplies for Communist forces south of the 17th Parallel.[1] U.S. air interdiction campaigns and special operations forces slowed, but by no means stopped the flow.[2] President Lyndon B. Johnson, primarily for political reasons, disapproved air strikes against stockpiles around Hanoi and Haiphong, which arguably might have been more successful.[3]

General William C. Westmoreland, who was Commander, United States Military Assistance Command, Vietnam (COMUSMACV), consequently commissioned Operation Plan (OPLAN) *El Paso*, a corps-sized operation timed to seal off the Ho Chi Minh Trail at Tchepone for 18 consecutive months during a dry season preceded and followed by torrential rains that would reduce vehicular traffic to a trickle.[4] Members of the small joint staff that prepared OPLAN *El Paso* between November 1967 and March 1968 found that geographic circumstances profoundly influenced proposed answers to every question connected with that large-scale, long-duration operation far from established support facilities. Results of their efforts follow, along with the unhappy outcome of Operation *Lam Son 719*, an ill-conceived substitute.

THE HO CHI MINH TRAIL

The Ho Chi Minh Trail, which initially nourished Viet Cong guerrillas in South Vietnam, was nothing more than a skein of rustic traces through the wilderness when it opened in the late 1950s. Dedicated men, women, boys, and girls bent bandy-legged beneath heavy loads trudged down those paths, all but ignored by senior officials in the United States and the Republic of Vietnam (RVN) because the invoices were unimpressive: a little rice, a few pitted handguns captured from the French, homemade weapons pieced together like Rube Goldberg toys. The tempo, however, gradually picked up and consignments increasingly included sophisticated items such as radios, pharmaceuticals, plastic explosives, recoilless rifles, and repair parts. Ammunition requirements multiplied exponentially after U.S. combat forces hit North Vietnamese regulars head on in 1965.[5]

Brutal courses that in the beginning traversed several hundred miles of exhausting, saw-toothed terrain between Vinh and the demilitarized zone (DMZ) later continued the grind through Laos, which in some cases more than doubled the distance to ultimate destinations in South Vietnam (map 63). Human bearers and assorted beasts struggled to tote swelling loads, yet gaps between supplies and demands became ever wider, because individual burdens grew progressively heavier—every 122-mm rocket, for example, weighed 102 pounds (46 kilograms), more than most of the porters; fewer than five would buckle the knees of pint-sized Annamese elephants which push and pull better than they bear cumbersome loads. Requirements for routes that could accommodate truck traffic thus were obvious (table 29), but most passageways in the back country were primitive, largely bridgeless, initially pitted with water buffalo wallows, and subsequently battered by bombs.

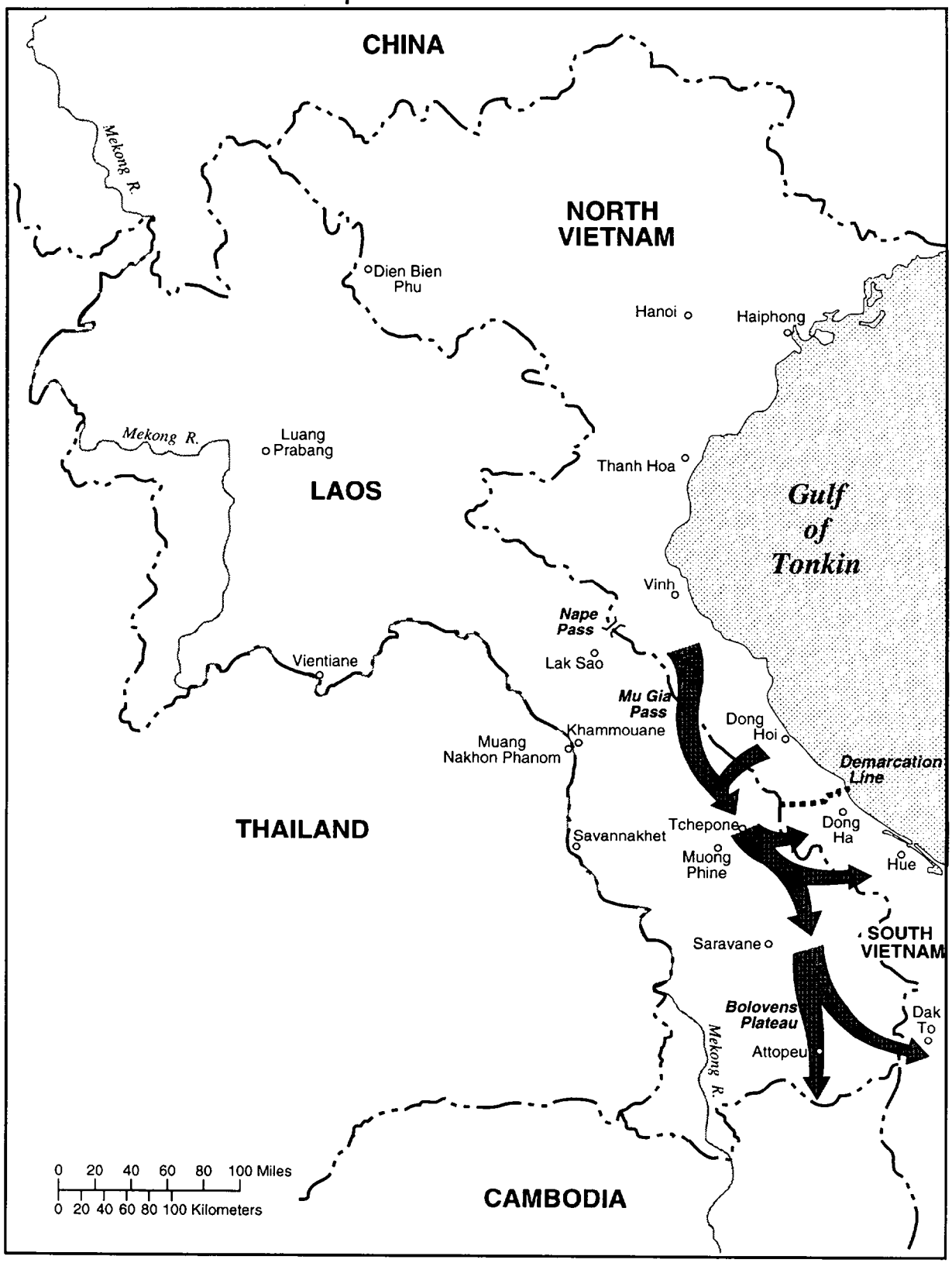
Table 29. ***Transportation on the Ho Chi Minh Trail*** [6]

Prime Movers	*Rated Capacity*	
Male Porters	68 lbs	(31 kg)
Female Porters	55 lbs.	(25 kg)
Elephants	440 lbs.	(200 kg)
Pack Bicycles	525 lbs.	(238 kg)
Ox Carts	2,200 lbs.	(998 kg)
Trucks		
GAZ-51	4,400 lbs.	(1,996 kg)
ZIL-151	5,500 lbs.	(2,495 kg)
STAR-66	7,720 lbs.	(3,500 kg)

Senior decisionmakers in Hanoi accordingly initiated ambitious renovation and expansion programs to widen rights of way, span streams, level humps, fill in hollows, corduroy spongy spots, and establish way stations. The improved Ho Chi Minh Trail, constructed and maintained with tools that ranged from shovels to bulldozers and scrapers, incrementally became a labyrinth of motorable roads, cart tracks, foot paths, and navigable streams that by early autumn 1967 furnished Communist forces in South Vietnam about one-fourth of all their supplies (more than 70 percent of arms and munitions). Aerial bombardments pocked those avenues like surfaces on the moon, but dogged peasants with military supervisors patched the wreckage and built bypasses, while convoys shuttled from point to point under cover of darkness and ever more effective antiaircraft umbrellas.

Business was necessarily cyclical, since seasonal rains made the Ho Chi Minh Trail a mush from mid-April at least until late September. North Vietnamese logisticians on the lee side of mountains that block the Southwest Monsoon therefore amassed stockpiles inside their home border during summer months, when skies were sunny along the coast, in preparation for great surges south as soon as roads in Laos were dry. Communist base areas honeycombed with caves, tunnels, bunkers, and subterranean storage pits in Laos held stocks pending distribution to using units.

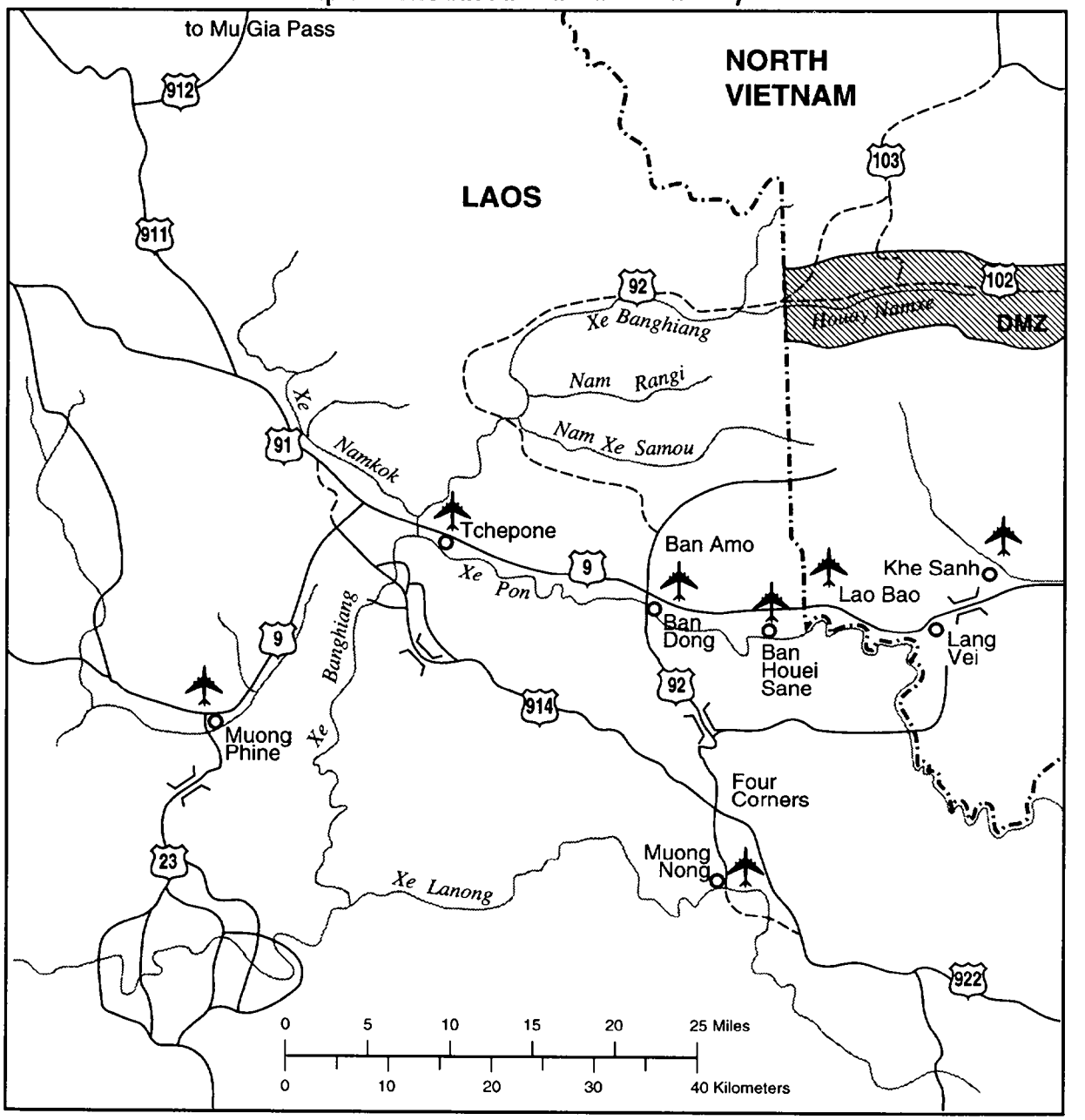
Map 63. *The Ho Chi Minh Trail*



LAOTIAN LANDSCAPES

The Laotian panhandle comprises three parallel regions roughly oriented from north northwest to south southeast: jumbled mountains straddle the eastern frontier; a rolling plain west of Muong Phine stretches all the way to the Mekong; a rough, fever-ridden, sparsely settled transition zone occupies space in between. The Ho Chi Minh Trail traversed all three (map 64).

Map 64. ***The Laotian Panhandle at Midpoint***



The Annam Mountain Chain. The highest peak along the border between Laos and Vietnam barely tops 5,500 feet (1,675 meters), and few other summits surpass 4,000 feet (1,220 meters), but such figures are deceptive, because mountain streams chisel razorbacked ridges and canyons from bedrock. Numerous inclines exceed 45 degrees or 100 percent (slopes climb one foot vertically for every horizontal foot). Topography is roughest north and west of the demilitarized zone (DMZ), where massive limestone deposits dissolve in tropical downpours, sculpting needle-shaped pinnacles, sink holes, and culs-de-sac. North Vietnamese Army (NVA) workshops, apartments, and stockpiles took advantage of giant caverns with cool, dry, blast-proof halls three or four stories high that extended 1,000 feet or more (300+ meters) into many hillsides.

Few convenient apertures other than Mu Gia Pass and the Khe Sanh Gap cross that mountain wall, because swift streams that cascade west from the divide carve constricted corridors studded with rapids—the Banghiang River traverses a gorge so steep that map contour lines sit one on top of another—and slopes everywhere are as slippery as bobsled runs when greased by rain.

Dank, gloomy, multistoried jungles with dense undergrowth mantle much of that redoubt with thick stands of teak and mahogany most of which tower 90 to 100 feet (27 to 30 meters), although occasional monsters are half again as high. Corded vines festoon the lower levels and lacerate unwary travelers with terrible barbs. Huge breaks of bamboo stretch from Khe Sanh to Ban Houi Sane, close clumped, almost impenetrable, some with stalks half a foot in diameter. Secondary growth quickly reclaims slash-and-burn plots that nomadic Montagnard tribes abandon.

The Transition Zone. Topography in the transition zone between mountains on the east and relatively level terrain on the west features discontinuous uplands that chop the Laotian landscape into a series of acute angle compartments. Two prominent east-west ridges a few miles apart with a conspicuous trough in between follow parallel paths for nearly 50 miles (80 kilometers) from Khe Sanh past Tchepone, where the northern runner peters out. Its companion, which plunges on for another 50 miles, is a natural barrier breached in just four places. The Lang Vei cleft farthest east expires south of Route 9 in a maze of serrated highlands that might have been fashioned with pinking shears. A second portal at Ban Dong widens to form a shallow, oblong bowl that generally centers on Four Corners. Tchepone, the best natural hub, boasts breakthroughs that lead southwest, southeast, and east. The final opening, farthest west, comprises a broad pass at Muong Phine.

The Banghiang River, 3 feet deep and 100 yards wide at Tchepone under optimum conditions, always is an impressive obstacle. More than 50 perpendicular runnels that drain wooded, broken ground just north of the Pon River and corrugate its flood plains are militarily insignificant during dry seasons, but become raging torrents when it rains, while trackless palisades up to 800 feet high (243 meters) shadow the south bank for 15 miles (24 kilometers) west of Ban Dong.

Blobs of blue and red that represent friendly and enemy armed forces on tactical maps more often than not are isolated from each other in the Transition Zone, where no vehicles move far off roads and trails. Foot troops may hike a mile or two an hour in open forests, but vegetative tangles make military columns backtrack and double or triple straight-line distances. Youthful Paul Bunyons wielding machetes can hew through bamboo thickets at a rate that approximates 100 yards or so in 60 blistering minutes, provided they take an

interest in their work, sergeants rotate point men frequently, and no one cares how much noise is made (the racket sounds like several unsynchronized Anvil Choruses).

Desolation typified the Transition Zone. Tchepone, the largest village, once housed maybe 1,500 civilian men, women, and children, but fewer than half remained by the mid-1960s. Most hamlets were deserted, their former inhabitants dead or departed. Panhandle life had shifted from traditional rural clusters to NVA base areas in dense woods or river towns that the Royal Laotian Government held.

The Savannakhet Plain. The Savannakhet Plain, as its name implies, is relatively low, gently rolling real estate overgrown with brush and savanna grass, except where subsistence agriculture plots take precedence. Most of the Ho Chi Minh Trail in 1967-68 was positioned well to the east, because its architects preferred better cover and more direct routes to destinations in South Vietnam.

MOTORABLE INFILTRATION ROUTES

The Combined Intelligence Center in Saigon estimated that 90 percent of all NVA troops infiltrated into Laos through the demilitarized zone via Routes 103 and 102, after which some marched south while others swung back into South Vietnam along the Nam Samou River and Route 9, both of which showered tributary tracks like Fourth of July sparklers (map 64). Supplies and equipment, however, took different tacks in 1967-1968.

Route 92. Route 92, a rude way no more than 10 or 12 feet wide (fewer than 3 meters), was passable to one-way motor traffic from the DMZ to Ban Dong, where trucks swam the Pon River during dry weather, then negotiated extremely tight turns and steep grades en route to Four Corners. Major improvements farther south transformed that byway into the preeminent infiltration corridor in southern Laos.

Route 914. Route 914, which opened operations in 1965, sucked in traffic from numerous sources, including Mu Gia Pass and inland waterways, until, by early 1968, it became the most heavily traveled supply route between Tchepone and Route 92 at Four Corners. Its width varied from 8 to 30 feet (2+ to nearly 10 meters), and a laterite surface tolerated tractor-trailers as long as the weather was fair. Route 914 didn't exactly tip on end after it forded the Banghiang River, but the road climbed 23 percent grades before it found an easier course.

Route 23. Route 23, the only other motorable north-south avenue on the Ho-Chi Minh Trail, went dormant and fell into disrepair as soon as convoys began to take the Route 914 short-cut. Convoy traffic ceased in 1966 after fighter-bombers destroyed the triple-span Banghiang bridge, because the river at that point was unfordable, but revived a bit some months later when barges and bypasses appeared. Construction crews, however, never restored or replaced the battered bridge and wasted little time improving the natural earth roadbed, which at best was 7 or 8 feet wide.

Route 9. Highway 9, the only east-west "turnpike" across the Laotian panhandle, in its salad days was a passing fair post road that connected Quang Tri Province on the Tonkin Gulf coast with the Mekong River town of Savannakhet, a distance of 200 miles (322 kilometers). War and neglect had taken their toll, but that artery still had greater potential than any other: a stable base; crushed stone and laterite surfaces that averaged 13 to 14 feet wide, not counting shoulders; gradients that never exceeded plus or minus 3 to 5 percent,

even through the Khe San Gap; and access to nearly every militarily significant feature in the study area, including transportation nodes along the Ho Chi Minh Trail and NVA base areas.

Notable liabilities nevertheless counterbalanced those assets. Several gullied or grossly overgrown stretches as much as a mile long restricted horizontal clearances to as little as 6 feet (fewer than 2 meters). Many lengthy meanders around fallen trees and bomb craters additionally reduced throughput capacities and increased transit times. Few bridges that colonial Frenchmen installed survived U.S. air strikes, which systematically took them out starting in 1966. The rickety relics still standing were unable to hold fully loaded three-quarter-ton trucks, but light NVA vehicles routinely sloshed across everywhere, including the broad sand and mud Banghiang River bottom, whereas 12-ton U.S. semitrailers would have bogged down there in the absence a pontoon bridge or ferry.

SEVEN SIGNIFICANT AIRFIELDS

U.S. Marines at Khe Sanh possessed the only operational fixed-wing airfield in the study area after January 1968. Six others were abandoned in various stages of disrepair (table 30).

Table 30. *OPLAN* El Paso *Airfields*

Airfield Name	*Runway Dimension (feet)*	*Elevation (feet)*	*Largest Potential Capacity*	*Status*
Lao Bao	1,100 x 65	650	C-7a	Abandoned
Ban Amo	2,250 x 75	480	C-7a	Abandoned
Ban Houei Sane	3,560 x 90	480	C-130	Abandoned
Tchepone	3,700 x 120	558	C-130?	Abandoned
Muong Phine	2,900 x 60	656	C-130	Abandoned
Muong Nong	1,300 x 60	500	C-123	Abandoned
Khe Sanh	3,897 x 60	1,608	C-130	Operational

Lao Bao and Ban Amo. Neither Lao Bao nor Ban Amo was worth rehabilitating, because neither had been very capable in its hey day, and both were badly in need of repair. Time, manpower, and money could have been better expended elsewhere.

Ban Houei Sane. Ban Houei Sane, on the outskirts of the sleepy village from which it took its name, served U.S. C-130 transports until January 1968, when North Vietnamese regulars overran it on their way to Khe Sanh shortly before Tet. The crushed stone and laterite runway received more than 20 deep craters at that time, but the rest was in fairly good shape and expansion room to the west was almost unlimited.

Tchepone. The former French airbase at Tchepone, 23 air miles farther west (37 kilometers), fell into Communist hands in 1961, after the Laotian Forces Armées du Royaume (FAR) withdrew. U.S. engineers believed its well-drained, well-compacted 3,700-foot (1,128-meter) runway could be rehabilitated rapidly, even though one end was pocked with big bomb craters and blocked by elephant grass and brush. A knife-edged ridge, which rose abruptly about one mile to the south, might have made C-130 landings and takeoffs iffy, but would not have interfered with light assault transports such as C-123s and C-17s.

Muong Phine. The derelict runway at Muong Phine, reclaimed by encroaching jungle, was scarcely visible from the air, but bomb damage was slight and its laterite surface overlaid a solid foundation. Refurbishment would have required extensive land clearing plus filling to repair erosion scars as well as one deep depression. Landings from and takeoffs to the west were unobstructed, although the runway unhappily pointed straight at a mountain mass in the opposite direction.

Muong Nong. The stubby 1,300-foot earth-surfaced runway at Muong Nong butted into a loop of the Lanong River 20-some miles (30+ kilometers) south of Route 9. Even so, there was room to double that length by planing off humps and draining a small swamp. Engineers equipped with air transportable earth-moving machines could have produced a C-123 strip in about 2 weeks.

Khe Sanh. The operational airfield at Khe Sanh combat base, just across the border in South Vietnam, was built on weathered basalt, a reddish substance that looks much like laterite, but contains few lateritic properties. Aluminum planking covered the runway, taxi strips, and parking area to ensure all-weather capabilities, because basalt churns to mush and ruts quickly after the slightest rain. Khe Sanh, unlike any other airfield in the study area, was fully-equipped with modern aids to navigation (TACAN and radio beacons), ground-controlled approach radar (GCA), and refueling facilities for helicopters as well as fixed-wing aircraft.

DROP ZONES AND LANDING ZONES

Open spaces that might serve as large-scale parachute drop zones (DZs) or helicopter landing zones (LZs) are scarce in the Laotian panhandle, except for sites on the Savannakhet Plain. Topography elsewhere is most often too formidable and vegetation too confining.

Parachute Drop Zones. Rice paddies around Muong Phine offered the only opportunities for sizable parachute assaults which, according to U.S. Seventh Air Force standards in 1968, required a reasonably clear drop zone 2,925 yards long for 64 troopers in a C-130, which is more than a mile and one-half (2.67 kilometers) Smaller clearings around Tchepone, Four Corners, and Ban Houei Sane, however, were more than adequate for container deliveries of ammunition, rations, POL, and other high priority items (35,200 pounds per C-130). Well-qualified crews equipped with the Parachute Low Altitude Delivery System (PLADS) generally could put 2,000-pound bundles onto 20-yard-square bullseyes on isolated hilltops or in jungle clearings, and the Low Altitude Parachute Extraction System (LAPES) could slide 18,000-pound platforms down any obstruction-free dirt road or other reasonably smooth surface 50 feet wide by 1,200 feet long.

