MOBILITY IN THE ARCTIC: APPLYING LESSONS FROM THE PAST TO THE NEW OPERATIONAL ENVIRONMENT

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The Arctic operational environment has and continues to present challenges to mobility at the tactical and operational level. Doctrine and training solutions require perspectives from the past as well as an understanding of the future developments to the operational environment. Three case studies were analyzed to inform doctrinal and training recommendations – the Battle of Suomussalmi, the Petsamo-Kirkenes Operation, and post-World War II Canadian exercises. The outcomes of this analysis when held against future Arctic factors of temperature, permafrost, precipitation, infrastructure, vegetation, and the Russian threat indicate that US doctrine provides a sufficient base to inform tactical mobility. Operational doctrine, however, needs to be updated to fully prepare commanders and staff for the mobility challenges awaiting an Arctic Brigade. Continuing multi-national training exercises across the Arctic, developing a permanent joint multinational training center, and standardizing Arctic training will further prepare ground forces for the mobility challenges of the future.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

MOBILITY IN THE ARCTIC: APPLYING LESSONS FROM THE PAST TO THE NEW OPERATIONAL ENVIRONMENT, by MAJ Dustin E. Lawrence, 147 pages.

The Arctic operational environment has and continues to present challenges to mobility at the tactical and operational level. Doctrine and training solutions require perspectives from the past as well as an understanding of the future developments to the operational environment. Three case studies were analyzed to inform doctrinal and training recommendations – the Battle of Suomussalmi (7 December 1939-8 January 1940), the Petsamo-Kirkenes Operation (7-29 October 1944), and post-World War II Canadian exercises (1945-1955). The outcomes of this analysis when held against future Arctic factors of temperature, permafrost, precipitation, infrastructure, vegetation, and the Russian threat indicate that US doctrine provides a sufficient base to inform tactical mobility. Operational doctrine, however, needs to be updated to fully prepare commanders and staff for the mobility challenges awaiting an Arctic Brigade. Continuing multi-national training exercises across the Arctic, developing a permanent joint multinational training center, and standardizing Arctic training will further prepare ground forces for the mobility challenges of the future.

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ACRONYMS

ASI	Additional Skill Qualifications
A2/AD	Area Access Area Denial
ADA	Air Defense Artillery
AMAP	Arctic Monitoring and Assessment Program
DOTMLPF-P	Doctrine, Organizational, Training, Military, Leadership, Personnel, Facilities, Policy
DoD	Department of Defense
JMRC	Joint Multi-national Readiness Center
LSAT	Land Surface Air Temperature
NATO	North Atlantic Treaty Organization
NOAA	National Oceanic and Atmospheric Administration
NORTHCOM	United States Northern Command
NSIDC	National Snow and Ice Data Center
NSR	Northern Sea Route
NWP	Northwest Passage
OE	Operational Environment
TTP	Tactics, Techniques, and Procedures
UN	United Nations
USARAK	United States Army Alaska
USINDOPACOM	United States Indo-Pacific Command
USSR	Union of Soviet Socialist Republics

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CHAPTER 1

INTRODUCTION

> It is for the possession of these thickly-populated regions, and of the northern ice-cap, that the three powers are constantly struggling. In practice no one power ever controls the whole of the disputed area. Portions of it are constantly changing hands, and it is the chance of seizing this or that fragment by a sudden stroke of treachery that dictates the endless changes of alignment.
>
> —George Orwell, *Nineteen Eighty-Four*

Background

For decades, nations sent their boldest explorers north with flags in hand to claim the top of the world. Champions representing their respective people battled across windswept ice, chasing the great prize. However, in the late nineteenth century the scientific community collectively realized the polar basin was an ice-covered sea. Any uncharted land remained on the periphery of the Arctic. The geo-political nature of exploration took on a sporting undertone. Often with noble scientific purposes justifying their adventures, these explorers competed in a dangerous race to stand atop the great northern podium. Through the century, many claimed to be the first. But it was not until 1968, that an American team led by insurance salesman Ralph Plaisted undeniably reached the North Pole. After the team reached 90.0000° North, 135.0000° West on Ski-Doo snowmobiles, a US Air Force jet, call sign "Lark 47," radioed the team, confirming the accomplishment for the first time. "I see them dead ahead. Four, three, two, one, North Pole. Dead on. Every direction from where you fellows are is south."[1]