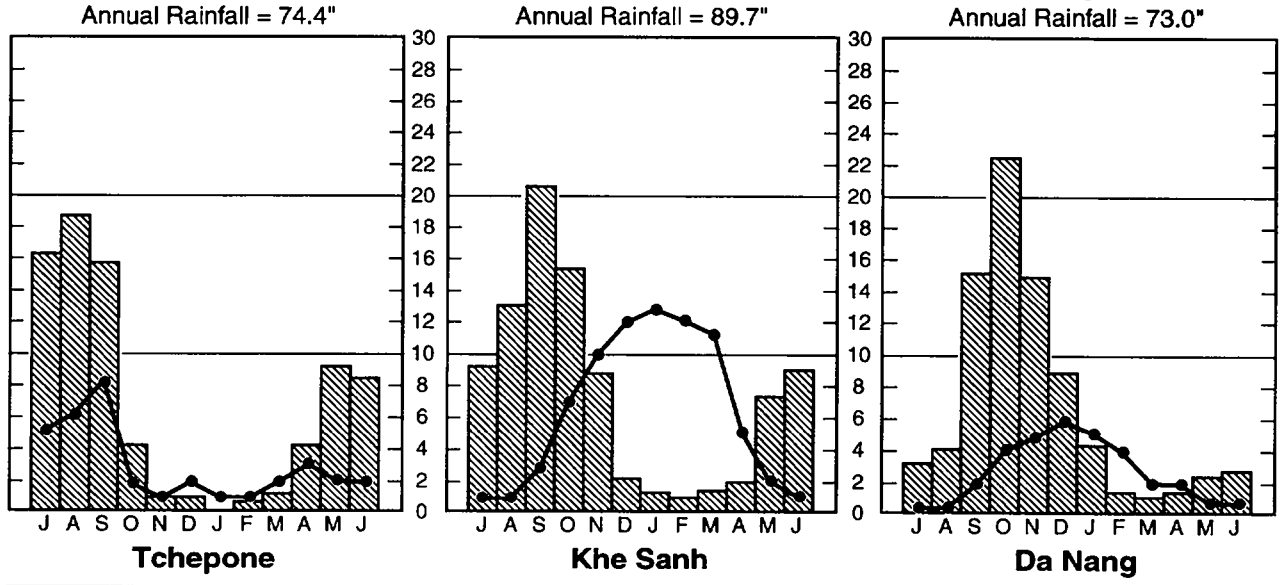
Helicopter Landing Zones. Helicopter transportation boded better than parachute delivery, although those versatile "birds" have definite limitations related to altitudes and temperatures, which affect lift capacities. Tilled flats bestraddling Muong Phine and interspersed along the Pon River could handle formation landings and takeoffs by multiple flights, but few open areas elsewhere could accommodate more than one or two ships simultaneously. High explosives and chain saws would have been required to create small chopper pads quickly in dense forests where no natural cavities reach the floor.

MONSOONAL INFLUENCES

Monsoonal rains, low ceilings, poor visibility, heat, humidity, and destructive winds complicated planning for Operation *El Paso*, because armed forces committed to combat in Laos would have to stage in and be supported from one distinctive climatic zone along the Tonkin Gulf coast yet fight in another that is diametrically different. Hard data were available for most stations in South Vietnam, where French meteorologists had compiled reliable records for many years, but U.S. intelligence services never found similar statistics for particular locations in Laos. Climatic predictions there involved guesswork.

The Annamese Mountains, which present a perpendicular front to prevailing winds, separate climatic regimes just as surely as a slammed door (map 65 and figure 40). When the Northeast Monsoon soaks South Vietnam from mid-October until March Laos is dry; coastal regions bask in sunlight when the Southwest Monsoon takes over from May until early September, while wet weather saturates Laos. Indefinite circulation during transition periods produces instability and thunderstorms on both sides of the Geologic Curtain.

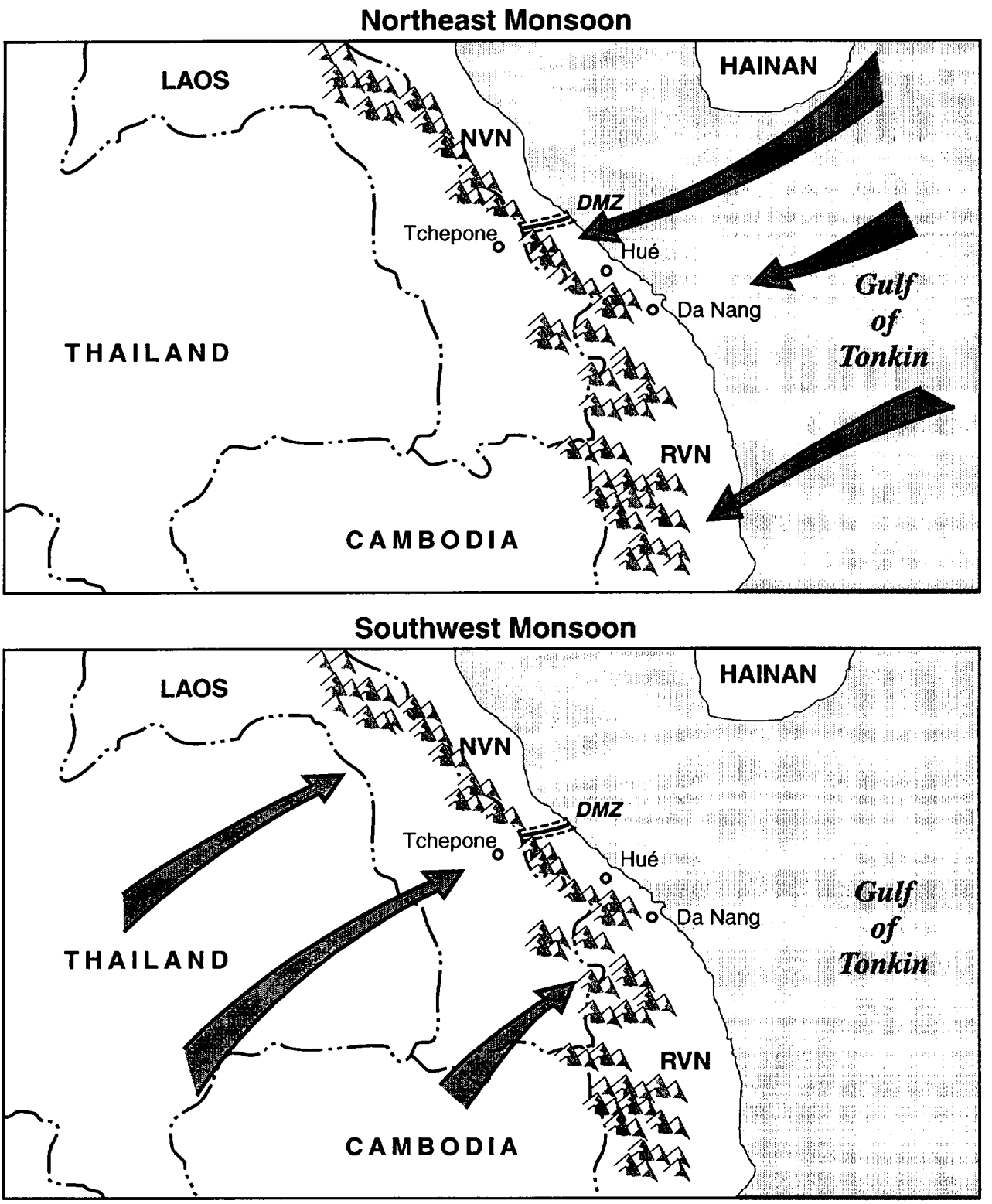
Figure 40. ***Monsoonal Regimes at Tchepone, Khe Sanh, and Da Nang***



Spring rains in the Laotian panhandle, which generally commence in April, increase exponentially when the Southwest Monsoon hits the next month, accompanied by frequent downpours and local flooding. Fair weather roads turn into quagmires, fords vanish beneath roiling runoff, and vehicular traffic ceased on the Ho Chi Minh Trail.

The Northeast Monsoon revs up between the 4th and 24th of October, normally about the 12th. Precipitation perseveres in Laos for a week or two thereafter, then subsides rapidly, but low-hanging clouds close mountain passes along the eastern frontier half the days of some months (see Khe Sanh in figure 40). Military construction stops in South Vietnam and

Map 65. *Monsoonal Regimes in South Vietnam and Laos*



flying weather over hill country becomes abominable as soon as the coastal rainy season starts. Fluctuations from the autumn norm moreover are fantastic. Hué, for example, has yo-yoed from 3.5 inches one year (8.9 centimeters) to 66 inches in another (168 centimeters), enough to float Noah's Ark. Typhoon Bess in September 1968 dumped 20 inches of water on Da Nang in 1 day (51 centimeters).

MISSION PLANNING

Operation Plan *El Paso*, which was designed to interdict traffic on the Ho Chi Minh Trail, proceeded apace after its architects identified the most logical lodgment area in Laos and a tactical area of responsibility (TAOR) within it. Thereafter, they determined optimum timing, postulated a concept of operations, estimated force requirements, and presented proposals to COMUSMACV for approval.

THE MISSION

The OPLAN *El Paso* mission, paraphrased as follows, was the soul of simplicity:

> Task Force Bottleneck seizes, secures, and as long as necessary blocks key choke points astride the Ho Chi Minh Trail beginning at H- Hour on D-Day to forestall the infiltration of NVA troops, supplies, and equipment from North Vietnam through the Laotian Panhandle into the Republic of Vietnam (RVN) and Communist sanctuaries inside Cambodia.

THE "COCKPIT"

Planning guidance earmarked one U.S. airmobile division, one U.S. infantry division, and the Army of Vietnam (ARVN) airborne division for Task Force Bottleneck, plus substantial combat and logistical support. Those allocations established requirements for a "cockpit" within which a corps-sized force could conduct sustained offensive and defensive operations without excessive risks or costs.

The Logical Lodgment Area. Selection of the OPLAN *El Paso* lodgment area presented no special problems, because only one site meshed well with the mission:

- Blocking positions at Mu Gia and Nape Passes were assessed as unsuitable, because they would have been too remote from staging and support bases in South Vietnam, too expensive, probably untenable, and easily bypassed.
- Blocking positions at the western end of the DMZ were assessed as unsuitable, because they would scarcely have affected motor traffic on the Ho Chi Minh Trail.
- Blocking positions anchored on the Bolovens Plateau far to the south were assessed as unsuitable, because they would have afforded enemy troops, equipment. and supplies free access to much of embattled South Vietnam.
- Blocking positions between Khe Sanh and Muong Phine were assessed as suitable, because they covered most tracks and all motorable routes that led from North Vietnam through Laos to the Republic of Vietnam. Friendly armed forces could have installed roadblocks farther west in the unlikely event that enemy truck convoys side-slipped via the Savannakhet Plain where they would be exposed to U.S. and Royal Laotian air strikes.

The Tactical Area of Responsibility. The tactical area of responsibility depicted on map 66 is a 2,400-square-mile (6,215 square-kilometer) oblate spheroid that measures roughly 40 by 60 miles (65 by 95 kilometers). It contained ample room within which to deploy the forces and enclosed seven key terrain features:

- The choke point and airfield at Tchepone
- The choke point and airfield at Muong Phine
- The choke point at Ban Dong
- The choke point at Four Corners
- Ban Houei Sane airfield
- Khe Sanh combat base
- Highway 9.

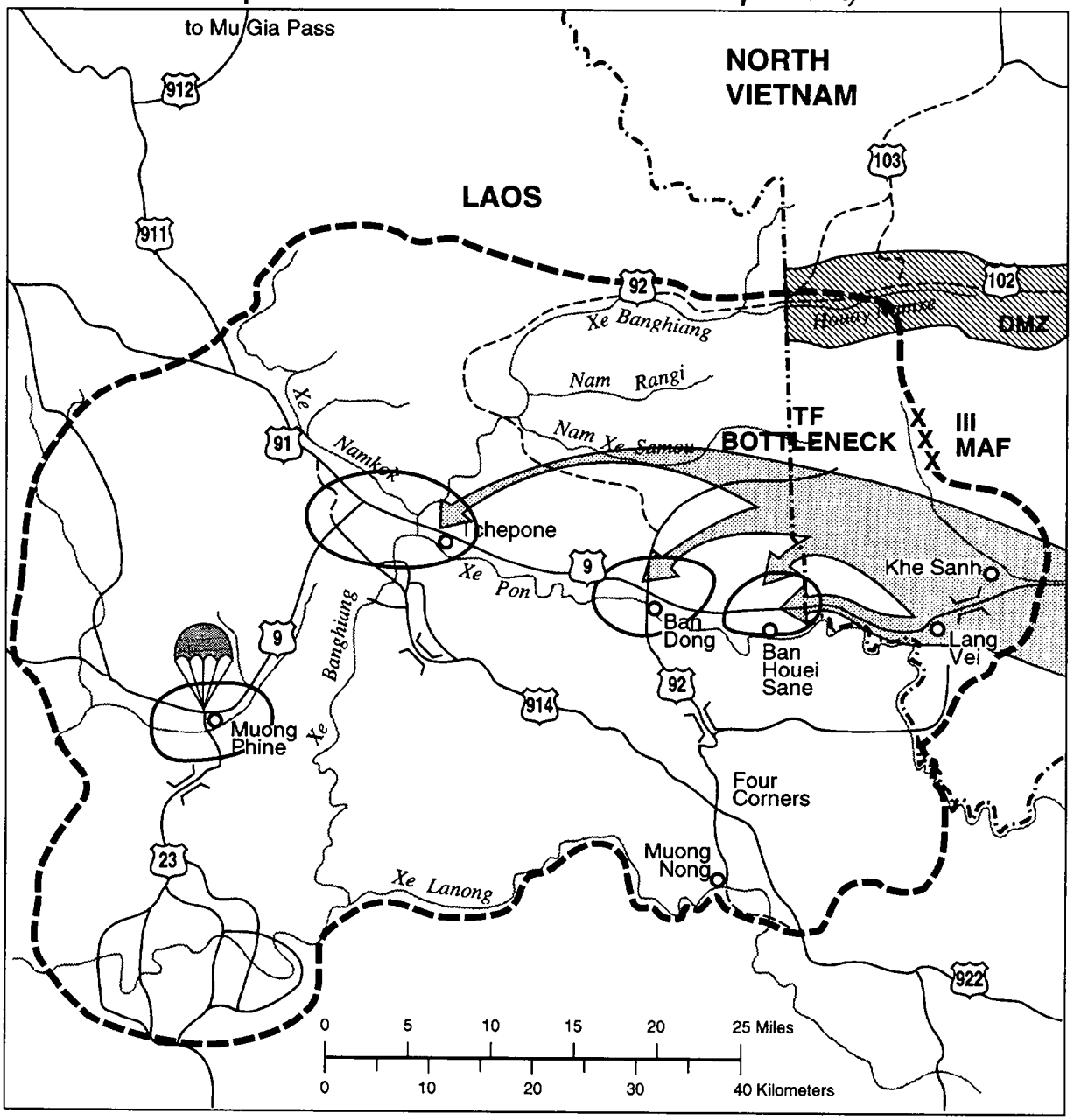
Tchepone, together with the huge, heavily defended North Vietnamese Army base area nearby, was the focal point for every motorable infiltration route from Mu Gia Pass except National Highway 23. Muong Phine and Ban Dong were two other corks in the bottle. Four Corners offered a possible alternative to the hornet's nest at Tchepone, because road blocks there would have shunted all enemy motor vehicles onto vulnerable Route 23 well to the west of Vietnam. The C-130-capable airfield at Ban Houei Sane would have been essential for any large-scale operation other than a raid. Khe Sanh combat base, airfield, and communications center was the only U.S. or ARVN installation able to stage and support a corps-sized venture into Laos (it sat on the Xom Cham Plateau which, although small, offered adequate room for additional POL tank farms, ammunition pads, and helicopter maintenance facilities, which are voracious space eaters). Military planners seldom consider lines of communication to be key terrain, but Route 9 was an indispensable Main Supply Route (MSR), because no combination of fixed-wing and heliborne delivery systems could have borne long-term logistical loads.

CONCEPT OF OPERATION

The OPLAN *El Paso* concept of operation called for the ARVN airborne division to drop on Muong Phine at H-Hour on D-Day while U.S. airmobile brigades seized Tchepone, Ban Dong, and the airfield at Ban Houei Sane. U.S. tanks and infantry were to attack west from Khe Sanh simultaneously along Route 9 and link up as soon as possible. All three divisions and corps-level combat forces thereafter were to block enemy movement southward.

Airfield rehabilitation and the conversion of Route 9 to a double-lane MSR were high-priority tasks for Army engineers. Restrictions consistent with the accomplishment of assigned missions were designed to keep supply tonnages down, since aerial delivery would have to suffice until those tasks were complete: few vehicles were to accompany assault echelons; rapid evacuation of personnel casualties and inoperative equipment promised to reduce requirements for medical and maintenance facilities in the TAOR; no base camps were to be built in Laos at any time.

Map 66. *OPLAN* El Paso's *Tactical Area of Responsibility*



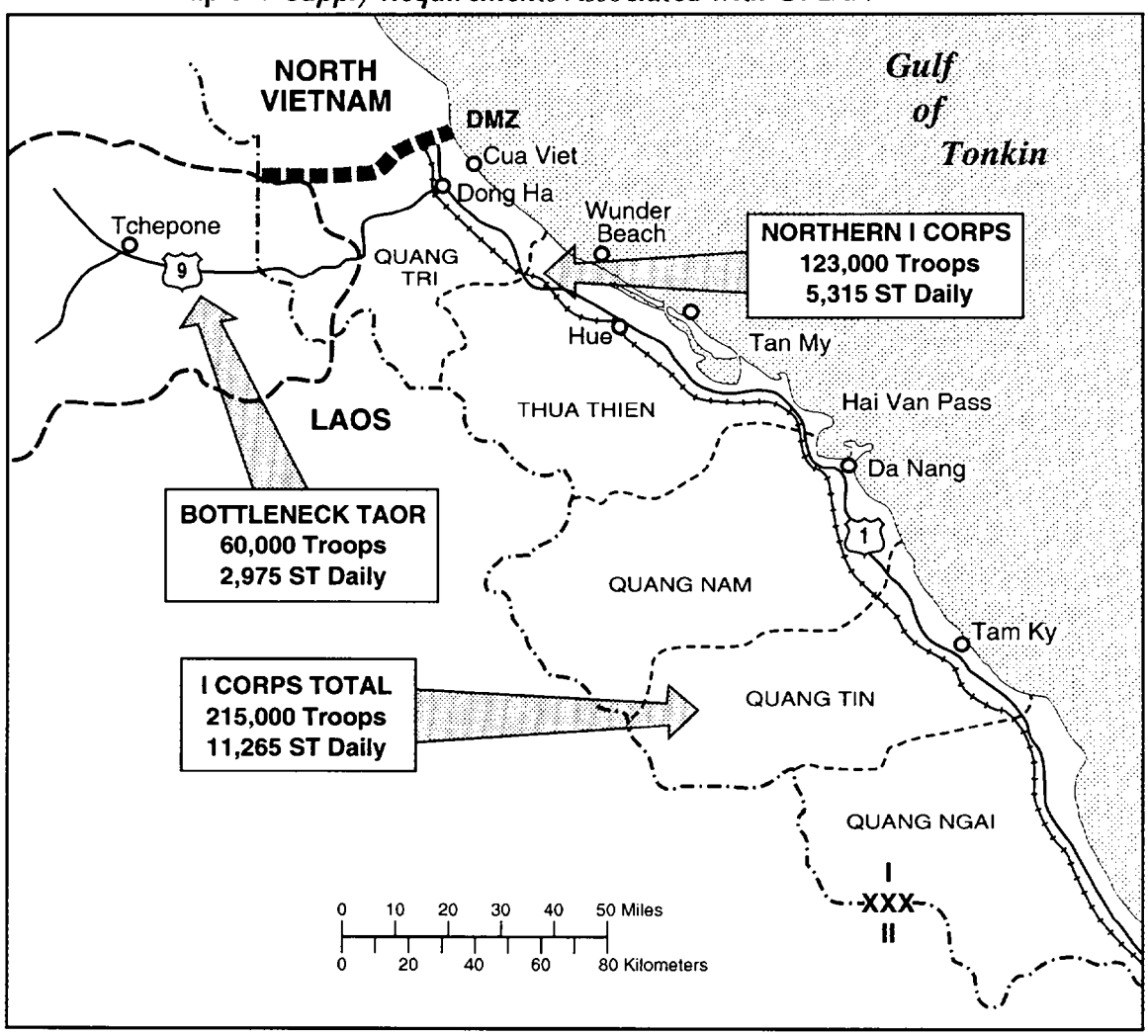
The optimum time to spring the trap would have been in November before communist commissaries in Laos began to replenish depleted larders in South Vietnam. There was no mandate for Task Force Bottleneck to search and destroy once it cleaned out the base area around Tchepone—the mission was merely to barricade the Ho Chi Minh Trail until the Southwest Monsoon again soaked Laos. One big "IF," however, remained: could U.S. logisticians sustain a three-division corps so far from established facilities?

LOGISTICAL LIMITATIONS WITHIN VIETNAM

All basic ingredients needed to support OPLAN *El Paso* were already in place within 10 or 12 miles (16 to 19 kilometers) of the Tonkin Gulf. Most dry cargo ships unloaded at the port of Da Nang, while petroleum tankers pumped bulk POL directly into storage bins at Tan My and Cua Viet. Fixed-wing aircraft, heavy-lift helicopters, and a meter-gauge railway transferred high-priority items to ultimate destinations. Armed forces and civilians shared coastal Highway 1, a heavily traveled artery that connected Saigon with Hanoi before Vietnam split in two at the 17th Parallel, whereas military traffic predominated on Route 9, which wandered west from Dong Ha to Task Force Bottleneck's prospective area of responsibility.

Logistical limitations and tactical vulnerabilities associated with that setup were as restrictive for purposes of OPLAN *El Paso* as choke points on the Ho Chi Minh Trail were to North Vietnamese infiltrators, because throughput capabilities in 1967-1968 fell far short of I Corps Tactical Zone (I CTZ) requirements combined with those of the Bottleneck TAOR (map 67). Solutions to related problems took more thought and absorbed more time than any other planning aspect.

Map 67. ***Supply Requirements Associated with OPLAN* El Paso**



PORT CLEARANCE CAPACITIES

Da Nang could have handled all dry cargo requirements under adverse weather conditions with room to spare, but abilities to shift supplies and equipment north from that central market were clearly inadequate during the period under consideration. POL distribution problems were at least as perplexing.

Coastal Waterways and Railroad. The cheapest way to move freight is by water or rail, but neither alternative showed much promise. Floods, tides, and littoral drift made a deep water port at Tan My impractical despite repeated proposals, while Logistics-Over-the-Shore (LOTS) operations at Wunder Beach a bit farther north were infeasible during the Northeast Monsoon. There was plenty of room for additional LST and LCU ramps at Cua Viet, but no way to move the burden inland; Seabees figured it would take 14 battalion months to build a road across coastal swamps.