[1] Guy Lawson, "The Incredible Journey," *Artful Living* (Autumn 2016), https://artfulliving.com/plaisted-polar-expedition-north-pole-adventure-travel/.

But Plaisted's victory did not end the race. While neoliberalism and collective scientific endeavor continued for several decades, a realist perspective returned to the Arctic.[2] Scientific expeditions surveyed the littoral seas, discovering vast riches below the chop and ice. Resources would not be the only opportunities the Arctic presented. The decades following the expedition were marked by an alarming phenomenon: the thick multi-year ice that supported Plaisted's expedition began to disappear as the climate warmed. Access to these resources opened, along with trade routes to key markets. Airplanes, dog-teams, or Ski-Doos, are no longer the preferred modes of travel over the Arctic – ships are.

As the Arctic becomes bluer, great power competition intensifies. The Arctic states, those with land claims in the Arctic, now seek to exploit their stakes. Non-Arctic states, namely China, will not be left out. Often under the guise of noble ventures, these countries invest in infrastructure, occupy territory for research and deploy military forces to the Arctic. Russia, however, occupies the largest and most advantageous position in the Arctic. Seeking to capitalize on their position, they have invested heavily in developing an advanced anti-access/area-denial (A2/AD) system along their northern frontier. Expanding this bubble and improving their ability to project power into the Arctic are major goals of the Kremlin.

The current Arctic environment now is far different than the one Plaisted and his team entered in 1968. And it continues to change. Despite these changes, moving across

[2] Kenneth Yalowitz and Ross A. Virginia, "Realism in the Arctic," *The National Interest,* 10 July 2020, https://nationalinterest.org/feature/realism-arctic-164489.

the harsh, vast environment will challenge US Army formations much like it challenged early Arctic champions.

Problem Statement

The Arctic, with its sparse expansive frozen landscape, will challenge mobility at the tactical, operational, and strategic levels of war. Because of the Arctic's vastness and limited settlement, history provides relatively few examples of Arctic warfare. Doctrine writers, to confront the challenges of mobility, must draw from history while keeping a keen eye on the future. The few historical cases of Arctic warfare offer insight and possible solutions to the mobility problems ground forces face in the Arctic. However, as the Arctic warms and the threat prepares for the next phase of Arctic warfare, old problems are compounded with new challenges. Some mobility solutions may transfer. Others may be left in the historical record as the landscape changes with the warming temperatures.

Purpose of the Study

The purpose of this study was to explore how the US Army, as a component of a joint force, should operate in the future Arctic operational environment. Specifically, this study focused on the challenges to tactical and operational mobility throughout the Arctic landscape. It applied lessons from history, weighed them against the emerging conditions, and offers doctrinal and training solutions for the new Arctic operational environment.

Research Questions

The primary research question of this thesis was "How do US Army Forces in the Arctic maintain tactical mobility, given the unique environment and potential threats?"

The secondary research question then was “What unique challenges has the Arctic presented to mobility?” Additionally, “What new challenges does the changing environment present to Arctic mobility?” And, “What doctrinal solutions and training solutions improve mobility?”