The railway trunkline was unserviceable and prospects for early rehabilitation appeared dim given the large number of demolished bridges between Da Nang and Dong Ha, including the whopper over the Perfume River at Hué. Optimistic members of the Vietnamese Railway System (VNRS) nevertheless wagered that in 70 days the line could be renovated for single-track, daylight operations at 10 miles per hour, and U.S. military engineers generally agreed, given sufficient physical security; North Vietnamese trains ran part of the time, they noted, despite savage aerial bombardments.

Highway 1. Highway 1 fortunately showed definite promise. Upgrading already had shifted into high gear, galvanized by lessons learned during the Communists' February 1968 Tet offensive. Parts of seven Seabee battalions assisted by a U.S. Army engineer group and civilian contractors were rapidly widening and paving the roadway, straightening hairpin curves in Hai Van Pass, creating turnarounds, strengthening bridges, and improving drainage. Capacities increased accordingly.

LAND LINES TO LAOS

The only feasible Main Supply Route between the Tonkin Gulf coast and Task Force Bottleneck's proposed TAOR lay directly south of the demilitarized zone where it was painfully exposed to enemy action. No suitable alternative was available.

Route 9. Maximum capacities of Route 9, which adequately served U.S. Marines at the Khe Sanh combat base, looked ludicrous compared with tonnages that OPLAN *El Paso* required. Enemy sappers had blown half of the 36 bridges east of Khe Sanh and ticklish bypasses cut in hillsides were impassable to heavy trucks. The roadway, which averaged 12 to 14 feet wide (barely 4 meters at best), originally was surfaced with asphalt prime, a bituminous treatment less than one inch thick. Some remained in 1968, buried under mud slides and debris, but a good deal was gone and shoulders (where they existed at all) were God's natural soil. Glutinous gumbo alternately gripped tires like molasses or caused wheels to slide during rainy seasons and clearly would continue to do so unless Route 9 received a solid, waterproof surface.

Petroleum Pipelines. Quang Tri and Thua Thien Provinces in 1967-68 sported barely 10 miles (16 kilometers) of 6-inch petroleum pipeline, which could pump 756,000 gallons (2,457 short tons) a day. Every drop of precious fuel for Khe Sanh consequently had to be trucked over Route 9 at that time. There was no possible way to satisfy Task Force

Bottleneck's insatiable thirst for POL short of extending that embryonic pipeline system into Laos or paving the road for use while the Northeast Monsoon pelted South Vietnam.

LOGISTICAL SHORTCOMINGS INSIDE LAOS

El Paso's planners assigned high priorities to road and airfield rehabilitation inside Laos beginning on D-Day, because blocking positions astride the Ho Chi Minh Trail otherwise would have been logistically unsupportable. Plans consequently called for some combat engineers to arrive by air and for others to follow closely behind ground linkup parties attacking west from Khe Sanh.

ROAD REHABILITATION

Route 9, degraded by bomb craters, blasted bridges, erosion, and encroaching jungles, was in sad shape on the Laotian side of the border, but construction crews, confident that they could adhere to tight schedules (table 31), predicted that convoys could truck in 750 short tons a day as far as Muong Phine well before three weeks elapsed. Few streams would have demanded spans in the dry season, except the Banghiang River at Tchepone, where progress would stall for about a day while engineers installed a floating bridge after clearing assembly areas and preparing approaches through a welter of water-filled craters. Subsequent actions to widen rights of way and scrape out forward support areas where trucks could dump their loads would have taken somewhat longer, as table 32 indicates.

Table 31. *OPLAN* El Paso *Road Opening Schedules*

Section	*Miles*	*Condition*	*Streams*	*Days*	*Completion*
Lang Vei to Lao Border	7.4	Poor	6	3	D+2
Lao Border to Ban Houei Sane	4.4	Fair	7	1	D+3
Ban Houei Sane to Ban Dong	8.7	Poor	10	4	D+7
Ban Dong to Tchepone Airfield	17.4	Fair	30	5	D+12
Tchepone Airfield to Muong Phine	20.5	Fair	19	5	D+17

Suitable materials could have come first from basalt beds just west of Khe Sanh, which is rather remote, then from the dry stream beds of many Pon River tributaries which have rocky bottoms and steep banks. There would have been no rush to widen Route 9 as far as Muong Phine, garrisoned at most by one or two light ARVN airborne brigades.

Table 32. *Schedules for Dual-Laning Route 9 in Laos*

Section	*Miles*	*Engineer Companies*	*Days*	*Completion*
Lang Vei to Ban Houei Sane	11.8	3	37	D+40
Ban Houei Sane to Ban Dong	8.7	2	40	D+47
Ban Dong to Tchepone Airfield	17.4	3	54	D+66

AIRFIELD REHABILITATION

No airfield in Task Force Bottleneck objective areas would have been serviceable on D-Day. Those at Tchepone and Muong Phine demanded immediate actions to clear obstructions, grade and compact surfaces, apply dust palliatives, then construct taxiways, parking lots, and cargo-handling areas. The runway at Ban Houei Sane looked like moldy cheese in mid-1968, but that strip otherwise was almost as good as new. D+11 was not an unreasonable date to anticipate full operational status.

WRAP-UP

Operation Plan *El Paso* was stillborn. COMUSMACV never got the "tickets" he needed to go to Tchepone, which consisted of additional muscle—firepower, mobility, supplies, equipment, funds—and, above all, political approval. President Lyndon B. Johnson in March 1968 announced his decision not to seek reelection and Richard M. Nixon, his successor, initiated "Vietnamization" programs that caused U.S. Armed Forces and military presence in Southeast Asia to shrink instead of expand.

POSTMORTUM SPECULATIONS

No one will ever know whether Operation Plan *El Paso* would have succeeded, but a few speculations seem appropriate. The mission would have been hard to accomplish with or without determined enemy opposition in the empty Laotian lands west of Khe Sanh, which were remote from every established military facility and magnified all the miseries of combat in Vietnam, including merciless terrain, malevolent jungles, heat, malaria, typhus, leeches, and running sores. Unopposed operations moreover seem most improbable, because North Vietnam had a vested interest in motorable routes through the Laotian panhandle, which constituted the lifeline of Communist forces in South Vietnam and Cambodia.

General Giap, who could read a map as well as General Westmoreland, might have framed his own mission as follows: "Task Force Spoiler severs Routes 1 and 9 between the Tonkin Gulf coast and Laos beginning at H-Hour on D-Day to prevent U.S. and South Vietnamese Armed Forces from blocking the Ho Chi Minh Trail." Task Force Bottleneck would have been on the knife edge of existence if the North Vietnamese Army successfully isolated the port of Da Nang from the TAOR while blockading brigades were living on daily

replenishment and logisticians were struggling to build up supplies in objective areas. A few well-placed enemy mortar rounds plumped periodically on airfield runways at Muong Phine, Tchepone, and Ban Houei Sane, plus attacks on ammunition pads and POL bladder farms, would have been particularly cost effective. The Bottleneck corps might have repulsed all such efforts, but the price in blood and sweat, if not tears, almost surely would have been high.

OPERATION LAM SON 719

"Vietnamization" programs designed to strengthen South Vietnam's defensive capabilities and concomitantly reduce U.S. casualties, cut budgetary costs, and enable U.S. Armed Forces to disengage gradually began to take shape in 1969, soon after President Nixon took office.[6] He and Henry A. Kissinger, who headed the National Security Council staff, contemplated a strictly South Vietnamese amphibious thrust against North Vietnam near Vinh or an incursion into Cambodia the following year as a test to determine progress, but in December 1970 settled instead on a sizable incursion into the Laotian panhandle, which South Vietnam's President Nguyen Van Thieu, U.S. Ambassador to Saigon Elsworth Bunker, and COMUSMACV General Creighton W. Abrams preferred. Secretary of State William P. Rogers, Secretary of Defense Melvin R. Laird, Richard Helms, the Director of Central Intelligence, and Admiral Thomas H. Moorer, who then was Chairman of the Joint Chiefs of Staff, acquiesced. Ambassador G. McM. Godley obtained prior approval from Laotian Prince Souvanna Phouma.[7]

Plans and Preparations. ARVN I Corps, minus U.S. advisers but with U.S. tactical air, helicopter, and long-range artillery support from bases in South Vietnam, launched Operation *Lam Son 719* on February 8, 1971, to interdict the Ho Chi Minh Trail and obliterate the North Vietnamese base area centered on Tchepone. Few factors, however, favored success:

- D-Day occurred too late to achieve greatest benefits, because NVA supply lines from larders in Laos had been active since the dry season began 3 months earlier.
- Planning and preparation times for such an ambitious operation were painfully short after President Nixon turned on the green light in late January 1971.
- Essential elements, such as the ARVN 1st Logistical Command, until the last minute were excluded from those closely held processes for security reasons.[8]
- Enemy commanders and most participants received notifications almost simultaneously when embargoed press reports leaked.[9]
- Assault units never received the latest tactical intelligence before battles commenced.
- Khe Sanh combat base, the springboard in South Vietnam, had been abandoned and largely dismantled since summer 1968.
- Neither U.S. Armed Forces nor ARVN I Corps completed imperative logistical preparations that OPLAN *El Paso* prescribed.

The Upshot. The upshot was predictable: *Lam Son 719*, according to a South Vietnamese major general on site, "was a bloody field exercise for ARVN forces under the command of I Corps. Nearly 8,000 ARVN soldiers and millions of dollars worth of valuable equipment and materiel [including more than 100 U.S. helicopters[10]] were sacrificed" before the last troops withdrew on March 24. Enemy body counts were considerable and ARVN raiders

destroyed copious supplies but, in the final analysis, *Lam Son 719* produced few if any lasting effects on North Vietnamese abilities to infiltrate down the Ho Chi Minh Trail.[11]

KEY POINTS

- Monsoon winds alternately encourage and discourage most military operations wherever they blow.
- Geographical circumstances affect supply, maintenance, transportation, medical, and other logistical requirements at least as much as they influence combat operations.
- Logistical problems multiply and intensify in direct proportion to the distance between support bases and supported forces.
- Construction requirements soar in underdeveloped areas of responsibility.
- Rudimentary road nets magnify military dependence on airfields and inland waterways.
- Jungle-covered mountains reduce the benefits that are obtainable from airmobile forces in open terrain.
- Parachute delivery systems and helicopters can sustain small, isolated units in jungles, but large formations need main supply routes with much greater capacities.
- Pipelines distribute large quantities of petroleum and water more cost-effectively than other forms of transportation.

NOTES

1. Chapter 19 relies extensively on evidence the author accumulated in 1967-68 as Chief, Campaign Planning Group, U.S. Army Vietnam, which prepared Operation Plan *El Paso*. Documentation below cites only sources that are accessible to readers.

2. Raphael Littauer and Norman Uphoff, eds., *Air War in Indochina*, Air War Study Group (Boston, MA: Cornell University, Beacon Press, 1972), 76-90,168-169.

3. Pentagon Papers: As Published by the New York Times (New York: Quadrangle Books,1971), 461, 479, 488, 498, 545, 585-588.

4. Bruce Palmer, Jr., *The 25-Year War: American's Military Role in Vietnam* (Lexington, KY: University of Kentucky Press, 1984), 106.

5. L. Stevens, *The Trail: A History of the Ho Chi Minh Trail . . .* (New York: Garland Publishing, Inc., 1993), x-xiii, 31-122; Nguyen Duy Hinh, *Lam Son 719* (Washington, DC: U.S. Army Center of Military History, 1979), v, 9-18, 25-31.

6, Richard M. Nixon, *U.S. Foreign Policy for the 1970's: A New Strategy for Peace*, February 18, 1970, 62-72 and *Building for Peace*, February 25, 1971, 58-91 (Washington, DC: Government Printing Office); Henry A. Kissinger, *The White House Years* (Boston, MA: Little, Brown, 1979), 980-989.

7. Palmer, *The 25-Year War*, 108; Kissinger, *The White House Years*, 988-989.

8. Nguyen Duy Hinh, *Lam Son 719*, 47-48.

9. Palmer, *The 25-Year War*, 109.

10. John J. Tolson, *Air Mobility, 1961-1971*, Vietnam Studies (Washington, DC: Dept. of the Army, 1973), 234-252.

11. For the conduct and outcome of Lam San 719, see David Fulgham and Terrance Maitland, *The Vietnam Experience: South Vietnam on Trial, Mid-1970 to 1972* (Boston, MA: Boston Publishing, 1984), 68-97; Palmer, *The 25-Year War*, 109-116

20. FINAL REFLECTIONS

Many of today's problems were yesterday's solutions.

Norman R. Augustine
Augustine's Laws

THE AIM OF EVERY AREA ANALYST IS TO EVALUATE THE INFLUENCES OF PHYSICAL, CULTURAL, AND POLITICAL geography on every aspect of military policies, plans, programs, and operations at particular points in time and space. That task is exceedingly difficult, because cogent factors are pervasive, as a few Key Points extracted from preceding chapters indicate:

- Land, sea, air, and space forces each must prepare area analyses to fulfill specialized needs of combatant and support commands at every echelon.
- Armed forces that are organized, equipped, and trained to function in any given environment perform less well elsewhere until they complete essential adjustments.
- Time, distance, and modes of transportation determine how rapidly armed forces can respond to distant contingencies.
- Logistical problems multiply and intensify in direct proportion to the distance between support bases and deployed forces.
- Surface materials strongly influence the lethality of nuclear as well as conventional explosives and the ability of motor vehicles to travel cross-country.
- The characteristics of salt water influence every naval activity from ship design to employment practices on or beneath the surface of oceans and contiguous seas.
- Low cloud ceilings, poor visibility, high winds, powerful air currents, and variable barometric pressures impose critical constraints upon all land-based and naval air operations.
- Topographic features that narrow the number of suitable drop zones and amphibious landing sites generally favor defenders who can concentrate forces at probable points of decision.
- Population patterns, languages, religious preferences, cultures, customs, and social structures in areas of responsibility (AORs) directly affect prospects for success or failure of many military operations.
- Military commanders engaged in urban combat commonly must divert precious resources and manpower to control refugees and sustain the civilian populace.
- Territorial boundaries that statesmen draw with scant regard for geographical realities often become political-military trouble spots.

Global and regional AORs require periodic reviews to ensure that they still serve stated purposes. Savvy analysts accordingly remain acutely aware that it seldom is wise to stamp any assessment "APPROVED" and stash it on the shelf, because settings, situations, tactics, techniques, and technologies are subject to frequent, often unanticipated, change.

Operation *Neptune* and Operation Plan *El Paso*, which demonstrate analytical techniques in chapters 18 and 19, are illuminating in such respects. Geographic circumstances in Normandy, for example, are much the same today as in 1944, but the implications are dissimilar. Long-range attack aircraft with diversified weapon systems, guided missiles, and helicopters able to hurdle beach obstacles might have enabled Anglo-American Armed Forces to open a Second Front in Europe south of the Loire, where the German *Wehrmacht* was weak, rather than hit massive Atlantic Wall defenses head-on. Operation Plan *El Paso* developed differently in 1967-68 than it would have in 1965, when Highway 23 was the only road fit for truck traffic anywhere along the Ho Chi Minh Trail, the Route 914 cutoff had not yet been conceived, choke points at Tchepone and Ban Dong were nonexistent, and Muong Phine was the only potentially important blocking position south of Mu Gia Pass. Similar conclusions accompany almost every other historical cameo used for illustrative purposes in this document.

Perhaps the single most important lesson to be learned from the previous pages is the folly of slighting geographic factors during the preparation of *any* military plan, the conduct of *any* military operation, or the expenditure of scarce resources and funds on *any* military program. President Dwight D. Eisenhower, whose military career culminated at the five-star level, perhaps put it best when he addressed the Corps of Cadets at West Point on April 22, 1959: "The Principles of War are not, in the final analysis, limited to any one type of warfare, or even limited exclusively to war itself . . . but principles as such can rarely be studied in a vacuum; military operations are drastically affected by many considerations, one of the most important of which is the geography of the region."

APPENDIX A
ACRONYMS AND ABBREVIATIONS

ACOM	U.S. Atlantic Command
AFCENT	Allied Forces Central Europe
ALOC	air line of communication
AOR	area of responsibility
BAM	Baikal-Amur Magistral
BMEWS	ballistic missile early warning system
BMNT	beginning of morning nautical twilight
CENTCOM	U.S. Central Command
CHOP	change operational control
COCOA	critical terrain, obstacles, cover and concealment, observation and fields of fire, avenues of approach
CTZ	corps tactical zone
DEW Line	Distant Early Warning Line
DZ	drop zone
EENT	end of evening nautical twilight
EEZ	exclusive economic zone
EMP	electromagnetic pulse
EUCOM	U.S. European Command
FSCL	fire support coordination line
GLCM	ground-launched cruise missile
GPS	global positioning system
HAZMAT	hazardous material
ICBM	intercontinental ballistic missile
IFR	instrument flight rules
LEO	low earth orbit
LOC	line of communication
LZ	landing zone
MBFR	mutual and balanced force reductions
MIZ	marginal ice zone
NATO	North Atlantic Treaty Organization
NVA	North Vietnamese Army
OCOKA	observation and fields of fire, cover and concealment, obstacles, key terrain, avenues of approach

OPLAN	operation plan
PACOM	U.S. Pacific Command
POW	prisoner of war
PSYOP	psychological operations
R&D	research and development
RDJTF	Rapid Deployment Joint Task Force
SAC	Strategic Air Command
SEAL	sea, air, land
SEATO	Southeast Asia Treaty Organization
SLOC	sea line of communication
SOUTHCOM	U.S. Southern Command
TAOR	tactical area of responsibility
UNCLOS	United Nations Convention on Law of the Sea
VFR	visual flight rules

APPENDIX B
GLOSSARY OF GEOGRAPHICAL TERMS

absolute humidity: The weight of water vapor present in a given volume of air, usually expressed as grams per cubic meter or grains per cubic foot.

abyss: Ocean depths beyond the continental slope. *See also* abyssal plain.

abyssal plain: The ocean floor. *See also* abyss.

acclimatization: Adaptation to a geographic environment significantly different from that to which one is accustomed.

active layer: Soil near the surface that seasonally freezes and thaws in frigid regions. *See also* permafrost.

aerocentric: A military mindset that emphasizes air power.

aerodynamic drag: Atmospheric force that slows flight, most notably near Earth's surface where air density is greatest. Resistance above about 60 miles (95 kilometers) takes days, weeks, or months to produce significant effects.

aerospace: Earth's atmosphere plus space. *See also* atmosphere; space.

Agent Orange: A herbicide that U.S. Armed Forces used extensively to defoliate vegetation that could conceal Communist troops in Vietnam.

air line of communication (ALOC): Any aerial route that nations depend on for commercial or military purposes. *See also* line of communication.

airspace control: Processes designed to prevent fratricide, enhance air defense, and otherwise promote safe, efficient, flexible air operations within and above an area of responsibility. *See also* airspace control area; area of responsibility.

airspace control area: Bounded territory within and above an area of responsibility, subdivided as required to ensure safe, efficient, flexible air operations. *See also* airspace control; area of responsibility.

alluvium: Clay, silt, sand, gravel, and other detritus that rivers deposit downstream.

altitude: Height above mean sea level, mainly applied to positions in the atmosphere above Earth's surface. *See also* elevation.

amphibious forces: A naval force and a landing force that are organized, equipped, and trained to conduct operations from sea to a hostile or potentially hostile shore.

aquifer: A water-bearing stratum of permeable rock, sand, or gravel.

archipelago: A string of islands, such as the Aleutians and Indonesia.

arctic sea smoke: Maritime fog that occurs most often over the Arctic or Antarctic Oceans when very cold air passes over much warmer water. Occasionally occurs over inland seas when very cold winter air shifts somewhat equatorward. *See also* fog.

area analysis: A process that assesses geographic influences on military plans, programs, and operations to ascertain probable effects on friendly and enemy courses of action.

area of influence: Territory within which a regional commander could, using weapon systems and mobility means under his or her control, conduct military operations. Such territory may be much larger than the commander's area of responsibility. *See also* area of responsibility.

area of interest: Territory outside of (but not necessarily contiguous to) a regional commander's area of responsibility that warrants close attention because activities therein could significantly affect military plans, programs, and operations within the commander's AOR. *See also* area of responsibility.

area of operations: Territory within which military activities of any kind occur. It may include all or a small part of a commander's area of responsibility. *See also* area of responsibility.

area of responsibility (AOR): Territory within which a regional commander exercises responsibility and authority over, and is accountable for, all military activities by armed forces under his or her control. *See also* tactical areas of responsibility; theater areas of responsibility.

area orientation: Missions, organizations, equipment, and training that prepare individuals and military formations for projected deployment to a specific geographical region. Repeated, lengthy tours of duty in relevant countries not only help foreign area officers hone their language and cross-cultural skills, but enable them to develop close personal relationships .

aridity: *See* desert; semi-arid.

arroyo: Spanish for the bed of a narrow, steep-sided stream that dries up seasonally or during droughts (a term most often used in Southwestern United States and Mexico). Heavy rains commonly cause flash floods in such watercourses. *See also* intermittent stream; wadi.

artesian spring, well: A natural or artificial source of water that hydrostatic pressures force from depths to the surface like a fountain. *See also* spring.

astrocentric: A military mindset that emphasizes space power.

atmosphere: the envelope of air that surrounds Earth. Air becomes thinner with altitude until the vacuum of space replaces it completely.

atmospheric pressure: The weight that a vertical column of air exerts on any given point below in response to gravitational attraction. Readings are highest at sea level and gradually decrease at greater elevations.

atoll: a circular reef of coral and other materials that encloses a lagoon. *See also* lagoon.

aurora borealis: "Northern lights;" ghostly displays of colored streamers, rays, arcs, bands, curtains, draperies, sheets, and/or patches that shimmer and flit across skies at high latitudes in the Northern Hemisphere. Called aurora australis in the Southern Hemisphere.

auroral zones: Arctic and Antarctic regions where charged particles ejected from the sun and deflected by Earth's magnetic field disrupt radio frequency propagation.

axis of advance: A control measure, usually a road, identifiable natural terrain corridor, or series of points that commanders order subordinate ground forces to follow from present positions to objectives in enemy territory.

bank: A mass of clouds or fog; a mound or ridge; plains below the ocean surface but above the continental shelf; the sloping margin of an inland watercourse or lake. River banks are designated left or right from viewpoints that face downstream.

bar: A submerged or partly submerged accumulation of alluvium along seashores, rivers, and smaller streams. Such obstructions inhibit or prevent navigation by ships and craft.

baseline: A line, usually the low water line, used to measure the breadth of a coastal state's territorial sea. *See also* exclusive economic zone; territorial sea.

beach: Relatively horizontal terrain that extends from a coastline inland to the first marked change in topography or vegetative cover. Cliffs and other vertical terrain that rise abruptly from the sea lack beaches.

beachhead: An area on a hostile or potentially hostile coast that, when seized and held, facilitates the continuous landing of troops and materiel. It also affords a base from which to expand operations inland. *See also* bridgehead.

beginning of morning nautical twilight (BMNT): A period of incomplete darkness before sunrise when the sun is 12 degrees below the celestial horizon.

blackout: The disruption of radio and radar transmissions for minutes or many hours after a nuclear detonation in space ionizes Earth's atmosphere over a wide area. Short-wave, high-frequency propagations are most susceptible. *See also* electromagnetic pulse.

blizzard: An intensely cold wind of 30 knots or greater velocity that blows snow and thereby reduces visibility to half a mile or less (about one kilometer) at ground level.

"blue water": Naval slang for high seas (open oceans) beyond the littoral.

bog: Spongy, poorly-drained soil variously covered with peat, sedges, heath, mosses, lichens, and other stunted plants. *See also* marsh; swamp.

boundary: A borderline, sharply- or ill-defined, between countries or military formations. *See also* frontier.

breakbulk ship: An oceangoing transport that carries undifferentiated dry cargo of various sizes and shapes. *See also* container ship.

breakwater: A wall or other offshore structure installed to protect a harbor or beach from waves that might damage ships or infrastructure.

bridgehead: An area on the far side of a river in hostile or potentially hostile territory that, when seized and held, facilitates the continuous crossing of troops and materiel. It also affords a base from which to continue offensive military operations or shield key terrain to the rear. *See also* beachhead.

"brown water": Naval slang for seas along the littoral; the milieu of riverine and swamp operations.

buffer zone: a territorial strip designed to separate the possessor from present or potential external aggressors and thus provide some degree of protection.

calving: The breaking away of ice masses from ice walls, ice shelves, and icebergs.

canal: a manmade channel that connects two or more bodies of water, such as rivers, seas, and oceans; some canals connect inland ports with open water.

canopy: The uppermost layer of foliage within a forest; two or more distinctive tiers typify most tropical rain forests. *See also* jungle; rain forest.

catch basin or catchment: *See* drainage basin.

ceiling: See cloud ceiling.

celestial sphere: An imaginary, nonrotating orb of indefinite radius with its center at Earth's core. Its equator is a projection of Earth's equator. Various features afford a frame of reference for locating orbital objects in space. *See also* declination; right ascension.

change operational control (CHOP): The date, Coordinated Universal Time, and sometimes the place that a military force passes from one commander's jurisdiction to another's. Commonly employed by naval forces.

channel: The deepest and usually swiftest part of any stream; the deepest, most navigable part of any strait; the deepest, most navigable water in harbors.

choke point: A constricted spot along any land or sea route. Such spots are especially vulnerable to interdiction.

circadian rhythm: The 24-hour biological cycle that governs most human activities on Earth. Disruptions due to "jet lag," which lengthy space flights magnify immensely, to greater or lesser degrees cause psychophysical problems such as fatigue, inattentiveness, and emotional instability.

circumterrestrial space: A region that abuts Earth's atmosphere at an altitude of about 60 miles (95 kilometers) and extends to about 50,000 miles (80,000+ kilometers). Most military space missions currently are confined therein.

cislunar space: Wedge-shaped territory between Earth and its moon. One point touches Earth's atmosphere, others touch lunar libration points L-4 and L-5. See also lunar libration points.

clan: A relatively small, tightly knit group of families whose members claim common ancestry or identify with a common totem. *See also* ethnic group; race; tribe.

climate: Weather patterns discernible from meteorological records that are most reliable when compiled hourly at specified locations over a period of years. Resultant statistics, which reveal means and extremes, indicate probabilities that particular conditions will prevail at particular times on particular days or months at each place. *See also* meteorology; weather.

cloud: A visible aggregate of minute water or ice crystals suspended in the atmosphere. Air-to-ground visibility by human eyes and most technological sensors is severely limited or nonexistent, whereas surface-to-surface visibility is unaffected. *See also* fog.

cloud ceiling: The distance between a cloud base and terrain directly below.

cloud cover: The amount of cloud at any given location, stated in eighths (1/8 to 4/8 is scattered; 5/8 to 7/8 is broken; 8/8 is overcast). Several layers of scattered clouds may cause broken or overcast conditions.

COCOA: Acronym for **C**ritical terrain; **O**bstacles; **C**over and concealment; **O**bservation and fields of fire; **A**venues of approach. *See also* OCOKA.

concealment: Protection against nothing more than enemy observation. *See also* cover.

container ship: An oceangoing transport that carries cargo in rectangular steel boxes that stack vertically in ready-made cells and horizontally on top of strong hatch covers so loading and unloading is rapid and wasted space is negligible. *See also* breakbulk ship.

continental shelf: A generally undulating submarine plain that declines gently seaward from major land masses. Widths vary from nonexistent to 800 miles or more (1,300 kilometers). Depths usually are less than 100 fathoms (600 feet, 180 meters) *See also* continental slope.

continental slope: A precipitous incline, generally 10-20 miles wide, that plunges from the continental shelf to the bottom of the oceanic abyss, which is several miles deep in some places. *See also* abyss; continental shelf.

corduroy: Logs laid at right angles across soggy roads, tracks, and trails to improve vehicular trafficability.

core area: A nationally important, even vital, center or region. *See also* key terrain.

corps tactical zone (CTZ): The area of responsibility for a corps-size military force.

cover: Protection against the effects of enemy weapons as well as observation. *See also* concealment.

crest: The top of a mountain, hill, or ridge. *See also* military crest; topographical crest.

critical terrain: *See* key terrain.

cultural geography: An interdisciplinary field that deals with spatial variations in learned human behavior, including the geographic diversity of settlements, languages, religions, social structures, the arts, economies, technologies, and other activities. *See also* geography; military geography; physical geography; political-military geography.

current: The flow of water in any stream, canal, sea, or ocean calculated in terms of direction and velocity.

D-Day: The date that any specified military operation is scheduled to commence or actually commences.

declination: The celestial equivalent of latitude. Specifically, the angular distance north or south of the celestial equator, measured along a great circle that passes through the celestial poles. *See also* celestial sphere; right ascension.

deep space: Interplanetary space beyond the Earth-Moon System. *See also* circumterrestrial space; outer space.

defilade: A position protected against enemy flat trajectory weapons; a natural or artificial mask, such as a ridge, hummock, building, or forest, between such weapons and their targets.

defile: A natural or artificial constriction along a surface route, such as a mountain pass, a gorge, a strait, or a narrow city street.

delta: Triangular alluvial deposits at the mouth of a river. Some deltas are small, others such as those of the Nile, Mekong, and Mississippi Rivers measure much more than 100 miles (160 kilometers) on each side. *See also* alluvium.

demography: The study of human populations, especially size, density, distribution, and other vital statistics. It is an interdisciplinary field that melds geography with mathematics, biology, medicine, sociology, economics, history, and anthropology.

density altitude: Air pressure at mean sea level (29.92 inches of mercury) and 59^0 F (15^0C) corrected to account for greater heights and higher temperatures, which *decrease* air density and *increase* density altitude. Density altitude calculations are critically important, because lighter air reduces aircraft motive power, limits lift capacities, demands faster true airspeed and a longer roll for takeoffs, slows rates of climb, requires faster true airspeeds to sustain flight, lengthens rolls after landings, and makes stopping more difficult.

deposition region: A dense radioactive layer that accumulates 25-30 miles (40-48 kilometers) above Earth when a cascade of gamma rays from a nuclear explosion at greater altitude

collides with the upper atmosphere. Resultant charge imbalances create electromagnetic pulse. *See also* electromagnetic pulse.

desert: A region in which average annual precipitation generally measures less than 10 inches (25 centimeters). Arctic regions that receive a bit less fail to qualify, because evaporation is slow. Hot regions that receive a bit more qualify, because evaporation is rapid. Deserts may be mountainous or flat, sandy or stony. *See also* semiarid.

dewpoint: The temperature at which water vapor turns into water droplets through a process called condensation.

Distant Early Warning (DEW) Line: A string of radar stations across the arctic from the Aleutian Islands to the Atlantic Ocean, installed during the Cold War to alert U.S. and Canadian defenders of a surprise Soviet attack over the North Pole.

diurnal: A daily occurrence or cycle.

divide: A watershed between two drainage basins. *See also* drainage basin.

doldrums: An atmospheric belt astride the equator, characterized by calms that shifting breezes and squalls intermittently interrupt.

drainage basin: Lands on one side of a topographical divide that accumulate rainfall and snow, then distribute runoff to lower elevations via a system of small streams that are tributary to rivers.

drift: Ocean current velocity. *See also* current; set.

drop zone (DZ): An area into which transport aircraft deliver troops, equipment, and supplies by parachute.

Earth-Moon System: Space and all its contents within an imaginary sphere that extends approximately 480,000 miles (772,000 kilometers) in every direction from Earth's core. Large, solid matter is confined mainly to Earth, its moon, and asteroids, but invisible atmosphere, gravity, and the Van Allen radiation belts are immensely important.

electromagnetic pulse (EMP): Prodigious current that results from a nuclear explosion in the upper atmosphere or space, peaks 100 times faster than lightning, then bolts toward Earth. Unshielded electronics within several hundred miles of the epicenter may be disabled. *See also* deposition region.

elevation: Height above mean sea level. Applied mainly to positions on Earth's surface. *See also* altitude.

enclave: Foreign territory within a country or coalition. East Germany, for example, enclosed West Berlin throughout the Cold War. *See also* exclave.

end of evening nautical twilight (EENT): Occurs after sundown when the sun is between the horizon and 12 °F below.

environment: Geographical circumstances that prevail at any given place; the sum total of all biological, chemical, and physical factors to which organisms are exposed.

estuary: An arm of the sea into which fresh water streams empty and mingle with intruding salt water tides.

ethnic group: Culturally distinctive peoples with common physical characteristics, customs, language, religion, and traits. *See also* clan; race; tribe.

exclave: Part of a country or coalition enclosed within the territory of a foreign power. West Berlin, for example, lay entirely inside East Germany throughout the Cold War. *See also* enclave.

exclusive economic zone (EEZ): A maritime area adjacent to territorial seas that is subject to legal provisions embedded in the United Nations Convention on Law of the Sea. Coastal states are authorized to exercise sovereignty over natural resources and jurisdiction over some scientific research and environmental projects within the EEZ. The outer limit may coincide with the outer edge of the continental shelf in some cases. *See also* continental shelf; territorial sea.

exosphere: Earth's atmosphere from an altitude of about 300 miles (480 kilometers) to 2,000+ miles (3,200+ kilometers), where it terminates in a hard vacuum.

exterior lines of communication: Relatively long routes that lead to any given area of operation from distant positions. Such routes not only make it difficult for military commanders to concentrate armed forces rapidly at decisive points and sustain them after arrival but may also be difficult to safeguard if they traverse hostile territory. *See also* interior lines of communication; line of communication.

fallout: *See* radioactive fallout.

fast ice: Sea ice that forms along, and remains attached to, coasts. It extends in some places as far out as the 10-fathom curve (60 feet, 18 meters) in late winter. *See also* ice shelf.

fetch: The distance over open seas that winds blow without a significant change in direction. Wind speeds and fetch determine wave heights.

field fortification: *See* fortification.

fire support coordination line (FSCL): An imaginary line, preferably drawn along well-defined terrain features, used to control fire support of military operations. It is drawn to ensure maximum freedom of military action, yet to minimize "fratricide" and aerial interference with ground schemes of maneuver.

fog: A cloud in contact with or just above ground level. Thin fog limits surface-to-surface visibility to no more than 1 nautical mile (1.3 kilometers); visibility in dense fog is 50 yards (45 meters) or less. *See also* arctic sea smoke; cloud: sea smoke.

folkways: Customary modes of thinking, feeling, and acting common to a social group. Key considerations include traditions, values, motivations, hopes, fears, and taboos; manners and mannerisms; religious beliefs; rites, rituals, and holidays; behavior patterns; social hierarchies; lines of authority; moral codes; sexual mores; work ethics; dietary regimes.

footcandle (fc): A unit of illumination equal to one lumen per square foot (929 square centimeters). Full sunlight at zenith produces about 10,000 fc on a horizontal surface; full moonlight provides about 0.02 fc. Illumination for steady reading demands about 10 fc.

fort: Any permanent strongpoint or fortified line occupied exclusively or primarily by a military garrison. The most durable are mainly subterranean. Modern construction materials favor stone, concrete, and steel. *See also* fortification; fortress.

fortification: Any permanent strongpoint or fortified line; temporary field fortifications typified by foxholes and weapon pits as well as elaborate trench and bunker systems. *See also* fort; fortress.

fortress: A permanent strongpoint, such as a castle or walled city, designed primarily to protect civilian inhabitants. *See also* fort; fortification.

frontier: Territory that parallels and somewhat overlaps the boundary between countries. *See also* boundary.

geography: An interdisciplinary field that studies the Earth, including land, sea, air, space, and all life within those mediums. *See also* cultural geography; military geography; physical geography; regional geography.

geopolitics: Interactions between geography and foreign policies; governmental policies that emphasize such relationships.

geostationary orbit: The only geosynchronous orbit that circles 22,300 miles (35,887 kilometers) above Earth's equator. Spacecraft on that path appear to stand still when viewed from Earth's surface, because they constantly maintain the same relative position. *See also* geosynchronous orbit; orbital period.

geosynchronous orbit: Any eliptical flight path that makes figure eights from a center line over Earth's equator at an average ground track altitude of 22,300 miles (35,887 kilometers). Spacecraft on such paths complete precisely one trip per day, because their 24-hour period is the time it takes Earth to rotate once. *See also* geostationary orbit; orbital period.

glacier: A mass of compacted snow and ice that continually moves from higher to lower ground or, if afloat, spreads continuously. Various types include island ice sheets, ice shelves, ice streams, ice caps, ice piedmonts, cirques, and mountain (valley) glaciers.

Global Positioning System (GPS): A U.S. Department of Defense-operated, spaced-based, radio-navigation system that in 1997 consisted of 24 satellites plus ground support. GPS precisely computes latitude, longitude, altitude, and time for fixed and mobile users wherever they may be. Such information is invaluable for navigational and weapon control purposes.

grade; gradient: A longitudinal slope, the steepness of which can be calculated by dividing the vertical rise or fall by the horizontal distance. A 23-foot rise or fall in 100 feet is a plus or minus 23% grade.

gravity (g): A force of mutual attraction between bodies as a result of their mass. Earth and its moon influence all matter within their respective fields. The effects of both fields diminish with the square of the distance from each source. One g is equivalent to the acceleration of gravity on a body at sea level. *See also* gravity well.

gravity well: Imaginary, funnel-shaped walls, steep at the bottom but level on top. Greater energy is required to climb out (gravity hinders) than to maneuver on top (where gravity is slight) or drop down (gravity helps). *See also* gravity.

great circle: Any ring formed by the intersection of Earth's surface with a plane that passes through Earth's center. A great circle is the shortest distance between any two or more points on such an arc.

"green water": Naval slang for solid waves (not sea spray) that wash over ships during storms or heavy weather, where they may damage equipment or wash crew members overboard.

harbor: A sheltered coastal location, natural or improved, that protects ships and smaller craft from winds and waves when they are not at sea. *See also* seaport.

hardstand: A stabilized soil or paved parking area at an airfield.

hazardous material (HAZMAT): Toxic and infectious wastes that require special treatment, storage, transportation, and disposal.

hazardous waste: Toxic, infectious, flammable, corrosive, explosive, and radioactive substances that await disposal.

H-Hour: The specific time on D-Day that any specified military operation is scheduled to commence or actually commences. *See also* D-Day.

high earth orbit: A flight path in circumterrestrial space above geosynchronous altitude, between 22,300 and 50,000-60,000 miles from Earth's surface (35,887 to 80,465-96,560 kilometers).

horse latitudes: Two atmospheric belts centered on 30 degrees north and 30 degrees south latitude, characterized by high barometric pressures and calms that shifting breezes occasionally interrupt.

humidity: Water vapor in the air. *See also* absolute humidity; relative humidity.

hydrology: A science that deals with the physical and chemical properties, transformations, combinations, and movements of water on Earth, including precipitation, its discharge into seas, evaporation, and return to the atmosphere.

hypothermia: A consequence of prolonged exposure to cold or wet conditions that cause human body temperature to drop below normal with deleterious, even fatal, effects.

hypoxia: A condition that occurs when body tissues receive insufficient oxygen, especially at high elevations and altitudes.

iceberg: A large chunk of fresh water ice, floating or aground, that a glacier has calved. *See also* calving; fast ice; glacier; ice floe.

ice floe: Floating sea water (salty) ice, more common than icebergs, that originates as slush, separates into "pancakes," then forms sheets. Some floes drift out of the Arctic Basin the first year, while those that remain become much harder and thicker. Often called pack ice. *See also* fast ice; iceberg; ice floe.

ice shelf: *See* fast ice.

illumination: A measure of sunlight, moonlight, starlight, and luminescent atmosphere. *See also* footcandle; light data.

infrastructure: All bases, facilities, other permanent or semi-permanent installations, and fabrications used to equip, train, control, move, and otherwise support armed forces.

inland waterway: Any river, stream, canal, lake, or interior sea that serves as a transportation route.

inner space: *See* circumterrestrial space.

instrument flight rules (IFR): Air traffic control regulations that limit flight clearances to pilots proficient in the use of navigational gear and to aircraft so equipped when low cloud ceilings, poor visibility, or other weather conditions are below specified minimums. *See also* Visual Flight Rules.

interior lines of communication: Relatively short, secure routes within any given area of operation that provide mobility advantages not available to enemy forces. Such routes enable military commanders to concentrate armed forces most rapidly at decisive points inside or near that area and sustain them after arrival. *See also* exterior lines of communication; line of communication.

intermittent stream: Any inland watercourse that dries up seasonally or during droughts. Common in deserts. *See also* arroyo; wadi.

ionosphere: A region of electrically charged (ionized) thin air layers that begins about 30 miles above Earth's atmosphere (48 kilometers) and overlaps the lower exosphere. The maximum concentration of electrons occurs at about 375 miles (600 kilometers). Effects on high frequency radio propagation are important. *See also* exosphere.

isothermal area: A region within which temperatures remain constant.

jetty: A breakwater that connects with the shore. *See also* breakwater; mole.

jungle: Tropical or subtropical woodlands with dense primary or secondary undergrowth. *See also* rain forest.

key terrain: Any geographical point or distinctive area the seizure, retention, destruction, or control of which would confer a marked (preferably decisive) advantage on any military force.

lagoon: A shallow body of normally placid sea water between a reef or other offshore barrier and an island or the mainland. *See also* atoll.

landing zone (LZ): A prepared or extemporaneous site suitable for operations by helicopters or fixed-wing aircraft with very short or vertical takeoff and landing capabilities.

latitude: The angular distance north and south from Earth's equator measured through 90^0. See also longitude.

lead: Any long crack or fracture through sea ice that is navigible by ships or smaller craft. Icebreakers look for and enlarge such passageways.

libration points: *See* lunar libration points.

light data: Tables that for particular periods and places compute morning and evening twilight, sunrise, sunset, moonrise, moonset, and moon phases. *See also* footcandle; illumination.

line of communication (LOC): Any foreign or domestic land, sea, air, or space route that nations depend upon for commercial purposes; any such route that military commanders use to deploy, employ, sustain, and control armed forces. *See also* air line of communication; exterior line of communication; interior line of communication; sea line of communication.

line-of-sight: An unobstructed view from point A to point B.

littoral: A coastal region that, for purposes of this document, extends no more than 100 miles (185 kilometers) seaward from the shoreline and an equal distance inland.

local relief: Differences in elevation between high and low ground within any given territory on Earth, its moon, or other planet. *See also* relief.

longitude: Meridians through any given place expressed in degrees east and west of the Prime Meridian (zero degrees), which passes through the original site of the Royal Observatory in Greenwich, England. *See also* latitude; meridian.

low earth orbit (LEO): Any flight path in circumterrestrial space between sensible atmosphere and the bottom of the Van Allen belts (60-250 miles, 95-400 kilometers), with some leeway in both directions. Elliptical orbits may dip in and out of LEO during each trip around Earth.

lunar libration points: Five three-dimensional positions in space, all influenced by the gravitational fields that surround Earth and its moon. L1, L2, and L3, on a line with Earth and the moon, are considered unstable. Spacecraft probably would have to expend energy to remain long at those locations. L4 and L5, 60^0 ahead of and behind the moon in its orbit, are considered stable. Spacecraft probably could remain at those locations indefinitely without expending fuel, because gravitational fields are in balance.

magnetosphere: A vast region dominated by Earth's magnetic field, which traps charged particles, including those in the Van Allen belts. The magnetosphere begins in the upper

atmosphere, where it overlaps the ionosphere, and extends several thousand miles farther into space. *See also* ionosphere.

marecentric: A military mindset that emphasizes sea power.

marginal ice zone (MIZ): A region of more or less mushy ice affected somewhat by waves and swell between open sea water and solid ice closer to shore. Widths vary from a few to about 50 miles (80 kilometers), depending on temperatures, winds, and currents.

marsh: Spongy, wet, or watery meadows covered with tall grass, reeds, and cattails. *See also* bog; swamp.

megalopolis: An immense urban area populated by at least 10 million people.

meridian: A great circle on Earth's surface that passes through the North and South Poles. *See also* great circle; longitude.

mesosphere: Atmosphere 30-50 miles (48-80 kilometers) above Earth's surface. Temperature inversions that occur in the stratosphere cease. Thermometer readings of -100 ^{0}F (-73 ^{0}C) are normal. *See also* stratosphere.

meteorology: A science that concerns atmospheric phenomena, especially weather conditions and forecasting.

military crest: The highest point on any slope, often lower than the peak, from which views are unobstructed all the way to the bottom. *See also* crest; topographical crest.

military geography: A geographic specialty that concerns all physical, cultural, and other environmental influences over military policies, plans, programs, and combat/support operations at all levels in global, regional, and local contexts. *See also* cultural geography; geography; geopolitics; physical geography; political-military geography.

mirage: An optical phenomenon that makes objects seem distorted, displaced (raised or lowered), magnified, multiplied, or inverted due to atmospheric refraction that occurs when a layer of air near Earth's surface differs greatly from surrounding air. Common in desert heat.

mole: A jetty with a road on top. *See also* breakwater; jetty.

neap tides: Tides about 20% lower than average, which occur twice a month when the sun offsets the moon's gravitational pull at the time of 1st and 3d quarters and the sun and moon are at right angles. *See also* spring tides; tides.

nuclear fallout: *See* radioactive fallout.

observation: The ability of military personnel or sensors to see objects within any given area.

obstacle: Any natural or manmade object that prevents, delays, or diverts the movement of military forces.

oceanography: A science that deals with the seas, especially their boundaries, depths, the physics and chemistry of salt water, underwater topography, marine biology, and resources.