Assumptions

The consensus from scientific model’s project sweeping environmental changes in the Arctic, primarily warming temperatures in the region, thawing permafrost, and reduction of multi-year ice. With various motives, Arctic nations, non-Arctic nations, international actors, and non-governmental organizations continue to interact in the Arctic arena. The geo-political space continues to change. For this reason, the following assumptions underpins the research:

1. The environmental changes in the Arctic will continue at the current pace or increase.
2. Given the challenges faced across the globe and the nature of the mission in the Arctic, the US will not appropriate a significantly larger proportion of resources to the Arctic in the near-term. Future force development will remain “zero growth.”
3. Strategic support will facilitate tactical mobility at the brigade-level and below.
4. Given its stakes and claims in the Arctic, Russia will remain the primary threat to US land forces in the Arctic. Although China continues to press into the Arctic, it continues to rely less on the military, but on the other elements of national power to secure its national interests.

Definition of Terms

The Arctic. The US defines the Arctic in Title 15 U.S.C. § 4111. However, this definition does not account for areas that both scientific bodies and other countries see as the Arctic. The Arctic Council, the intergovernmental forum that promotes the cooperation, coordination, and interaction among the Arctic States (see below), established other definitions through the *Arctic Human Development Report*, the Arctic Monitering and Assessment Programme Working Group, and Conservation of Arctic Flora and Fauna. These definitions include additional land beyond the Arctic Circle such as permafrost regions in Canada and Russia, and parts of the Atlantic Ocean such as the Labrador Sea. For the purposes of this study, the Arctic Monitoring Assessment Programme (AMAP) will be used (see Figure 1).[3]

[3] Working Group of the Arctic Council, *Physical and Geographical Characteristics of the Arctic* (Oslo, Norway: The Arctic Monitoring and Assessment Programme, January 1998), 9-10.

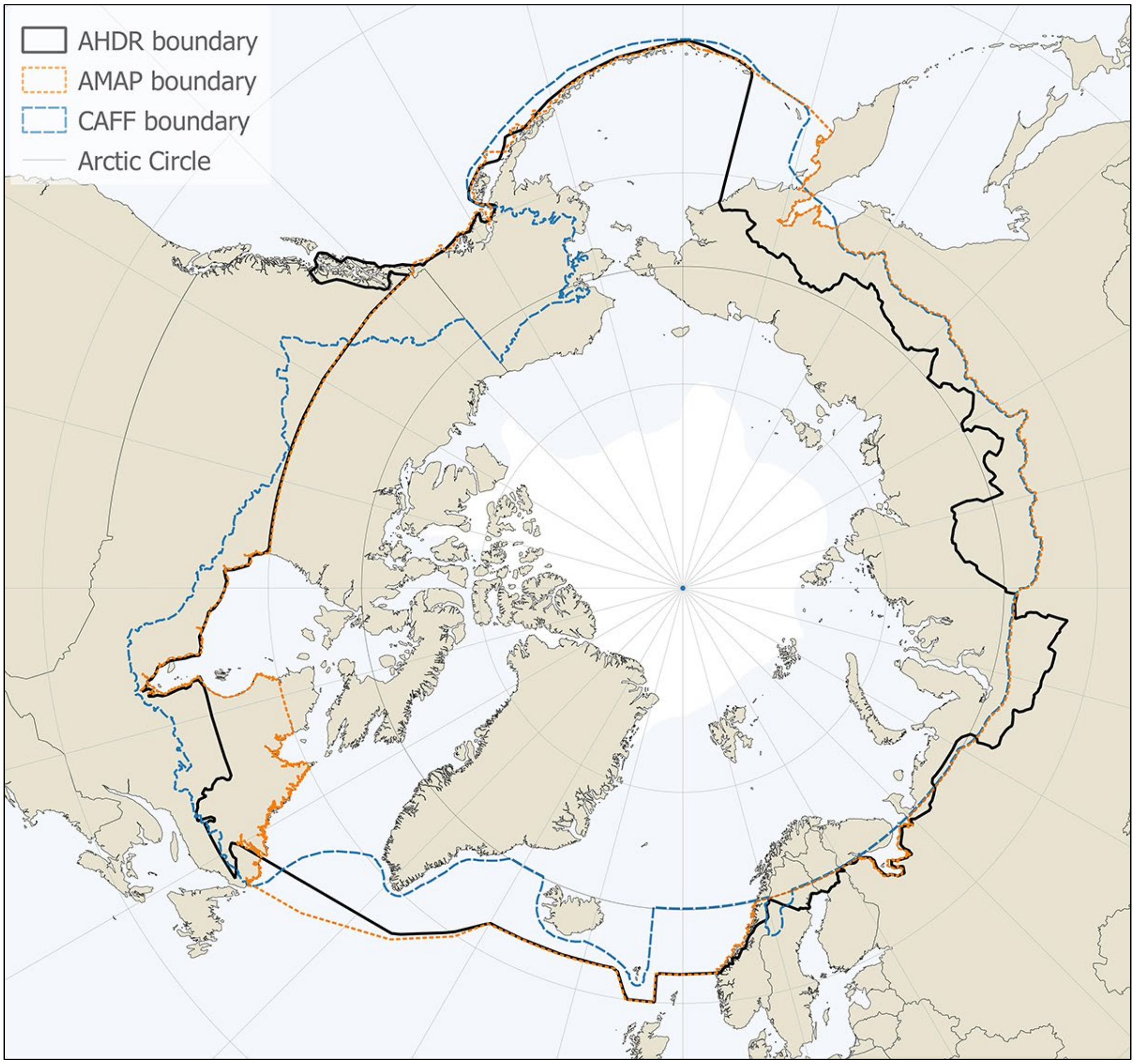

Figure 1. Map of the Boundary Used to Define the Arctic (AMAP)

Source: Arctic Centre, University of Lapland "The Arctic as Defined by the Arctic Council Working Groups," accessed 9 March 2022, https://www.arcticcentre.org/EN/arcticregion/Maps/definitions.

Arctic Circle. A line of latitude at 66° 33' N, marking the point where the sun does not rise above the horizon on the shortest day of the year.[4]

Arctic Nation. Refers to the eight nations who can exercise sovereignty over the lands within the Arctic Circle. They are the US, Canada, Kingdom of Denmark (through Greenland and the Faroe Islands), Finland, Iceland, Norway, Sweden, and Russia.

Arctic Autumn. October to December.[5]

Arctic Winter. January to March.[6]

Arctic Spring. April to June.[7]

Arctic Summer. July to September.[8]

Mobility. A quality or capability of military forces which permits them to move from place to place, while retaining the ability to fulfill their primary mission.[9]

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[4] National Snow and Ice Data Center, University of Colorado, "Arctic Circle," Cryosphere Glossary, accessed 10 April 2022, https://nsidc.org/cryosphere/glossary/term/arctic-circle#:~:text=a%20line%20of%20latitude%20at,day%20of%20the%20winter%20solstice.

[5] The seasons are based on seasonal conditions. The range represented in this study represents the seasons as defined by the Arctic Report Card. T. J. Ballinger, J. E. Overland, M. Wang, U. S. Bhatt, E. Hanna, I. Hanssen-Bauer, J. Kim, and J. E. Walsh, "Surface Air Temperature," in *Arctic Report Card 2021*, ed. T. A. Moon, M. L. Druckenmiller, and R. L. Thoman (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2021), 8-14, https://doi.org/10.25923/53xd-9k68.

[6] Ibid.

[7] Ibid.

[8] Ibid.

[9] Headquarters, Department of the Army (HQDA), Army Doctrine Publication (ADP) 1-02, *Terms and Military Symbols* (Washington, DC: Army Publishing Directorate, August 2018), 1-66.

Motti. Finnish term created during the Soviet-Finnish Winter War, which denotes an isolated and immobile enemy formation.[10]

Multi-Domain Operations. Operations conducted across multiple domains and contested spaces to overcome an adversary's (or enemy's) strengths by presenting them with several operational and/or tactical dilemmas through the combined application of calibrated force posture; employment of multi-domain formations; and convergence of capabilities across domains, environments, and functions in time and spaces to achieve operational and tactical objectives.[11]

Tactical Mobility. The ability of friendly forces to move and maneuver freely on the battlefield relative to the enemy (US Army).[12]

The Arctic Goblin. A term first used by Canadian Armed Forces to describe the fears and misconceptions that soldiers have about the northern environment and the potential hardships, which damage morale, reduce motivation, and diminish performance.[13]

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[10] There are several theories to how the term was coined. The above definition comes from the context used by most of the sources presented in the literature review.