OCOKA: Acronym for **O**bservation and fields of fire; **C**over and concealment; **O**bstacles; **K**ey terrain; **A**venues of approach. *See also* COCOA.

open city: Any urban center that enemies on request agree to refrain from or cease attacking, but generally may occupy unopposed.

orbit: The path of any object that flies through space in accord with the physical laws of energy and momentum. Spacecraft that circumnavigate Earth must maintain enough velocity to counterbalance gravity, but not enough to overcome its pull.

orbital period: The time it takes a spacecraft or other object to circumnavigate Earth, its moon, or another planet.

outcrop: Any bedrock exposed on the surface.

outer space: All of the Earth-Moon System except circumterrestrial space. It extends from about 50,000 miles (80,465 kilometers) above Earth's surface to about 480,000 miles (772,000 kilometers), twice the distance from Earth to its moon. *See also* circumterrestrial space; deep space.

pack ice: Any sea ice, other than fast ice, no matter what form or how disposed. *See also* fast ice.

permafrost: Perennially frozen soil at various depths beneath Earth's surface in frigid regions. *See also* active layer.

permeability: The capacity of porous rocks and soils to hold or transmit water.

physical geography: An interdisciplinary field that deals with all Earth and space sciences. Typical topics include astronomy, biology (plant and animal life), climatology, geology, geomorphology (land forms), hydrography, meteorology, oceanography, and pedology (soil sciences). *See also* cultural geography; military geography; political-military geography.

physiography: *See* physical geography.

pier: A wharf that projects into harbor waters and thus provides berths on both sides (sometimes at the head as well). *See also* wharf.

plimsoll lines: Markings drawn on the hull of a cargo ship to indicate whether it is safely loaded.

political-military geography: An interdisciplinary field that concerns relationships between foreign policy, military affairs, and geography. Typical topics include areas of responsibility, diplomacy, foreign relations, dissimilar military Service perspectives, strategy, operational art, and tactics. *See also* cultural geography, geography; military geography; physical geography.

port: *See* seaport.

precipitation: Moisture that falls from clouds. Air and surface temperatures determine whether precipitation takes the form of rain, snow, sleet, hail, or icy glaze.

pressure: *See* atmospheric pressure.

quay: A wharf. *See also* wharf.

race: Genetically distinctive people derived from Amerind, Austroloid, Caucasoid, Mongoloid, or Negroid stock. *See also* clan; ethnic group; tribe.

radioactive fallout: The precipitation of radioactive particles from clouds of debris produced by nuclear detonations, especially surface bursts that suck huge amounts of material into mushroom stems, after which winds aloft may waft a deadly mist over immense areas.

rain forest: Dark, dank, tropical woodlands where annual precipitation exceeds 100 inches (250 centimeters) and lofty evergreen trees form a continuous canopy that may contain two or more tiers. Little undergrowth exists except along streams and in clearings where sunlight reaches the forest floor. *See also* jungle.

reef: A chain of rocks, a ridge of sand, or a coral formation slightly submerged or nearly so which blocks or impedes passage between open ocean and beaches, even for flat-bottomed boats.

region: A large geographic area that is physically or culturally homogeneous. *See also* regional geography.

regional geography: A multidisciplinary field that subdivides Earth and space into such distinctive areas as Europe, Asia, and Africa south of the Sahara, then describes the attributes of each, with particular attention to political, military, economic, social, and other implications. Regional geography in a different vein addresses such homogeneous areas as mountains, deserts, and jungles. *See also* geography.

relative humidity: The actual amount of water vapor in the air compared with the greatest amount possible at the same temperature. Usually expressed as a percentage. *See also* absolute humidity; humidity.

relief: The irregularities of land surfaces and submarine topography; differences in elevation between adjacent terrain features. *See also* local relief.

right ascension: The celestial equivalent of longitude. The constellation Aires, against which spectators on Earth see the sun when it crosses Earth's equator (the vernal equinox), defines the prime meridian. Astronomers measure angular positions in space east from that celestial counterpart of Greenwich Observatory. *See also* declination.

riverine operations: Military activities along rivers and in wetlands. *See also* "brown water;" wetlands

Rome Plow: An armored bulldozer fitted with a blade designed to clear small trees and dense vegetation. Used extensively by U.S. Armed Forces in Vietnam.

runoff: Precipitation that does not sink into the ground, but flows over the surface into rivers and other streams.

savanna: Tropical or subtropical grasslands with scattered trees and drought-resistant plants.

sea line of communication (SLOC): Any maritime route that nations depend on for commercial or military purposes. *See also* line of communication.

seaport: A harbor that includes berthing, cargo-handling, storage, maintenance, and clearance facilities. *See also* harbor.

sea smoke: A phenomenon that occurs when very cold air over relatively warm open water produces steamy condensation that sometimes rises several hundred feet (100+ meters). *See also* arctic sea smoke.

semiarid: A region in which average annual precipitation measures between 10 and 20 inches (25-50 centimeters). *See also* desert; steppe.

set: The direction that ocean currents move. *See also* current; drift.

sight defilade: A position screened against or shielded from enemy observation. *See also* concealment; defilade.

slope: *See* grade; gradient.

soil trafficability: The capacity of surface materials to support cross-country movement by motor vehicles.

solar flares: Spectacular, pervasive outbursts of energy that emanate periodically from the sun, accompanied by high-speed protons that comprise a potentially lethal radiation hazard to any unshielded form of life in space. Intense and sudden ionospheric disturbances inflict fadeouts and other debilitating effects on long-range telecommunications. Major flares last from a few minutes to several hours.

space: The universe and all of its contents, except Earth and its atmosphere. *See also* circumterrestrial space; cislunar space; deep space; outer space.

spacecraft: Any manned or unmanned vehicle intended primarily for operations beyond Earth and its atmosphere.

space weather: Phenomena that occur 30 miles (50 kilometers) or more above Earth.

spring: A natural flow where the water table intersects Earth's surface. *See also* artesian spring, well.

spring tides: Tides about 20 percent greater than average arise twice a month when the sun reinforces lunar pull at the time of new and full moons and the Earth, sun, and moon are directly in line. *See also* neap tides; tide.

steppes: Vast, semiarid, treeless, grassy plains in European Russia and Central Asia. *See also* semiarid.

stratosphere: Atmosphere 10 to 20 miles (16 to 48 kilometers) above Earth's surface. Life support systems are essential. Temperatures decrease with altitude in lower layers, but inversions occur at the top, where maximum readings reach about 45 °F (7.2 °C).

swamp: A generic term for wetlands. *See also* bog; marsh.

swell: Long, low, parallel, crestless waves that continue almost indefinitely after motivating winds abate. *See also* wave.

tactical area of responsibility (TAOR): Any AOR below theater level. *See also* area of responsibility; theater.

taiga: Moist, subarctic, coniferous forests, mostly spruce and fir, the northern frontier of which touches tundra.

terracentric: A military mindset that emphasizes land power.

terrain: All physical and cultural geographical features within any given area.

territorial sea: A maritime area that includes air space and the seabed over which coastal countries exercise sovereignty. Such countries may claim rights up to 12 nautical miles from the baseline, according to the United Nations Convention on Law of the Sea. *See also* baseline.

theater: A regional area of responsibility, such as Western Europe, North Africa, and Southeast Asia. *See also* area of responsibility; region.

thermocline: A layer of increasingly colder, saltier ocean water that separates relatively light, seasonally-variable mixtures near the surface from a dense isothermal layer several thousand feet below. *See also* isothermal area.

thermosphere: Thin atmosphere 30-50 miles (48-80 kilometers) above Earth's surface, where tremendous inversions cause temperatures to increase dramatically. Peak readings near the top may reach 2,250 °F (1,250 ° C). Diurnal variations probably are several hundred degrees.

tidal current: The alternating horizontal movement of water that rises and falls with tides. The direction in relatively open locations rotates continuously through 360 degrees diurnally or semi-diurnally. Local topography strongly influences tidal current characteristics in coastal waters. *See also* tide; tidewater.

tide: The rising and falling of oceans, seas, and large lakes twice daily in response to unequal gravitational attractions of the sun and moon. *See also* neap tide; spring tide; tidal current; tidewater.

tidewater: That portion of any river affected by the ebb and flow of tides. *See also* tide.

tombolo: A sand or gravel bar that connects an island to the mainland or another island.

topographical crest: The highest point on any slope. *See also* crest; military crest.

topography: The configuration of land or underwater surfaces, especially relief and other natural features. *See also* relief; terrain.

town plan: The current configuration of any city, town, village, or hamlet, which may or may not reflect a preconceived design.

trafficability: *See* soil trafficability.

tribe: A group of culturally and linguistically homogeneous people who occupy certain territory. *See also* clan.

troposphere: Atmosphere from Earth's surface to about 10 miles (16 kilometers) above the equator and half of that altitude near the North and South Poles. Most clouds, winds, precipitation, and other weather phenomena occur in this region.

tundra: An arctic or subarctic plain, level to undulating, treeless, with permanently frozen subsoil and a mucky surface that supports stunted plants such as mosses and lichens.

twilight: Periods of incomplete darkness before sunrise and after sunset. Durations vary from a few minutes to many hours, depending on latitude and season. *See also* Beginning of Morning Nautical Twilight; End of Evening Nautical Twilight.

urban area: Any city or built-up portion thereof. *See also* urbanization; urban sprawl.

ubanization: Any plot of land where population densities equal or exceed 1,000 persons per square mile (about 3 square kilometers). *See also* urban area; urban sprawl.

urban sprawl: The coalescence of several cities to form a contiguous metropolitan area many miles long and wide.

Van Allen belts: Two intense radiation layers trapped in Earth's magnetosphere from 45 degrees north to 45 degrees south latitude. The lower layer begins between 250 and 750 miles (400-1,200 kilometers) above Earth's surface and tops at 6,200 miles (9,655 kilometers). A low particle slot separates it from the upper layer, which terminates at 37,000-52,000 miles (59,550-83,685 kilometers), depending on solar activity. Protons are most prominent at 2,200 miles (3,550 kilometers). Electron flux peaks at approximately 9,900 miles (15,930 kilometers). Spacecraft need shielding to transit either Van Allen belt safely. *See also* magnetosphere.

visibility: The greatest distance at which observers with 20/20 eyesight can see and identify prominent objects unaided by binoculars or night vision devices.

visual flight rules (VFR): Air traffic control regulations that pertain when cloud ceilings, visibility, and other weather conditions are more favorable than specified minimums.. *See also* Instrument Flight Rules.

wadi: The bed of a stream that dries up seasonally or during droughts (a term most commonly used in North Africa and the Middle East). Heavy rains commonly cause flash floods in such water courses. *See also* arroyo; intermittent stream.

watershed: *See* drainage basin.

water table: The upper limit of saturated soil, which may be on the surface or many feet (meters) below.

wave: Solid water that forms peaks and troughs above and below the normal surface of oceans, seas, and large lakes. Waves on open seas are generated in four ways: by winds that act on the surface; by changes in atmospheric pressure; by seismic disturbances such as earthquakes; and by tidal attractions of the sun and moon. *See also* wave period.

wave period: The time it takes one wave crest to succeed another.

weather: The condition of Earth's atmosphere at present and for the predictable future. *See also* climate; meterology; weather forecast.

weather forecast: Predicted atmospheric conditions at a point, along a route, or within a given area for a specified period of time. Reliability decreases as forecast periods increase. Predictions from 48 to 96 hours in the future are called "outlooks."

wetlands: Any swamp, bog, or marsh.

wharf: A structure built alongside, or at an angle to, the shore of a seaport or navigable inland waterway where ships and smaller craft receive and discharge cargo and passengers.

whiteout: A weather phenomenon that occurs when snow obliterates surface features, overcast eliminates shadows, and the horizon is invisible. Earth and sky seem inseparable.

wind chill: The effect of moving air on exposed flesh at any given temperature. High velocities produce low sensible temperatures.

wind shear: See-saw effects along boundaries between strong air currents that race in opposite directions above and below one another.

APPENDIX C
A BASIC GEOGRAPHIC LIBRARY

The basic geographical library below consists entirely of books and military manuals. For relevant magazine and newspaper articles that address specific topics from various perspectives and in greater detail see:

- Notes in this document as well as endnotes, footnotes, and bibliographies in books cited below
- *Air University Library Index to Military Periodicals*, Maxwell Air Force Base, AL, Air University Library, 1963- , distributed on CD ROM by EBSCO Publishing, Peabody, MA, 01960
- *Bibliography of Military Geography*, vols.1-4, West Point, NY, Dept. of Geography and Computer Science, U.S. Military Academy (U.S. Government Printing Office, 1968)
- *Bibliography of Military Geography*, compiled by Louis C. Peltier, Military Geography Committee, Association of American Geographers, April 1962

PHYSICAL GEOGRAPHY

GENERAL

Gabler, Robert E. 1996. *Essentials of Physical Geography*. 5th ed. New York: Harcourt, Brace, and Jovanovich.

Strahler, Arthur N., and Alan H. Strahler. 1978. *Modern Physical Geography*. New York: John Wiley. Deffontaines, Pierre, ed. 1965. *Larousse Encyclopedia of World Geography*. 1965. New York: Odyssey Press.

LAND

Overviews

Field Manual 30-10: *Terrain Analysis*. March 27, 1972. Washington, DC: Dept. of the Army (superseded by FM 5-33, same title, but contains more detailed information).

Technical Manual 5-545: *Geology*. July 1971. Washington, DC: Dept. of the Army.

Mountains

Field Manual 90-6: *Mountain Operations*. June 30, 1980. Washington, DC: Dept. of the Army.

Milne, Loris J., and Margery Milne. 1962. *The Mountains*. Life Nature Library. New York: Time-Life Books.

Deserts

Field Manual 90-3/Fleet Marine Force Manual 7-27: *Desert Operations*. August 19, 1977. Washington, DC: Dept. of the Army.
George, Uwe. 1976. *In the Deserts of the Earth*. New York: Harcourt, Brace, Jovanovich.
Leopold, A. Starker. 1961. *The Desert*. Life Nature Library. New York: Time-Life Books.

Jungles

Bergerud, Eric. 1996. *Touched by Fire: The Land War in the South Pacific*. New York: Viking Press.
Field Manual 90-5: *Jungle Operations*. August 16, 1982. Washington, DC: Dept. of the Army, Commandant of the Marine Corps.

Forests

Farb, Peter. 1961. *The Forest*. Life Nature Library. New York: Time-Life Books.
Miller, Edward G. 1995. *A Dark and Bloody Ground: The Hürtgen Forest and the Roer River Dams, 1944-1945*. College Station, TX: Texas A&M University Press.

Rivers and Swamps

DA Pamphlet 20-231: *Combat in Russian Forests and Swamps*. July 1951. Washington, DC: Dept. of the Army.
Field Manual 90-13/Fleet Marine Force Manual 7-26: *River Crossing Operations*. September 30, 1992. Washington, DC: Dept. of the Army and Commandant of the Marine Corps.
Fulton, William B. 1985. *Riverine Operations, 1966-1969*. Washington, DC: Dept. of the Army.

Frigid Terrain

Field Manual 30-70: *Basic Cold Weather Manual*. April 1968. Washington, DC: Dept. of the Army.
Field Manual 31-71: *Northern Operations*. 1971. Washington, DC: Dept. of the Army.

OCEANS AND SEASHORES

Oceanography

Davis, Richard A., Jr. 1972. *Principles of Oceanography*. Reading, MA: Addison Wesley Publishing Co.
Dutton, Benjamin, and Elbert S. Maloney. 1942. *Dutton's Navigation and Piloting*. 14th ed. Annapolis, MD: U.S. Naval Institute Press.
Engel, Leonard. 1969. *The Sea*. Life Nature Series. New York: Time-Life Books.
Maury, Matthew F. 1855. *The Physical Geography of the Sea*. New York: Harper and Brothers.

Thurman, Harold V. 1978. *Introductory Oceanography*, 2d ed. Columbus, OH: Charles E. Merrill Publishing Co.

Geographic Factors in Shipbuilding

Gates, P. J., and N. M. Lynn. 1990. *Ships, Submarines, and the Sea*. London: Brassey's (UK).

U.S. Navy Cold Weather Handbook for Surface Ships. May 1988. Washington, DC: Chief of Naval Operations, Surface Ship Survivability Office (OP 03C2).

The Littoral

Alexander, Joseph H., and Merrill L. Bartlett. 1995. *Sea Soldiers in the Cold War: Amphibious Warfare 1945-1991*. Annapolis, MD: U.S. Naval Institute Press.

Koburger, Charles W., Jr. 1990. *Narrow Seas, Small Navies, and Fat Merchantmen*. New York: Praeger.

Vagts, Alfred. 1946. *Landing Operations from Antiquity to 1945*. Harrisburg, PA: Military Service Publishing.

ATMOSPHERE

Climate

DA Pamphlet 20-291: *Effects of Climate on Combat in European Russia*. February 1952. Washington, DC: Dept. of the Army.

Kendrew, W. B. 1953. *The Climates of the Continents*. 4th ed. New York: Oxford University Press.

Weather Overviews

Burrows, William James. 1991. *Watching the World's Weather*. New York: Cambridge University Press.

Donn, William L. 1946. *Meteorology with Marine Applications*. New York: McGraw-Hill.

Heavy Weather Guide. 1965. Part I: Edwin T. Harding, *Hurricanes*; Part II: William J. Kotsch, *Typhoons*. Annapolis, MD: U.S. Naval Institute Press.

Muchie, Guy. 1954. *The Song of the Sky*. Boston, MA: Houghton Mifflin.

Military Weather

Air Force Doctrine Document 45: *Aerospace Weather Operations*. August 31, 1994. Washington, DC: Dept. of the Air Force.

Field Manual 34-81: *Weather Support for Army Tactical Operations*. 1989. Washington, DC: Dept. of the Army and Dept. of the Air Force.

Fuller, John F. 1990. *Thor's Legions: Weather Support to the U.S. Air Force and Army, 1937-1987*. Boston, MA: American Meteorological Society.

Joint Pub 3-59: *Joint Doctrine for Meteorological and Oceanographic Support*. December 22, 1993. Washington: Office of the Chairman, Joint Chiefs of Staff.

Light Data

The Air Almanac. Issued annually. Washington, DC: Government Printing Office.

SPACE

Cochran, Curtis D., Dennis M. Gorman, and Joseph D. Dumoulin, eds. January 1985. *Space Handbook*. Maxwell AFB, AL: Air University Press.

Collins, John M. 1989. *Military Space Forces: The Next Fifty Years*. Washington, DC: Pergammon-Brassey's.

Stein, G. Harry. 1981. *Confrontation in Space*. Englewood Cliffs, NJ: Prentice-Hall.

Zombeck, Martin V. 1982. *Handbook of Space Astronomy and Astrophysics*. New York: Cambridge University Press.

CULTURAL GEOGRAPHY

PEOPLE

Demographics and Linguistics

Allen, John, and Doreen Massey, eds. *Geographical Worlds*. 1995. New York: Oxford University Press.

Cavalli-Sforza, L. Luca, et al., eds. 1994. *The History and Geography of Human Genes*. Princeton, NJ: Princeton University Press.

Jones, H. R. 1981. *Population Geography*. New York: Harper and Row.

Jordan, Terry G., Mona Domosh, and Lester Rowntree. 1997. *The Human Mosaic: A Thematic Introduction to Cultural Geography*. 7th ed. New York: Longman.

Religious Preferences

Haught, James A. 1995. *Holy Hatred: Religious Conflicts of the 1990s*. Amherst, New York: Prometheus Books.

Nielsen, Niels Christian. 1983. *Religions of the World*. New York: St. Martin's Press.

Parrinder, Edward Geoffrey. 1984. *World Religions: From Ancient History to the Present*. New York: Facts on File.

Sopher, David E. 1967. *Geography of Religions*. Englewood Cliffs, NJ: Prentice Hall.

Thompson, Henry O. 1988. *World Religions in Peace and War*. Jefferson, NC: McFarland and Co.

Endemic Diseases

Bennett, Peter B., and David H. Elliott, eds. 1992. *The Physiology and Medicine of Diving*, 4th ed. Philadelphia, PA: W. B. Saunders.

Disease and Environmental Alert Reports. 1992. Washington, DC: Armed Forces Medical Intelligence Center, Defense Intelligence Agency.

Kiple, Kenneth F., ed. 1993. *The Cambridge World History of Human Disease*. New York: Cambridge University Press.

McNeill, William H. 1976. *Plagues and Peoples*. New York: Anchor Books.

Stamp, L. Dudley. 1965. *The Geography of Life and Death*. Ithaca, New York: Cornell University Press.

Street Fighting

Bell, J. Bowyer. 1966. *Besieged: Seven Cities Under Siege.* New York: Chilton Books.
Field Manual 90-10: *Military Operations on Urbanized Terrain.* August 15, 1979. Washington, DC: Dept. of the Army.

Urban Bombardment and Defense

Gouré, Leon. 1976. *War Survival in Soviet Strategy.* Miami, FL: Center for Advanced International Studies, University of Miami.
The United States Strategic Bombing Survey, 1976, 10 vols. New York: Garland Publishers.
Yegurov, P. T., et al. Undated. *Civil Defense: A Soviet View,* and N. M. Titov, et al. July 1975. *Civil Defense.* Both books ed. and trans. Oak Ridge National Laboratory, Oak Ridge, TN.

PRODUCTS

Route Construction and Destruction

Anders, Leslie. 1965. *The Ledo Road: General Joseph W. Stilwell's Highway to China.* Norman, OK: University of Oklahoma Press.
Field Manual 5-25: *Explosives and Demolitions.* March 1996. Washington, DC: Dept. of the Army.
Field Manual 5-36: *Route Reconnaissance and Classification.* March 1985. Washington, DC: Dept. of the Army.
Field Manual 5-430-00-2, Air Force Joint Pamphlet 32-8013: *Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations,* 2 vols. September 1994. Washington, DC: Dept. of the Army and Dept. of the Air Force.
Pei-Ying, Tan. 1945. *The Building of the Burma Road.* New York: McGraw-Hill.

Telecommunications

Kellerman, Aharon. 1993. *Telecommunications and Geography.* New York: Halsted Press.

U.S. Military Bases

Evinger, William R., ed. *Directory of U.S. Military Bases Worldwide.* 2d ed. 1995. Phoenix, AZ: Oryx Press.
Guide to Military Installations in the U.S.: A Reference to the Top 220 Bases, Posts and Stations. Updated periodically. Washington, DC: *Army Times, Navy Times, Air Force Times.*

Forts and Fortifications

Brice, Martin H. 1990. *Forts and Fortresses.* New York: Facts on File.
Field Manual 5-15: *Field Fortifications.* June 27, 1972 (superseded by FM 5-103: *Survivability,* June 10, 1985, restricted distribution). Washington, DC: Dept. of the Army.
Hogg, Ian. 1981. *The History of Fortifications.* New York: St. Martin's Press.
The Value of Field Fortifications in Modern Warfare. December 1, 1979. Washington, DC: prepared for Defense Nuclear Agency by Historical Evaluation and Research Organization (HERO).

ECONOMIC GEOGRAPHY

Davidian, Zaven N. 1994. *Economic Disparities Among Nations: A Threat to Survival in a Globalized World*. Oxford: Oxford University Press.

Knox, Paul L., and John Agnew. 1994. *The Geography of the World Economy: An Introduction to Economic Geography*. New York: Routledge, Chapman, and Hall.

REGIONAL GEOGRAPHY

GENERAL

*Area Handbook Series (*DA Pamphlet 550*)*. Various dates and authors. Many volumes cover various countries and regions. Washington, DC: Federal Research Division, Library of Congress, Government Printing Office.

Cole, J. P. 1996. *Geography of the World's Major Regions*. New York: Routledge.

de Blij, Harm J. and Peter O. Muller. 1997. *Geography: Realms, Regions, and Concepts*. New York: John Wiley.

The World Factbook. Printed version discontinued in 1995. Available on the Internet via the World Wide Web. Washington, DC: National Foreign Intelligence Center, Central Intelligence Agency (unclassified).

THE AMERICAS

Caviedes, Caesar, and Gregory Knapp. 1995. *South America*. Englewood Cliffs, NJ: Prentice-Hall.

Keegan, John. 1996. *Fields of Battle: The Wars for North America*. New York: Alfred A. Knopf.

James, Preston E., and Clarence W. Minkel. 1986. *Latin America*. New York: John Wiley.

McKnight, Tom L. 1992. *Regional Geography of the United States and Canada*. Englewood Cliffs, NJ: Prentice-Hall.

West, Robert C. 1989. *Middle America: Its Lands and Peoples*. 3^{d} ed. Englewood Cliffs, NJ: Prentice-Hall.

EUROPE

Berentsen, William. 1997. *Contemporary Europe: A Geographic Analysis*. New York: John Wiley.

Hoffman, George W., ed. 1990. *Europe in the 1990s: A Geographic Analysis*. 6th ed. New York: John Wiley.

SOVIET UNION AND SUCCESSOR STATES

Berg, L. S. 1950. *Natural Regions of the U.S.S.R.* Trans. Olga Adler Titelbaum. New York: Macmillan.

Curtis, Glenn E. 1997. *Russia: A Country Study*. Washington, DC: Federal Research Division, Library of Congress

Lydolph, Paul E. 1979. *Geography of the USSR: Topical Analysis*. Elkhart, WI: Misty Valley Publishing.

Shaw, Denis J. B., ed. 1995. *The Post Soviet Republics: A Systematic Geography*. New York: John Wiley.

EAST ASIA

Drakakis-Smith, David. 1992 *Pacific Asia*. New York: Routledge.
Ginsberg, Norton. 1959. *The Pattern of Asia*. Englewood Cliffs, NJ: Prentice-Hall.
Lemley, Kendall M., ed. 1976. *Geography of the People's Republic of China*. West Point, New York: U.S. Military Academy, Dept. of Earth, Space, and Graphic Sciences.
Zhao, Songgiao. 1994. *Geography of China: Environment, Resources, Population, and Development*. New York: John Wiley.

MIDDLE EAST

Beaumont, Peter et al. 1988. *The Middle East: A Geographic Study*. New York: John Wiley.
Fisher, W. B. 1950. *The Middle East: A Physical, Social, and Regional Geography*. New York: E. P. Dutton.
Kemp, Geoffrey, and Robert E. Harkavy. 1997. *Strategic Geography and the Changing Middle East*. Washington, DC: Carnegie Endowment for International Peace/Brookings Institution.

AFRICA

Aryeetey-Attoah, Samuel. 1997. *Geography of Subsaharan Africa*. Upper Saddle River, NJ: Prentice-Hall.
Joffú, George, ed. 1993. *North Africa: Nation, State, and Region*. New York: Routledge.

AUSTRALIA AND OCEANIA

McKnight, Tom L. 1995. *Oceania: The Geography of Australia, New Zealand, and the Pacific Islands*. Englewood Cliffs, NJ: Prentice-Hall.

POLAR REGIONS

The Arctic Basin. 1963. Coord. John E. Slate. Centerville, MD: Tidewater Publishing for the Arctic Institute of America.
Ley, Willey. 1962. *The Poles*. Life Nature Library. New York: Time-Life Books.

POLITICAL GEOGRAPHY

Bennett, Robert J., and Robert Estall, eds. 1991. *Global Change and Challenge: Geography for the 1990s*. New York: Routledge.
Cohen, Saul Bernard. 1963. *Geography in a World Divided*. New York: Random House.
Demko, George J., and William B. Woods. 1994. *Reordering the World: Geopolitical Perspectives on the 21st Century*. Boulder, CO: Westview Press.
Glassner, Martin I., and Harm J. de Blij. 1989. *Systematic Political Geography*. New York: John Wiley.

MILITARY GEOGRAPHY

GENERAL

Brinkerhoff, John R. 1964. The Nature of Modern Military Geography. Thesis, Columbia University.

May, Edward S. 1909. *An Introduction to Military Geography*. London: Hugh Rees.

Miller, W. 1983. *The Geography of Warfare*. New York: St. Martin's Press.

O'Sullivan, Patrick E. 1991. *Terrain and Tactics*. New York: Greenwood Press; and with Jesse

Peltier, Louis C., and G. Etzel Pearcy. 1966. *Military Geography*. Princeton, NJ: D. Van Nostrand.

Readings in Military Geography. 1990. Comp. Gerald E. Galloway, Jr. West Point, New York: U.S. Military Academy, Dept. of Geography.

HISTORICAL PRECEDENTS

Chandler, David. 1987. *The Dictionary of Battles*. London: Ebury Press.

Dupuy, R. Ernest, and Trevor N. Dupuy. 1993. *The Harper Encyclopedia of Military History*. 4th ed. New York: Harper Collins.

Fuller, J. F. C. 1954. *A Military History of the Western World*. 2 vols. New York: Funk and Wagnalls.

Poole, Walter S., et al. February 1995. *The History of the Unified Command Plan, 1946-1993*. Washington, DC: Joint History Office, Office of the Chairman, Joint Chiefs of Staff.

VARIOUS PERSPECTIVES

Douhet, Guilio. 1983. *Command of the Air*. Eds. Richard H. Kohn and Joseph P. Harahan. Trans. Dino Ferrari. Washington, DC: Government Printing Office (originally published 1921).

Mackinder, Halford J. 1942. *Democratic Ideals and Reality*. New York: Henry Holt and Co. (original publication 1919).

Mahan, Alfred Thayer. 1957. *The Influence of Seapower Upon History, 1660-1783*. American Century Series. New York: Hill and Wang (original publication 1890).

de Seversky, Alexander. 1950. *Air Power: The Key to Survival*. New York: Simon and Schuster.

TROUBLE SPOTS

Anderson, Ewan W. 1993. *An Analysis of World Flashpoints: A Sourcebook of Geopolitical Crises*. New York: Facts on File.

Day, Alan J., ed. 1987. *Border and Territorial Disputes*. A Keesings Reference Publication., 2d ed. Detroit, MI: Gale Research.

Dunnigan, James E., and Austin Bey. 1985. *A Quick & Dirty Guide to War*. New York: William Morrow and Co.

Keegan, John, and Andrew Wheatcroft. 1986. *Zones of Conflict*. New York: Simon and Schuster.

COLD WAR CONSIDERATIONS

Farrington, Hugh. 1989. *Strategic Geography: NATO, the Warsaw Pact, and the Superpowers.* 2d ed. New York: Routledge.

Glasstone, Samuel. 1964. *The Effects of Nuclear Weapons.* 1964. Washington, DC: DA Pamphlet 39-3, Government Printing Office.

POLITICAL-MILITARY ATLASES

Barraclough, Geoffry. 1978. *The Times Atlas of World History.* Maplewood, NJ: Hammond.

Chaliand, Gérard, and Jean Pierre Rageau. 1992. *A Strategic Atlas: Comparative Geopolitics of the World Powers.* 3d ed. New York: Harper Perennial.

Esposito, Vincent J., chief ed. 1995. *The West Point Atlas of American Wars.* 2 vols. West Point, New York: U.S. Military Academy, Dept. of Military Art and Engineering.

Friedman, Lawrence. 1985. *Atlas of Global Strategy.* New York: Facts on File.

Hartman, Tom. 1984. *A World Atlas of Military History, 1945-1984.* New York: Hippocrene Books.

Keegan, John. 1994. *The Times Atlas of the Second World War.* New York: Crescent Books.

Kidron, Michael, and Dan Smith. 1983. *The War Atlas: Armed Conflict—Armed Peace.* New York: Simon and Schuster.

Lobeck, Armin K. 1993. *Things Maps Don't Tell Us: An Adventure into Map Interpretation.* Chicago, IL: University of Chicago.

Natkiel, Richard, and Antony Preston. 1985. *Atlas of Maritime History.* New York: Facts on File.

Summers, Harry G., Jr. 1995. *Historical Atlas of the Vietnam War.* New York: Houghton Mifflin.

The West Point Atlas of Warfare Since 1945. 1994. West Point, New York: U.S. Military Academy, Dept. of History.

INDEX

Abyss
  characteristics, 48, 49, 59
  HAZMAT disposal, 300
Acclimatization, 6, 93, 112
Acid rain, 298
Aerial bombardment
  railroads, 226
  rain forests, 120
  roads, 223
  urban areas, 207-209
Aerodynamic drag, 141
Afghan desert operations, 114
Agent Orange, 298. *See also* Herbicides
Aideed, Mohammed Farah
  bushwhacks U.S., U.N. forces, 205
  son as U.S. interpreter, 184
Air. *See* Atmosphere
Aircraft
  against caves, 30-31
  antisubmarine warfare, 65-66
  altitude limits, 139
  Berlin Airlift, 21, 23-24, 201, 321
  carpet bombing, 207-208
  close air support, 85, 97, 105, 120
  cold, 96, 97
  density altitude, 85, 106, 395
  deserts, 114
  forests, 119-120
  instrument flight rules, 84, 399
  jet lag, 14
  mountains, 103, 105-107
  "no fly zones" in Iraq, 323
  Normandy, 362-363
  precision bombing, 207
  route packages, 323-324
  runways, 33, 228-231, 362
  transoceanic travel, 14
  visual flight rules, 84, 405
  weather, 70, 75, 84-85
  wind chill, 71-73, 88
Air currents, 70
Airfields. *See* Military air bases
Airports. *See* Military air bases
Airpower proponents, 280, 282
Airspace (vertical limits), 287
Aksai Chin, 297
Alamo, 268
Aleutian Islands, 73, 84, 99
Alexander the Great, xxi, 108
Alexander VI, Pope (first political boundary), 285
Algeria (urban combat), 205
Altitude (related to airfields), 229. *See also* Density altitude
Amphibious operations
  beaches and approaches, 55-57
  Inchon, 62-64
  light data, 361, 400
  Normandy, 351-353, 356-358, 361
  St. Nazaire, 62
  Tarawa, 62, 321-322
  tides, 50, 52, 62, 361, 404
  weather effects, 64, 84, 361
Andrews, James J., 224
Annamese mountain weather, 375-377
Antarctica
  described, 293
  light data, 78
  sea ice, 55
  territorial claims, 293
  treaty provisions, 293
Antisubmarine warfare
  acoustics, other, 65-66
  bastions inhibit, 57
  littoral, 129-130
  under arctic ice, 100, 102
ANZUS Treaty (members), 248
Aral Sea, 299-300
Archimedes, 11
Archipelagos (vulnerabilities), 23
Arctic
  de Severski's strategic view, 280, 282
  light data, 78
Arctic Ocean
  bergs and pack ice, 52, 54-55, 100-101
  borders USSR, 11
  landscapes, seascapes, 100,102

marginal ice zone, 99-100, 401
Arctic sea smoke, 74, 392
Ardennes (1940 and 1944), 7
Area analyses, 8-9, 339-344, 392
Area of influence, 392
Area of interest, 392
Area of operations, 392
Area of responsibility (AOR)
aerial, 321, 323-24
British, World War II, 308
Caribbean, 317-318
defined, 392
Middle East, 315, 317
NATO, 311-313
naval, 321-322
need for, 307, 341
no man's lands, 325
Northeast Asia, 315
Southeast Asia, 315
South Pacific, 313, 314-316
space, 325
theater and tactical, 318-325
U.S. combatant commands, 308-318
Area orientation, 392
Armor
desert, 111, 113
fording capabilities, 221
forests, 6, 41, 119-120
hedgerows, 360-361
mountains, 103
on the moon, 148
snow, 97
soil influences, 37, 80, 113
urban combat, 201, 203-204
Artesian springs, 35, 36
Artillery
against caves, 30-31
biological warfare munitions, 86
deserts, 83, 111
forests, 41, 119-120
mountains, 29, 104-105
soil influences, 38, 83
urban combat, 203-204
Assayyid, Muhammad Ahmad Ibn, 186
Atlantic Ocean
bottlenecks, 57
hurricanes, 83
Atlantic Wall, 20, 271, 349, 360, 388
Atmosphere
air currents, 70-71
distinctive medium, 4, 69
layers, 139-140
pollution, 298
pressure, 70, 83, 85
rarefied, 106-107, 139, 181
thins rapidly, 69
Attitudes (attributes), 187-188
Australia, 18, 254
Avalanches, 107-108
Avenues
described, 343
Normandy, 356-360
Azores (U.S. use), 16, 253, 257

Baghdad (missile attack on), 207
Baie de la Seine, 349, 351
Baikal-Amur Magistral (railroad), 226, 228
Ballistic Missile Early Warning System (BMEWS), 16, 247, 249
BAM construction, 226, 228
Bare base kits, 230
Barents Sea
Murmansk run, 100 , 102
submarine bastion, 57, 100
winter ice, 98
Barometric pressure
affects air operations, 85
related to temperature and altitude, 70
Bases. *See* Military bases
Bataan, 20
Battle of the Bulge
Patton's prayer, 69
Salient, 20-21
Bay Marchand oil fire, 162
Bay of Pigs, 7
Beaches. *See also* Seashores
described, 55-57, 393
exits, 128
Inchon, 63-64
Normandy, 351-353, 358-359
reconnaissance, 56-57
trafficability, 56
variabilities, 55
Beam weapons
in atmosphere, 88
in space, 147-148
Beaufort Wind Scale
sea states, 54
wind speeds, 54, 71
Beginning of morning nautical twilight (BMNT), 78, 345, 393
Beirut Marine barracks, 206
Belgium (U.S. bases), 252
Berlin
aerial bombardment of, 207
airlift, 21, 23-24, 201, 321
devastation, 207
freedom fighters, 205

importance, 21
Biological warfare
heat, 115
in space, 148
shelters, 273
weather effects, 86
Blockades, 129
Blue water defined, 393
Blumentritt, Major General Günter, 349
BMNT, 78, 345, 393
Bocage described, 350, 360-361, 364-365
Bog. *See* Wetlands
Bolivia (Ernesto Che Guevara), 7-8
Boundaries
abstract, 286
air operations, 321, 323-324
airspace, 287
amphibious assault, 321
between naval AORs, 321
Canada, with USA, 18, 285-286
coalitions, 319-320
defensive land operations, 319
Ethiopia, 296
first political, 285
Jammu and Kashmir, 296-297
linkups, 320
military requirements, 318-319
no man's lands, 325
offensive land operations, 319
political obstacles, 16
regional, 6
Sino-Soviet, 290-291
Somalia, 296
space, 325
tactical AORs, 318-325
territorial waters, 286-287
theater, 318
topographical, 286
United States (with Canada), 18, 285-286
Brest siege, 200
Brezhnev, Leonid, 226
Bridges
Baikal-Amur Magistral, 226
Burma Road, 222-223
demolitions, 223
Ho Chi Minh Trail, 372-373
mountains, 103
Normandy, 349, 356
Operation *Market Garden*, 20
types, characteristics, 218-221
Britain
aerial bombardment of, 207
Afghan wars, 114
AORs in World War II, 308
lifelines of empire, 15
secure location, 14
U.S. bases, 250-251
Browning, Lieutenant General Frederick, 20
Brown water, 393. *See also* Littoral; Riverine warfare
Budapest (freedom fighters), 205
Buffer zones in Europe (Soviet), 288-290
Burma Road. *See also* Ledo Road
bridges, 222-223
construction, 121, 221-223
river transportation, 239
Burundi, 180
BW. *See* biological warfare

Caen
climate, 354
importance, 356
population, 355
Calais. *See* Pas de Calais
Calvados
terrain, 349-350
weather and climate, 353-354
Cambodia
genocide, 182-183
sanctuary, 16
Canada-U.S. boundary, 18, 285-286
Canals
Barents to Black Sea, 240
Panama, 240-241
Suez, 57, 240
Caribbean AORs, 317-318
Carpet bombing, 207-208
Carter, President Jimmy, 317
Cassino, 105, 343
Castro, Fidel, 102
Casualties
compared with population size, 178
Coventry, 207
disease, 181-182
Dresden, 207
Hamburg, 207
Japanese cities, 208
Leningrad, 200-201
London, 207
Messines Ridge, 272
World Wars I and II, 178
Caucasus linguistic clutter, 184-185
Caves, 30-31
CENTCOM. *See* U.S. Central Command
Central Command. *See* U.S. Central Command
Champs-Elysées tank duel, 201
Change operational control (CHOP), 321
Changjin Reservoir, 83

Chargoggagog. . . Lake, 286
Chemical warfare (CW)
cold, 95
decontamination, 32, 36
heat, 114-115
in space, 148
shelters, 273
street fighting, 203
urban bombardment, 207
waste disposal, 300
weather, 86-87
Cherbourg
climate, 354
destruction of, 235
importance, 349, 356-357, 362
population, 354-355
Cheyenne Mountain, 272
Chiang, Generalissimo Kai-Shek, 107
Chief Joseph, 17
Chile (elongated shape), 20
China. *See also* Mao Zedong
Assured Destruction, 209
border disputes, 290-291
peasant power base, 177
Spratly Islands, 291-292
Choke points
mountain passes, 103
straits, 57-58, 240, 291
trouble spots, 291
Choltitz, General Dietrich von, preserves Paris, 200
CHOP, 321
Chosin Reservoir, 83
Churchill, Sir Winston
Iron Curtain speech, 270
U.S.-British Pacific AORs, 308
Circadian Rhythm
in space, 150
on Earth, 14
Cicumterrestrial space, 143
Cislunar space, 144-145
City. *See* Urban areas; Urban bombardment; Urban combat
Civic action, Civil Affairs
area orientation, 191
Kuwait, 191
urban combat, 203-204
urban facilities, 197-198
well digging, 35
Civil defense, 209, 272-273
Civil War railroads, 224
Clans, 394
Clausewitz, Major General Carl von
land power proponent, 278
on fortifications, 267
on mountain defense, 109
Cleveland, Ohio, natural gas explosion, 162
Climate
classifications, 79, 81
defined, 394
Ho Chi Minh Trail, 368, 375-377
importance to planners, 79-80
Normandy, 353-354
OPLAN *El Paso,* 372, 375-377
Clinton, President William J., 205
Close air support, 85, 97, 105, 120
Clouds
air operations, 84-85
compared with fog, 74
cover and ceilings, 74, 77
types, 74-76
Cluséret, General P.-G., 204-205
Coastwatchers on Guadalcanal, 118
COCOA, 8-9
Cold weather
air operations, 97
clothing, 6, 94-95
defensive operations, 96
food and water, 95
frozen rivers, lakes, 97
leadership, 95-96
maintenance, 96
mountains, 104
naval problems, 98-100
New Guinea, 117
offensive operations, 96
overland mobility, 97
permafrost, 97, 226
personnel, 88
shelter, 95
supply requirements, 98
survival paramount, 94
Collins, General Joseph (refugees), 204
COMUSMACV. *See* Westmoreland, General William C.
Construction. *See also* Military bases; Railroads; Roads
Siberia, 196
surface materials, 36-37
urban areas, 196
Continental shelf, 57, 59
Continental slope, 57, 59
Corbett, Sir Julian (sea power proponent), 280
Corduroy roads, 122, 395
Core areas
Normandy, 356
Soviet, 341-342
Corregidor, 17

COSSAC. *See* Morgan, Lieutenant General Sir Frederick.
Cotentin Peninsula
bottleneck, 356-357
terrain, 350
Counterterrorism, 206
Coventry (aerial bombardment of), 207
Cover and concealment
differentiated, 344, 394-395
steppes, 42
Critical terrain
Normandy, 356
OPLAN *El Paso,* 378
typified, 343
Cuba. *See also* Cuban missile crisis
President Carter's concern, 317
Castro's guerrillas, 102
desalinization, 35
Guantanamo, 21, 35, 261
Cuban missile crisis
U.S. and Soviet LOCs, 15
U.S. railroads, 224
Culin, Master Sergeant Curtis, 360-361
Cultural geography
defined, 395
factors, 4, 5, 340
Currents
air currents, 70
Inchon, 64
ocean currents, 49-51, 64

Dams
targets, 32
water diversion, 299
Danang
climate, 375, 377
important seaport, 380-381
Danzig (trouble spot), 21, 286
D-Day determination (Normandy), 361
Declination, 139
Deep battle (boundaries), 325
Defilade, 29-30
Defoliation. *See* Herbicides; Agent Orange
Deforestation, 298
de Gaulle, President Charles
evicts NATO, 20, 252
frees Algeria, 205
Dehydration
Cold weather, 88, 95
Hot weather, 89, 113
in mountains, 106
Demilitarized zones
boundaries, 286
Korea, 14, 270, 272, 286
utility, 14
Vietnam, 14, 286, 371
Demography
defined, 395
key factors, 4, 178, 180
Demolitions, 223
Density altitude
affects air operations, 85
defined, 395
in mountains, 106
Desalinization, 35
Deserts
ancient warfare, 109
clothing, 111
compared with seas, 113
disease, 112
diversification, 110
land navigation, 113
locations, 110
logistics, 115
maintenance, 111-112
trafficability, 113
vegetation, 39, 40, 41
visibility, 113-114
water, 35, 36, 79, 112-113
weather, 111-112
de Seversky, Alexander, 280, 282
DEW Line, 16, 247, 250
Diego Garcia, 15, 254
Dien Bien Phu, 7, 31, 120
Disease
Aral Sea, 299-300
casualties from, 181-182
countermeasures, 181-182
deserts, 112
heat, 89
rain forests,121
Rung Sat Special Zone, 126
urban areas, 203
water related, 34
Distant Early Warning Line, 16, 247, 250
Doldrums, 47, 396
Douhet, Brigadier General Guilio
air power proponent, 280
urban bombardment theory, 207
Dresden (bombardment of), 207
Drop zone (DZ)
Corregidor, 17
Laotian panhandle, 374
linkup at Arnhem, 20
Normandy, 360-361

Earth
gravity well, 146-147

orbits sun, 141
rotation, 49, 141-142
Earth-Moon System
constituents, 137-139
future military operations, 137
orbits sun, 141
strategic locations, 146-147
Eben Emael, 267, 269
EENT, 78
EEZ. *See* exclusive economic zone.
Eisenhower, General of the Army Dwight D.
analyzes European AOR, 311
D-Day doubts, 271
importance of geography, 388
linkup with Russians, 320
mission in Europe, 341, 364
Paris liberation, 319
Normandy lodgment, 355
U.S.-British AORs, 308
weather decision, 361
Electromagnetic pulse (EMP), 147-148
Enclaves in hostile territory, 21, 23
End of evening nautical twilight (EENT), 78
Entebbe, 287
Environmental friction
military countermeasures, 300-301
typified, 297-300
Environmental warfare. *See also* Agent Orange; Herbicides
in Vietnam, 298
Ethiopian cultural conflict, 294, 296
Ethnic cleansing in Bosnia, 293
Ethnic groups differentiated, 182-183
EUCOM. *See* U.S. European Command
Europe
deforestation, 39
inland waterways, 32, 238-239
Mackinder's Heartland, 278-279, 283
metals and minerals, 155
oil for, 157
railways, 18, 224-226
rivers, 32
Second Front, 347, 388
Soviet buffer zone, 288-290
wet cold, 88
European Command. *See* U.S. European Command (EUCOM)
Everglades, Seminole Wars, 124-125
Exclaves in hostile territory, 21, 23, 286
Exclusive economic zone (EEZ)
Antarctica, 293
fisheries, 300
law of the sea, 287
Expeditionary airfields
characteristics, 230
Normandy, 362-363
Exterior lines of communication, 397
Exxon Valdez, oil spill, 299

Fallout. *See* Nuclear weapons
Fast Relocation from France, 20, 252-253
Federal Republic of Germany. *See also* Germany
Allied Forces Central Europe (AFCENT), 313-314
Ground Launched Cruise Missiles (GLCMs), 249, 252
narrow waist, 20, 253
U.S. bases, 253, 256
Ferries, 221
Fields of fire, 343-344
Finland
Mannerheim Line, 270
Russo-Finnish War, 80, 121
Soviet annexations, 288
Fire support coordination line (FSCL), 325
Fisheries (depletion of), 300
Flashpoints. *See* Trouble spots
Fog
affects air operations, 84-85
characteristics, 74
visibility in, 74
Folkways
defined, 397
importance, 189-190
Fords, 221
Foreign area specialists, 190-191
Forests
deforestation, 298-299
guerrillas, 119
military significance, 41-42
tidewater, 125-126
types, 39-41
Fortifications
Atlantic Wall, 20, 271, 349, 360, 388
coastal and island, 268
Eben Emael, 267, 269
historical examples, 267
impromptu, 268
Korean tunnels, 272
Kursk, 269
Maginot Line, 270
manmade obstacles, 343
nuclear defenses, 272-273
Siegfried Line, 270-271
Viet Cong tunnels, 269
Fortresses. *See* Fortifications
Forts. *See* Fortifications

France
denies overflight rights, 16
forces reenter Paris, 319
frees Algeria, 205
ousts NATO, 20, 252-253, 255
LOCs in, 252-253, 255
railroads destroyed, 226
U.S. bases, 252-253, 255
FRELOC, 20, 252-253
Frictional heat in space, 141
Frontages (defensive), 319
FSCL, 325
Fulda Gap, 313-314

Gaylor, Admiral Noel, 323
Gates, Thomas S., Jr., 317
Gauges (railways), 225
Geneva Conventions, 188
Genocide, Africa and Asia, 182-183, 293
Geographic mediums (service predilections), 277-282
Geographic regions, 6
Geography defined, 3, 397. *See also* Cultural geography; Military geography; Physical geography; Political geography; Regional geography
Geostationary orbits, 143, 146
Geosynchronous orbits, 143
Germany. *See also* Federal Republic of Germany
aerial bombardment of, 207-208
allied with Japan, 15
four-front war, 14
inland waterways, 239
lines of communication, 253
minerals and metals, 155
national character, 189
railroads destroyed, 226
urban sprawl, 198-199
U.S. bases, 253, 256
Warsaw Pact avenues, 313-314
Ghenghis Khan, xxiii
Giap, General Vo Nguyen,
Dien Bien Phu, 120
Ho Chi Minh Trail, 383
Glubb, General John Bagot (lava fields), 38
Gold Beach, 352-353
Gooseberries (artificial harbors), 235
Gordon, General Charles George, 186
Göring, Field Marshal Hermann, 207
Gradients
calculation, 28-29
related to airfields, 229
Grasslands. *See also* Steppes
locations, 39 40, 42
Graves registration (rain forests),121
Gravity
artificial, 150
space flight, 141-142
Gravity wells, 144-145, 147
Great Britain. *See* Britain
Greece (U.S. bases), 253-254, 259
Greenland. *See also* Thule.
Greenland-Iceland-Norway Gaps, 57-58
sea ice source, 54, 99, 101
Guadalcanal
coastwatchers, 118
vegetation, 116
Guantanamo
U.S. base, 21, 35, 261
water desalinization, 35
Guevara, Ernesto (Che), 7-8
Gulf Stream, 50, 98
Gurkhas, 181

Hague Conventions, 188
Haiphong mining, 129
Hamburg bombardment, 207
Hannibal (crosses Alps), 6, 108
Harbors
characteristics, 232
ice, 98
prefabrication, 235-236, 362
Haushofer, Karl, *Lebensraum*, 278
Hazardous waste disposal, 300
Health. *See* Diseases
Heartland
applied to space, 282
Mackinder's theory, 278-279, 283
Heat. *See* Hot Weather
Hedgerows, 350, 360
Hennecke, Rear Admiral Walther (destroys Cherbourg), 235
Herbicides in Vietnam, 43. *See also* Agent Orange
H-Hour (Normandy), 357, 361
Highway 1 in Vietnam, 380-381
Himalayas
border skirmishes, 181
obstacle, 343
rarefied atmosphere, 106
Hiroshima (atom bombing of), 159, 207, 209
Hitler
Atlantic Wall, 271
Autobahns, 215
Brest, 200
Cherbourg, 235
Danzig, 21, 286
Heavy water plant, 31

Lebensraum, 180
Operation *Barbarossa*, 17
Paris, 200
Pripet Swamp, 122
Rome, 200
violates Low Counries, 16
Ho Chi Minh Trail
development, capacities, 367-369
motorable roads, 372-373
settlements, 372
Hof Corridor, 313-314
Holland. *See* Netherlands
Hong Kong, 291
Horse Latitudes, 47
Hot weather
acclimatization, 112
aircraft, 111
biological warfare, 115
chemical warfare, 86-87, 89, 114-115
personnel, 89
rain forests, 117, 121
water requirements, 35-36, 89, 112-113
Humidity (related to temperature), 73
Hump (Himalayan), 107
Hungary (freedom fighters), 15, 205
Hurricanes in Atlantic, 83
Hutu tribe, 180, 293
Hydrology defined, 399
Hydropolitics (Middle East), 299
Hypothermia
causes, effects, 89
frigid waters, 99
in mountains, 106
warm waters, 89
Hypoxia, 106

ICBM silo hardening, 272
Ice
surface ship stability, 60, 84, 99
trafficability, 55, 97
Icebergs and floes, 52, 54-55, 99-101
Icebreakers, 98-99
Illumination. *See also* Light data; Night vision
atmospheric influences, 87
deserts, 114
light levels, 77-78
night vision, 87
Normandy invasion, 361
related to latitudes, seasons, 78
sea water resists, 48
snow reflects, 96
twilights differentiated, 78
Inchon landing, 62-64
Indonesia (fragmented shape), 24
Inland waterways, 238-240
Inner space. *See* Circumterrestrial space
Innocent III, Pope (heretics), 186
Instrument flight rules (IFR), 84
Inter-American Treaty of Reciprocal Assistance, members, 248
Intercontinental ballistic missile (hardening), 272
Interior lines of communication, 399
Iraq
linguist shortage (U.S.), 184
"no fly" zones, 323
pipelines, 241
resource war by, 161, 165
Iron Curtain (speech), 270
Islands
fortified, 268-269
stepping stones, 16
Israel
boundaries, 20, 286
Entebbe, 287
population, 178
Sinai roads, 216
two-front wars, 14
Yom Kippur war, 187
Italy
mountains, 105
mud, 80
peninsular combat, 20
Rome, 200
U.S. bases, 253, 254, 258
Iwabuchi, Rear Admiral Sanji, Manila, 200

Jackson, General Andrew (Seminole Wars), 124
Jammu and Kashmir, 296-297
Japan
allied with Germany, 15
bombardment of, 207-209
fragmented shape, 24
jungle warfare pamphlet, 116
national character, 189
natural resources, 155, 159-161
secure location, 14
U.S. bases, 260-261, 263
World War II holdings, 18, 160
Jet lag
in space, 150
on Earth, 14
Jet stream, 70
Johnson, President Lyndon B.
OPLAN *El Paso*, 383
Vietnam targets, 367
Julius II, Pope (political boundaries), 285
Jungles. *See also* rain forests
defined, 399

U.S., Japanese manuals, 116
Juno Beach, 352-353

Kamikazi, 83, 161
Kashmir, 296-297
Kasserine Pass, 113
Key terrain. *See* Critical terrain
Khe Sanh
airfield, 374
exposed position, 31
value, 378
Khrushchev, Nikita, 15
Kingston, Major Robert C., 231
Kokoda Track, 118-119
Korea
AOR disputes, 315
casualties, 181
demilitarized zone, 14, 270, 272, 286
Inchon, 62-64
mountains, 109, 343-344
non-Asian POWs, 181
North, destitute, 291
peninsular warfare, 20
Seoul vulnerable, 18
tunnels, 272
urban sprawl, 198
U.S. bases, 260, 263
Kurds
"no fly" zone, 323
stateless, 293
Kuril Islands, 291
Kursk (epic battle), 30, 269
Kuwait
civil affairs, 191
Kuwait City liberation, 320
oil fires, 161, 299

Lake boundaries, 286
Land breezes, 70, 72
Land clearing techniques, 42-43. *See also* Agent Orange; Herbicides
Land forms. *See* Topography
Landing zone (LZ)
Laotian panhandle, 374
Normandy, 271, 360-361
Land power proponents, 278
Languages
dialects, slang, 184
distribution, 183-184, 185
English is universal, 184
Ethiopia, 294
interpreters, 191
language families, 183, 185
military importance, 184, 191-192
U.S. Central Command AOR, 184
U.S. Pacific Command AOR, 184
LANTCOM. *See* U.S. Atlantic Command
Laotian panhandle
airfields, 373-374
drop zones, landing zones, 374
roads, 372-373, 375
terrain, 370-372
Lasers
atmospheric effects on, 87-88
space, 147
Latin America
Caribbean AORs, 317-318
Inter-American Treaty members, 248
U.S. bases, 261
Laterite
airfields, 373-374
construction material, 38-39
roads, 372
Law of the Sea, 286-287
Lebensraum
Hitler's aim, 180
roots of, 278
Ledo Road construction, 121, 221. *See also* Burma Road
Legal constraints, 188. *See also* Geneva Conventions; Hague Conventions; United Nations Convention on Law of the Sea
Lenin, Vladimir
on homeland defense, 209
urban guerrilla, 205
Leningrad
casualties, 200-201
road of life, 97
Libration points, 138, 144-147, 282
Libya
SAS attacks airfields, 230-231
U.S. raid, 16, 287
Liège fortifications, 269
Light data. See Illumination; Night vision
Lillyman, Captain Frank L. (pathfinder), 361
Lines of communication. *See also* Harbors; Inland waterways; Military air bases; Pipelines; Railroads; Roads; Seaports
defined, 400
exterior, 397
France, 252-253, 255
Ho Chi Minh Trail, 367-370
I CTZ, 380-382
importance, 5, 215
inland waterways, 238-240
interior, 399
Laotian panhandle, 372-374, 382-383

mountains, 103
oil, 15, 16, 292
OPLAN *El Paso*, 384-387
rain forests, 121, 221-223
related to distance, 14-15
space, 146, 236-238
wetlands, 125-126
Listening posts (U.S.), 259
Littoral
blockades, 129
defined, typified, 126-128
historical warfare, 17
compared with open ocean, 128
Locations
dominant, 15-16
secure, 14
LOCs. *See* Lines of communication
Logistics
arctic, 96, 99
deserts, 112-113, 115
mountains, 105
OPLAN *El Paso*, 380-383
rain forests, 120-121
urban areas, 203-204
Loire Valley (lodgment prospects), 349
London (aerial bombardment of), 207
Long March, 19, 30, 177
Loyalties, importance, 187
Lunar libration points, 138, 144-147, 282

MacArthur, General of the Army Douglas
Inchon, 62, 64
Pacific AOR, 313-316
Machiavelli, Niccoló (on military geography), 27
Mackinder, Sir Halford J.
land power proponent, 278-279, 283
theory applied to space, 282
Maden, Lieutenant Colonel (Mount Everest rescue), 85
Maginot Line, 270
Mahan, Rear Admiral Alfred Thayer (sea power proponent), 278, 280-281
Manche
topography, 349-350
weather, climate, 353-354
Manchuria (sanctuary), 16
Manila (urban combat), 200
Mao Zedong
Long March, 17-19, 177
power of people, 177
Marcos, Ferdinand (U.S. bases), 260
Marginal ice zone (MIZ), 99-100, 401
Marighela, Carlos (urban guerrilla), 205
Marine Corps *Small Wars Manual*, 116
Marion, Brigadier General Francis (Swamp Fox), 122
Marsh Arabs
Iraq persecutes Sunnis, 124, 187
"no fly" zone, 323
Marshall, General of the Army George C.
on morale, 188
on oceanography, 47
Marshes. *See* Wetlands
Mask (terrain), 29
Mauldin, Bill, 4
Maury, Lieutenant Matthew F., 47
MBFR, 15
McNamara, Robert S.,
Assured Destruction, 209
jointness, 283
MEAFSA, 17
Medical. *See* Disease
Mediums. *See* Geographic mediums
Mekong Delta
artillery, 38
construction, 125
riverine warfare, 125
Merrill's Marauders, 118
Messines Ridge, 271-272
Metabolic clock, 14, 150
Metals (natural resources), 153-156
Meteorology. *See* Weather
Microwave weapons
atmospheric effects, 87-88
in space, 147
Middle East
area of responsibility (AOR) disputes, 309, 311, 315, 317
capital cities vulnerable, 180
hydropolitics, 299
oil LOCs, 15-16, 292
U.S. bases, 254
Military air bases
construction, 228-231
defense, 230-232
expeditionary airfields, 230, 362-363
France, 251
Laotian panhandle, 373-374, 383
Normandy, 362-363
requirements vary, 228
runways, 228-229
Military base purposes, 245
Military crest, 29, 31, 401
Military geography
defined, 3, 401
key factors, 3-5
olden times, xxi
study slighted, xxi

Military service schools of thought, 277-283
Minerals (natural resources), 153-156
Mines (naval), 128-129
Mitchell, Brigadier General William (Billy), 280
Mobile Offshore Bases, 235-236
Mogadishu "peacekeeping," 205
Moltke, General Helmut Karl von (The Elder) (railroads), 223
Momyer, General William W. (on air AORs), 323
Monsoons
  Burma, 116
  Vietnam, Laos, 79, 368, 375-377
Monte Cassino, 109
Montgomery, Field Marshal Sir Bernard L.
  desert flood impedes, 111
  Market Garden, 20, 22
Montreux Convention, 240
Moon
  influences tides, 50, 52
  military boundaries on, 325
  terrain, 144
  weapon performance, 147-149
Moral constraints
  military importance, 188
  open cities, 199-200
Morale, 188
Morgan, Lieutenant General Sir Frederick
  on beach exits, 356
  on Normandy lodgment, 347, 349, 356
Mortise Line, 270
Motion sickness in space, 149-150. *See also* Sea sickness
Mountain sickness (hypoxia), 106
Mountains
  Annamese, 371
  avalanches, 107-108
  boundaries, 286
  close air support, 105
  defenses, 109
  highest, 106
  imprecise term, 27-28, 102, 106
  Italy, 105, 343
  logistics, 105
  mobility, 103-104
  observation posts, 343
  rarefied atmosphere, 106-107
  special skills, 105
  telecommunications, 105
  trafficability, 29, 103
  vegetation, 41
Mountbatten, Earl Louis, Admiral of the Fleet
  Jammu and Kashmir, 296
  NATO assignment, 313
Mount Everest (helicopter rescue), 85
Mud. *See also* Wetlands
  Battle of the Bulge, 69
  beaches, 56, 129
  Buna, 125-126
  Inchon, 63-64
  Italy, 80
  Normandy, 350
  soil types influence, 37
  Ypres, 80
Mu Gia Pass, 369, 371
Mulberries (artificial harbors), 235, 362
Murmansk, 100, 102
Mussolini, Benito, rescue, 85
Mutual and Balanced Force Reductions, 15

Nagasaki, atom bombing, 159, 208-209
Nasser, Gamal Abdel, 57, 240
NATO. *See* North Atlantic Treaty Organization
Natural resources
  compared with raw materials, 153
  enumerated, 5
  minerals and metals, 153-156
  petroleum, 157, 161-165
  rubber, 157-159, 161
  stockpiles, 158
Nautilus, under ice, 100
Navaho "Code Talkers," 184
Navarre, General Henri, 7
Netherlands (U.S. bases), 249, 252
New Guinea
  Kokoda Track, 118-119
  rain forests, 116-117
  tidewater swamps, 125-126
Night vision. *See* Illumination
Nimitz, Fleet Admiral Chester W. (Pacific AOR), 313-315
Nixon, President Richard M.
  Cambodia, 16
  Lam Son 719, 384
"No man's lands," 325
Nonlethal weapons (urban combat), 204
Normandy
  airfields, 362-363
  alternative lodgments, 347-349
  ancient roads, 216
  artificial harbors, 235, 362
  Atlantic Wall, 20, 271, 349, 360, 388
  beaches, 351-353, 358, 359
  casualties, 271
  Cherbourg, 235, 349, 354, 355-357, 362
  core areas, 356
  Cotentin peninsula, 350, 356-357
  critical terrain, 356
  cross-channel approaches, 357-358

dams and locks, 350, 356
D Day determination, 361
Eisenhower fears failure, 271
geographic data, 364
geographic regions, 349-350
Gooseberries, 235
H-Hour determination, 361
light data, 361
lodgment options, 347-349
missions, 341
Mulberries, 235, 362
Pluto pipelines, 241
roads, 216, 355
settlements, 354-355, 360
staging bases, 357-358
tides, 361
weather and climate, 353-354, 361
North Atlantic Treaty Organization
AOR problems, 311-313
avenues into, 312-313
enlargement, 290
members, 248
U.S. Cold War bases, 254, 255-259
Norway
heavy water plant, 31
U.S. bases, 249
Northeast, Northwest Passages, 100
Nuclear waste disposal, 300
Nuclear weapons
city targeting, 18, 180, 208-209
civil defense, 209, 272-273
ICBM silos, 272
in deserts, 114
in space, 147
radioactive fallout, 86, 298
soil influences, 38
U.S. bases abroad, 250, 252, 254
use by small nations, 18, 180
weather effects, 85-86

Observation, geographic influences, 343-344
Obstacles
Normandy, 360-361
typified, 343
Oceans. *See also* Sea water
abyss, 48, 59
Arctic Ocean, 11, 52, 54-55, 100-101
Atlantic Ocean, 57, 83
beaches and approaches, 55-57, 393
compared with space, 137, 139
continental shelf, 57, 59
continental slope, 57, 59
currents, 49-51, 64
distinctive medium, 4
hazardous material (HAZMAT) disposal, 300
ice, 52, 54, 55, 60, 84, 97, 99-101
sea states, 54
Soviet access, 11
straits, 57
surf, 52, 53
swell, 50
tides, 50, 52, 62, 64, 361
U.S. access, 11
waves, 50, 52, 53
Oceanography, 401
OCOKA, 9
Oil. *See* Petroleum
Okinawa (U.S. bases), 254, 260, 261, 263
Omaha Beach, 352 353, 359
Open cities, 199-200
Operation *Arctic Night*, 97-98
Operation *Barbarossa*, 17
Operation *Desert Storm*, 42
Operation *Lam Son 719*, 384-385
Operation *Market Garden*, 20, 22, 84
Operation *Neptune*
airfield construction, 362-363
beaches, 351-353, 358, 359
Gooseberries, 235
H-Hour, D-Day determination, 361
lodgment area options, 347-349
Mulberries, 235, 362
regions, 349-350
settlements, 354-355, 360
weather and climate, 353-354, 361
Operation *Overlord* mission, 341
Operation Plan (OPLAN) *El Paso*
airfields, 373-374, 383
area of responsibility, 377-378, 379
mission and concept, 367, 377-379
roads, 372-373, 381
seaports, 380, 381
speculative outcome, 383-384
weather, 375-377
Operation *Pluto*, pipeline to Normandy, 241
Operation *Provide Comfort*, "no fly zone," 323
Operation *Southern Watch*, "no fly zone," 323
Operation *Vittles*, Berlin airlift, 21, 23-24, 201-321
Operation *Zitadelle*, Kursk, 30, 269
Orbit types, 145-146, 238-239
Osceola, Chief, Seminole Wars, 124
Outer space, 146, 402
Overflight rights, 16, 287
Ozone depletion, 298

Pacific Command. *See* U.S. Pacific Command (PACOM)

Pack ice, 55, 100-101
PACOM. *See* U.S. Pacific Command
Pagonis, Lieutenant General William C. ("Gus"), desert logistics, 112, 115
Pakistan
  cultural conflicts, 21, 286
  Jammu and Kashmir, 296-297
Panama
  Canal, 240-241
  U.S. bases, 261
Paris
  liberation, 200, 319
  unfortunate sabotage, 206
Particle beams
  in atmosphere, 88
  in space, 147-148
Pas de Calais, 349
Patton, General George S., Jr.
  roads in Normandy, 216
  weather prayer, 69
Paul Doumer bridge, 207
Peninsulas, warfare on, 20
Permafrost
  airfield construction, 97
  BAM construction, 226
Persian Gulf petroleum, 157, 159, 161-165
Peru-Chile Trench, 59
Pétain, Marshal Henri
  Ardennes, 7
  Maginot Line, 270
Petroleum
  Japanese tanker losses, 161
  lines of communication to East Asia, 15-16, 259
  oil fires and spills, 160-161, 299
  pipelines, 240-241, 255, 381-382
  production, reserves, 157
  sabotage potential, 162
  Saudi Arabian facilities, 161-164
  Southeast Asia, 160-161
Physical geography
  defined, 402
  factors, 3-4, 340
Philippine Islands
  Bataan, 20
  fragmented shape, 24
  U.S. bases, 254-255, 262
Pipelines, 240-241, 255, 381-382
Plains, 29-30
Plateaus, 29-30
Plimsoll Lines, 60
Political-military geography, 402
Pollution (atmospheric), 298
Pope Alexander VI (first political boundary), 285
Pope Innocent III (heretics), 186
Pope Julius II (political boundaries), 285
Populations
  casualties, 178
  densities, 180
  distribution, 179-180
  folkways, 189-190
  Ho Chi Minh Trail, 372
  loyalties, 187
  minorities, 182-183
  moods and morale, 188
  national characters, 189
  Normandy, 354-355
  physical characteristics, 180-181
  public health, 181-182
  urban, 198-199
Portugal (Azores), 16, 253, 257
Powell, General Colin L., Iraqi salient, 20
Prairies Marécageus, 350, 355
Precipitation
  averages and types, 75
  deserts, 111
  monsoons, 79, 116, 368, 375-377
Precision bombing, 207
Prepositioned stocks, 15, 249, 252
Pressure. *See* Atmospheric pressure
Pripet Swamp, 122-123
Principle of Military Necessity, 298
Principle of Regional Peculiarity, 93
Principles of War, 388
Prisoner of war (POW) escapees, 180-181
Psychological operations (PSYOP), area oriented, 191
Puerto Rico (U.S. bases), 261
Puller, Colonel Lewis B. (Chesty), 60

Races, 182, 183
Radioactive fallout
  attributes, 86
  peak years, 298
Railroads
  Baikal-Amur Magistral (BAM), 226, 228
  bottlenecks, 224
  characteristics, 224-227
  compared with roads, 224-225
  early military uses, 224
  I Corps Tactical Zone, 380-381
  modernization, 224
  Trans-Siberian, 18, 224, 226, 228
  vulnerabilities, 226
Rain forests. *See also* Jungles
  aerial firepower, 119-120
  armor, 119-120
  artillery, 119-120

described, 6, 41, 116-117
guerrillas, 119
Ho Chi Minh Trail, 371
small units, 117-118
supply and maintenance, 120-121
telecommunications, 118
Ramcke, General Bernhart-Hermann, 200
Rapid Deployment Joint Task Force, 317
Raw materials
compared with resources, 153
experimental, 158-159
stockpiles, 158
RDJTF, 317
R&D. *See* Research and development
Reagan, President Ronald
Libyan raid, 16
Strategic Defense Initiative, 209
Red Ball highways, 218
Refugees
conflicts cause, 180
from deforestation, 298
Korea, 204
Pakistan, 180
Regional geography
classifications, 5-7
defined, 402-403
Regions. *See also* Regional geography
related to boundaries, 6
Relief, 27, 29
Religions
conflicts, 186-187, 296
denominations, 186
military manipulations, 187
Remagen bridge, 218
Research and development, urban combat, 204
Reservoirs, as targets, 32
Resistance movements, 205-206
Resources. *See* Natural resources
Revolutionary uprisings, 204-205
Right ascension, 139
Rio Pact, members, 248
River crossings
considerations, 34
Operation *Market Garden*, 20, 22
Rhine, 218
Russia, 34
Sava, 7
Riverine warfare. *See also* Wetlands
Mekong Delta, 124, 126
Rivers. *See also* Bridges; Inland waterways
boundaries, 286, 291
Burma Road, 222-223
characteristics, 32-34
deserts, 111 112
Europe, 32
fords, ferries, 221
Ho Chi Minh Trail, 371
Normandy, 349-351, 353, 356
seasonal fluctuations, 32
water diversion, 299-300
Roads. *See also* Bridges
all-weather, 216, 218
characteristics, 215-218
compared with railways, 224
construction, 221-223
demolitions, 223
fair weather, 218
fords, ferries, 221
Ho Chi Minh Trail, 367-368, 372-373
I CTZ, 380, 381
Laotian panhandle, 372-373, 375
Normandy, 216, 355
Red Ball highways, 218
tunnels, 221
Rock
characteristics, 36-37
construction materials, 38-39, 350
Rome, open city, 200
Rome Plows, 42, 269, 298
Rommel, Field Marshal Erwin
Atlantic Wall, 271
Libyan air bases, 230-231
water rationing, 113
Rommel's asparagus, 271, 360
Roosevelt, President Franklin D.
Japanese embargo, 160
on change, 339
World War II AORs, 308, 313
Rorke's Drift, 268
Rotation, Earth's, 49, 141, 142
Route 9
in Laos, 372-373
in Vietnam, 380-381
upgrading, 378, 382-383
Route packages, over North Vietnam, 321, 323, 324
Rubber sources, 157-159
Rung Sat Special Zone
defoliation, 43
described, 124, 126
Runstedt, Field Marshal Gerd von, on Loire lodgment, 349
Russia. *See also* Soviet Union
absorbs Chinese territories, 290
icy ports, 98
large size, 17, 18
linguistic problems in Caucasus, 185
national character, 189

population patterns, 180
Russian Revolution, 205

Sabotage
heavy water plant, 31
oil installations, 162
urban combat, 206
Saddam Hussein
desert warfare, 42
"no fly zones" deter, 323
oil grab, 157, 165
oil spills, fires, 161, 165, 299
persecutes Shiites, 124, 187
pipeline problems, 241
Salients, 20
Salinity (sea water), 47-48
Sanctuaries, 16
Sanitation. *See* Diseases
Saudi Arabia
folkways, 190
petroleum installations, 161-164
water desalinization, 35
Schlesinger, James R., on opinions, 277
Schlieffen, Field Marshal Graf von, invasion plan, 199, 343
Scorched earth, 17, 124, 160-161
Sea breezes, 70, 72
Sea ice, typified, 52, 54-55. *See also* Icebergs and floes; Pack ice; Marginal ice zone
Sea lines of communication. *See also* Harbors; Seaports
bottlenecks, 57, 240, 291
described, 232-236, 403
littoral, 129
Philippines straddle, 254
security for, 314-315, 317-318
Soviets threaten, 15-16
SEAL teams (Navy)
beach reconnaissance, 56-57
hypothermia, 89
patrol boats, 84
Rung Sat Special Zone, 126
Sea of Okhotsk, submarine bastion, 57, 100
Seaports. *See also* Cherbourg
artificial harbors, 235-236, 362
Danang, 380, 381
facilities, 232-234
Sea power proponents, 278, 280
Sea sickness, 60, 99
Sea shores, 126-128. *See also* Beaches
SEATO, 248
Sea water. *See also* Oceans
density, 48
magnetic anomalies, 65
permeability, 48
salinity, 47-48
sound propagation, 48, 65
stratification, 48
submarine communications, 48, 65
Second front, 347
Seoul
population, 198
vulnerability, 18
Sepoy mutiny, 186
Shape (geographical), 18-23
Ships. *See* Submarines; Surface ships
Sieges, 200-201
Siegfried Line, 270-271
Sinai roads, 216
Size (geographical), 17-18
Skate, under arctic ice, 100
Skorzeny, Captain Otto, 85
Slim, Field-Marshal Sir William
mountains, 103
river transportation, 239
tanks, 120
SLOC. *See* Sea lines of communication
Slopes. *See* Gradients
Small Wars Manual, jungles, 116
Snow
avalanches, 107-108
fuel requirements, 98
reflects light, 96
skis vs. snowshoes, 97
trafficability, 97
Soil
beaches, 55-56
characteristics, 36-37
construction materials, 38-39
trafficability, 37-38
weapon performance, 38
Solar flares, 143
Somalia
cultural conflict, 296
linguistic shortage (U.S.), 184
urban combat, 205
SOUTHCOM. *See* U.S. Southern Command
Southeast Asia Treaty Organization (SEATO), 248
Soviet Union. *See also* Russia
access to oceans, 11-13
Afghan War, 114
airfields, 230
assured destruction of, 209
border disputes, 290-291
border security, 18
containment of, 246, 280-281
core areas, 341, 342
Cuban missile crisis, 15

Elbe linkup, 320
European buffers, 288-290
Finland, 121-122
German cold casualties, 88
icy ports, 98-99
large size, 17, 18
merchant fleets, 234-235
minerals, metals, 155, 156
Murmansk run, 100, 102
mutual force reductions, 15
naval bottlenecks, 13, 57
nuclear waste disposal, 300
railroads, 18, 224, 226, 228
river crossings, 34
roads, 226
spaceports, 236-237
threatens sea lanes, 15-16
two front war, 14
urban defense, 209
U.S. AOR, 309
U.S. "eavesdropping posts, 259
Space. *See also* Circumterrestrial space; Lunar libration points; Moon; Orbits; Vacuum
aerodynamic drag, 141
atmospheric interfaces, 139-141
"cabin fever," 150
chemical, biological warfare, 148
compared with oceans, 137, 139
critical terrain, 146-147
distinctive medium, 4, 6, 137
Earth-Moon System, 137-139
gravity, 141-142, 144-147
longitude and latitude, 139
Mackinder's Theory, 282
maps, 144
motion sickness, 149
radiation, 143, 149
reentry, 141
school of thought, 282
space ports, 236-237
subsistence, sanitation, 149
telecommunications, 139
time-distance, 139
weightlessness, 149-150
weapon performance, 147-149
weather, 139, 141
Spain (U.S. bases), 253, 254, 257
Special Air Service, North Africa, 230-231
Spratly Islands, 291-293
Spykman, Nicholas, land power proponent, 278
Stalin, Joseph
Baikul-Amur Magistral, 226, 228
Berlin, 201
buffer zone, 14, 288-290
containment of, 280-281
Finland, 80
Second Front, 347
Stilwell, General Joseph, 116
St. Lô, importance, 356
St. Nazaire, amphibious raid, 62
Steppes. *See also* Grasslands
military significance, 42
Stimson, Henry L., on U.S. Navy, 278
Stirling, Major David, desert tactics, 114, 230-231
Storms, differentiated, 75
Straits, typified, 57, 239-240, 291
Strategic Bombing Survey, 161, 208
Street fighting, 201-203
Streets, characterized, 196, 198
STRICOM, 317
Struble, Vice Admiral Arthur D., 64
Submarines. *See also* Antisubmarine warfare
barnacles, seaweed, 61
buoyancy, 60-61
communications, 48, 65
early uses, 64
littoral, 128-129
signatures, 65
under ice, 100, 102
U.S. bases, 247, 251, 252, 253
Suez Canal
significance to Soviets, 240
sunken ships, 57, 240
Sun, influence on tides, 50, 52
Sun Tzu
know enemies, 177
on cities, 195
Surf, 52-53
Surface ships
barnacles, seaweed, 61
icing, 60, 84
salt water effects, 61
seaworthiness, 59-60
storage space, 99
weather effects, 83-85
Swamps. *See* Wetlands
Swell (ocean), 50
Sword Beach, 352, 353

Taiga, 39, 121-122
Tanks. *See* Armor
Tan, Pei-Ying, Burma Road, 222
Tarawa
boundaries, 321,322
fortifications, 268
landings, 62

Taylor, General Maxwell D., AOR in Northeast Asia, 315
Tchepone
airfield, 373
critical terrain, 378
size, importance, 372, 378
"tickets to," 367, 383
Tedder, Air Marshal Sir Arthur on air AORs, 323
Telecommunications
electromagnetic pulse, 147-148
in and from space, 139
in sea water, 48, 65
key factors, 5
rain forests, 118
satellites, 146
solar flares, 143
submarines, 48, 65
U.S. bases abroad, 251, 259, 262-263
Temperature. *See also* Cold weather; Hot weather
airfields, 229
altitude, 72
deserts, 311
maximums, minimums, 71, 72
moon, 144
mountains, 104
thermal crossovers, 113 114
thermosphere, 143
water density, 48
wind chill, 71-73, 88, 97-98
Terrain
defined, 404
masks, 29, 31
Territorial airspace, 287
Territorial waters
claims, 286-287
law of the sea, 286-287
Terrorism, 206
Thanh Hoa bridge, 207
Theater, 318-319, 404
Thermal crossovers, 113-114
Thermocline, 48, 49
Thermosphere, 140-141, 143
Thunderstorms, 75, 78
Thule, Greenland
Operation *Arctic Night*, 97-98
SAC, BMEWS base, 16, 247-248, 249
sea ice trafficability, 55
Tibet, 29, 297
Tides
characteristics, 50, 52
Inchon, 62, 64
Normandy, 357, 361
tidewater swamps, 125-126
Time-distance
factors, 14-15, 139
mountains, 103
Panama Canal, 241
Topographical crest, 29, 31, 405
Topography
defined, 405
perspectives differ, 3-4
types, 27-32
Town plans, 196, 405
Tokyo, aerial bombardment of, 208
Trafficability
beaches, 56
brush, high grass, 42
deserts, 113
fords, 221
ice, 55, 97
Laotian panhandle, 371-373, 375
mountains, 29, 103
New Guinea, 118
Normandy, 355, 358, 360
rain forests, 118, 120-121
snow, 97
soil influences, 37-38
swamps, 122
Training teams, area orientation, 190-191
Trans-Iranian Railroad, 224
Transportation. *See* Lines of communication
Trans-Siberian Railroad
bottlenecks, 226
importance, 18
vulnerability, 224, 228
Treaty on Outer Space, 325
Treaties (U.S.), defense pacts, 246, 248
Treaty of Tordesillas, 285
Trench foot, 88
Tribal friction, 182-183, 293
Trouble spots
cultural conflicts, 293
geographic causes, 285
typified, 287-288
Trucks
deserts, 113, 115
mountains, 103
snow, 97
Truman, President Harry S, Unified Command Plan, 308
Tundra, 39, 121
Tunnel rats (Vietnam), 269
Tunnels
demolitions, 223
described, 221
Korea, 272
Messines Ridge, 271-272

railways, 224, 226
Viet Cong and North Vietnam Army, 269
Turkey (U.S. bases), 253, 254, 259
Turkish Straits, 240, 253
Tutsi tribe, 180, 293
Twilight types, 77 78
Typhoons
Danang, 377
Inchon, 64

Unified Command Plan (U.S.)
Areas of Responsibility, 308-311
complexities, 311
reviews of, 309, 318
seams, 311
United Nations Convention on Law of the Sea, 286-287
United States. *See also* U.S. Cold War bases
access to oceans, 11
AORs, World War II, 308
Canadian boundary, 18, 285, 286
city defense, 209, 272-273
Cuban missile crisis, 15, 224
defense pacts, 246, 248
environmental policies, 300-301
merchant fleets, 234
minerals and metals, 155-156
mutual force reductions, 15
national character, 189
railway modernization, 224
sanctuaries, 16
space ports, 236-237
urban sprawl, 198
Urban areas
described, 196-198
populations, 198, 199
Urban bombardment
defense, 209, 272-273
experience, 206-208
future applicability, 208
Urban combat
bypasses, 199
disadvantages of, 195
historical examples, 201
logistics, 203-204
nonlethal weapons, 204
open cities, 199-200
refugees, 203-204
resistance movements, 205-206
revolutionary uprisings, 204-205
sieges, 200-201
street fighting, 201-203
suburbs, 196, 199
terrorism, 206
weapon effectiveness, 201, 203
Urban sprawl, 198, 199
U.S. Atlantic Command, 309, 317-318
U.S. Central Command, 184, 309-311, 315, 317
U.S. Cold War bases
Africa, 254
arctic, 247, 248, 249, 250
Australia, 254
Britain, 250-251
closures, 261, 264
France, 252-253, 255
Germany, 253, 256
Greece and Turkey, 253, 254, 259
home bases, 245-246
Italy, 253, 254, 258
Japan, 260-261, 263
Korea, 260, 263
Latin America, 261
Middle East, 254
Philippines, 254-255, 262
Spain, 253, 254, 257
U.S. European Command, 309, 311-313
U.S. Pacific Command, 184, 309, 315
U.S. Southern Command, 309, 317-318
U.S. Strike Command, 317
USS *Skate*, under arctic ice, 100
Utah Beach, 351,352

Vacuum
beam weapons, 87-88, 139, 147-148
combat on moon, 148-149
light, 139, 143
maneuverability, 146
nuclear weapons, 147
sound, 139
Van Allen Belts
bypasses, 146
described, 143
radiation risks, 149
Varius, Publius Quintillius, *Teutoburgerwald*, 41
Vegetation. *See also* Agent Orange; Grasslands; Herbicides; Rain forests; Steppes; Wetlands
deserts, 113
Ho Chi Minh Trail, 371-372
mountains, 41
types, 4, 39-42
Vietnam. *See also* Agent Orange; herbicides; Operation Plan *El Paso*
AOR disputes, 315
bridges bombarded, 207
close air support, 85
demilitarized zone, 14, 286, 371
disease, 181

monsoons, 79, 368, 375-377
non-Asian POWs, 181
route packages, 321, 323-324
Tet, 187
tunnels, 269
Visibility
deserts, 113-114
natural light, 77-78
rain forests, 117
Visual flight rules (VFR), 84
Vosges Mountains, defensible, 109

Wadis, 111
Warsaw Pact
avenues into NATO, 313
members, 289
Washington, General George, crosses Delaware, 80
Water
causes conflicts, 299
chemical decontamination, 32, 36
dehydration, 88, 95, 106, 113
desalinization, 35
deserts, 35-36, 79, 112-113
military purposes, 32
rationing, 113
requirements, 34, 112-113
sources, 34-36
wells, 35-36
Water table, 35-36
Waves (ocean)
characteristics, 50, 52-53
ship stability, 60
Weather. *See also* Cold weather; Hot weather
air operations, 70, 75, 84-85, 103
biological warfare, 86
chemical warfare, 86-87
electro-optical systems, 87
forecasting, 80
Inchon, 64
mountains, 103-104
naval warfare, 83-84
Normandy, 353-354, 361
nuclear weapons, 85-86
OPLAN *El Paso*, 375-377
space launches, 139, 141
trafficability, 80
weapon performance, 83, 85, 87-88
Weightlessness, 149-150
Wells, 35, 36
West Germany. *See* Federal Republic of Germany
Westmoreland, General William C.
monsoon plans, 79
on MACV AOR, 315
OPLAN *El Paso*, 367
Tchepone, 367, 383
Westwall, 270-271
Wetlands
construction, 125
disease, 126
grassy wilderness, 122, 124
Mekong Delta, 38, 124-125
Normandy, 350-351, 355, 360
perennial swamps, 122, 124-126
seasonal swamps, 121-122
tidewater forests, 125-126
types differentiated, 121
Weyand, General Maxime, 200
Wind chill
effects, 71-73
parachutists, 97-98
Winds
air operations, 70, 85, 106-107
deserts, 111-112
mountains, 107
ocean currents, 49
sea states, 54
spacecraft, 139, 141
surface, 70-71
Winter Line in Italy, 109
Wolmi Do Island, 63, 64
Woodlands. *See* Forests
World Trade Center, terrorism, 206

Yamashita, General Tomoyuki, 200
Ypres mud, 80
Yugoslavia
cultural diversity, 182
cultural conflict, 293

ABOUT THE AUTHOR

John M. Collins, who is currently a Distinguished Visiting Research Fellow at the National Defense University, has devoted his entire adult life to military affairs. He joined the U.S. Army as a private in 1942, retired as a colonel in 1972 after wartime service in Europe, Korea, and Vietnam, then spent the next 24 years as Senior Specialist in National Defense at the Library of Congress. He earned a Master's Degree in geography at Clark University, Worcester, Massachusetts, in 1951, and applied lessons learned to practical problems throughout the rest of his career. Ten previous books on military subjects gained wide respect in the United States and abroad; some were variously translated into Russian, Chinese, Japanese, Korean, and Spanish.

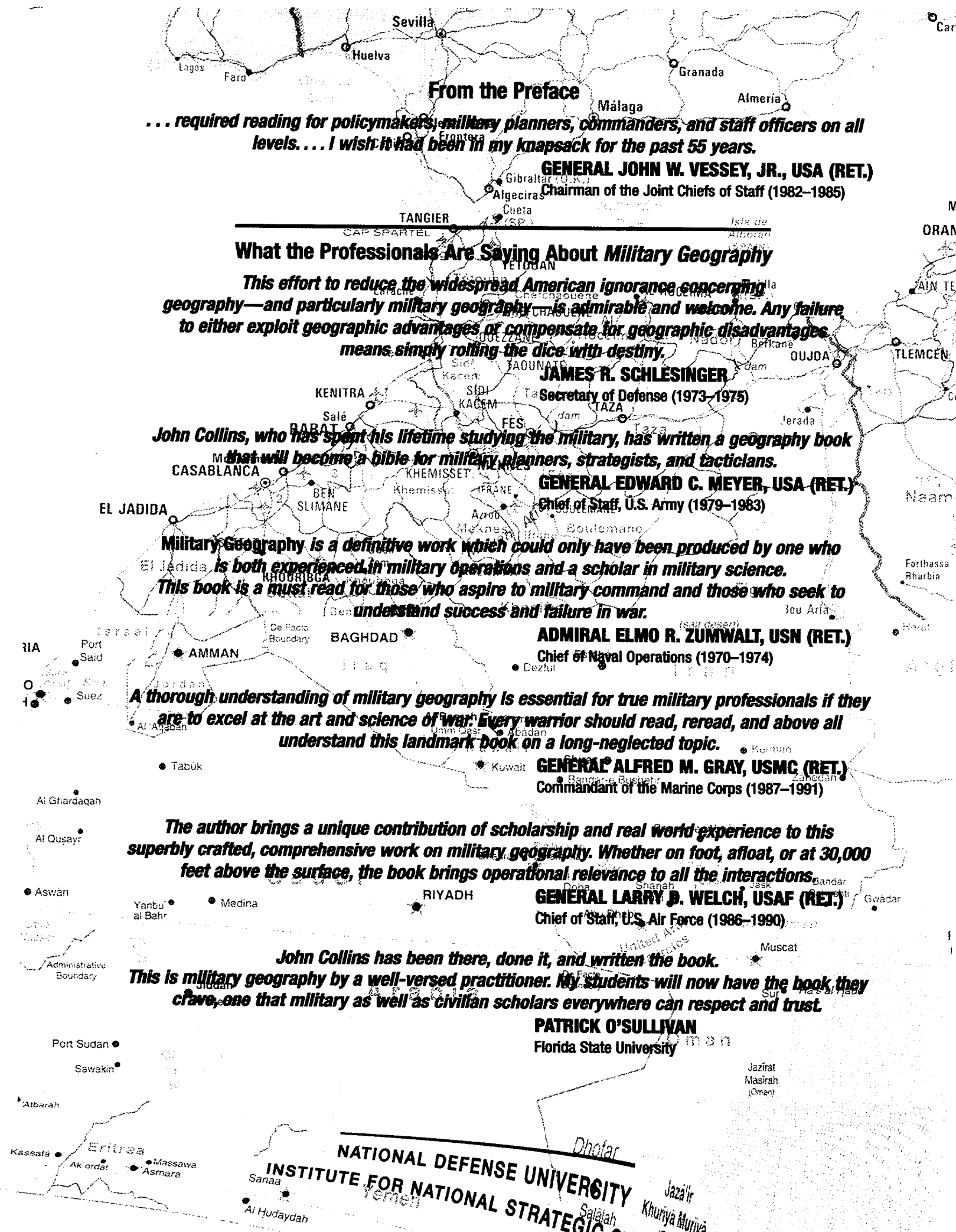
ISBN 0-16-049405-2



For sale by the U.S. Government Printing Office
Superintendent of Documents, Mail Stop: SSOP, Washington, DC 20402-9328
ISBN 0-16-049405-2

Typeset in Optima
Titles in Umbra

Cover design and artwork by the
Typography and Design Division,
U.S. Government Printing Office



From the Preface

. . . required reading for policymakers, military planners, commanders, and staff officers on all levels. . . . I wish it had been in my knapsack for the past 55 years.

GENERAL JOHN W. VESSEY, JR., USA (RET.)
Chairman of the Joint Chiefs of Staff (1982–1985)

What the Professionals Are Saying About *Military Geography*

This effort to reduce the widespread American ignorance concerning geography—and particularly military geography—is admirable and welcome. Any failure to either exploit geographic advantages or compensate for geographic disadvantages means simply rolling the dice with destiny.

JAMES R. SCHLESINGER
Secretary of Defense (1973–1975)

John Collins, who has spent his lifetime studying the military, has written a geography book that will become a bible for military planners, strategists, and tacticians.

GENERAL EDWARD C. MEYER, USA (RET.)
Chief of Staff, U.S. Army (1979–1983)

Military Geography is a definitive work which could only have been produced by one who is both experienced in military operations and a scholar in military science. This book is a must read for those who aspire to military command and those who seek to understand success and failure in war.

ADMIRAL ELMO R. ZUMWALT, USN (RET.)
Chief of Naval Operations (1970–1974)

A thorough understanding of military geography is essential for true military professionals if they are to excel at the art and science of war. Every warrior should read, reread, and above all understand this landmark book on a long-neglected topic.

GENERAL ALFRED M. GRAY, USMC (RET.)
Commandant of the Marine Corps (1987–1991)

The author brings a unique contribution of scholarship and real world experience to this superbly crafted, comprehensive work on military geography. Whether on foot, afloat, or at 30,000 feet above the surface, the book brings operational relevance to all the interactions.

GENERAL LARRY D. WELCH, USAF (RET.)
Chief of Staff, U.S. Air Force (1986–1990)

John Collins has been there, done it, and written the book. This is military geography by a well-versed practitioner. My students will now have the book they crave, one that military as well as civilian scholars everywhere can respect and trust.

PATRICK O'SULLIVAN
Florida State University

NATIONAL DEFENSE UNIVERSITY
INSTITUTE FOR NATIONAL STRATEGIC