[11] US Army and Training and Doctrine Command (TRADOC), TRADOC Pamphlet 525-3-1, *The US Army in Multi-Domain Operations 2028* (Fort Eustis, VA: TRADOC, 6 December 2019), GL-7.

[12] Headquarters, Department of the Army (HQDA), Army Doctrine Publication (ADP) 3-90, *Offense and Defense* (Washington, DC: Army Publishing Directorate, July 31, 2019), 2-16.

[13] P. Whitney Lackenbauer, Peter Kikkert, and Kenneth C. Eyre, "Lessons in Arctic Warfare: The Army Experience, 1945-55," in *Canadian Arctic Operations, 1941-2015: Lessons Learned*, *Lost, and Relearned,* ed. Adam Lajeunesse and P. Whitney Lackenbauer (Fredericton, NB: The Gregg Centre for the Study of War & Society, University of New Brunswick, 2017), 51.

Scope

This study will focus on the US Army as an element of the joint force. Although international and inter-service solutions are required for success in the Arctic, they are beyond the scope of this research paper. Geo-political and joint considerations will be used for context, this paper focuses on what the US Army can do as a component of the joint force in the Arctic.

Limitations and Delimitations

The primary limitation of this paper was time. As with many aspects of the rapidly developing future operational environment, time is the most precious resource. New research and developments arise regularly. However, the joint services have published their strategies. US Army Futures Command is packaging their latest concept for the Arctic Brigade Concept. Across the pole, Russia continues to posture its forces even as it conducts operations in Ukraine. And China is expanding the Belt and Road Initiative north to the Arctic States. Meanwhile, the Arctic continues to warm. This study attempted to answer the research questions given these current conditions.

The study will use the AMAP to define the Arctic. This definition represents a combination of political boundaries, vegetation (Arctic tree line), human populations, and geospatial considerations. The definition provides the most extensive boundaries on land and most internationally recognized definition of the Arctic. It also allows for inclusion of more Arctic cases to be considered from the historical record.

The study of mobility was limited to the context of offensive and defensive tasks at the operational and tactical levels. Although Defense Support of Civil Authorities and

Stability operations are potential missions for units based in the Arctic, the study will not include them.

All the warfighting domains were considered, but solutions across these domains were not explored in depth. The maritime and air domains are a major component to Arctic great power competition. Solutions in the land domains require adjustments in the air and at sea. Again, tactical and operational mobility, not strategic mobility, were the focus.

Any Arctic mobility solutions will involve solutions across the spectrum of doctrine, organizations, training, materiel, leadership, personnel, facilities, and policy (DOTMLPF-P). However, because of the limitation of time this study explored solutions in the doctrinal and training realms of change.

Lastly, this study did not venture beyond the 2050 Arctic operational environment. While study of the future operational environment draws from peer reviewed scientific models, forecasting beyond that time invites too many unknown variables. Additionally, Army Futures Command is currently developing and staffing concepts for 2035 to 2050.

Significance of the Study

The Army and the other services of the joint force are coming to grips with the need for solutions across the DOTMLPF-P spectrum. The Army Chief of Staff Paper #1, pledged a Multi-Domain Task Force – the Army’s premier unit to tackle the challenges of the future operation environment – to the Arctic.[14] This year 2021 also saw the release of the US Navy and Air Force Arctic strategies. The Army is staffing its concept for an Arctic Brigade – its vanguard unit for Arctic operations. Now, more than ever, it is important to establish Arctic doctrinal and training solutions to confront the challenges of the emerging operational environment.

For these reasons US Army Alaska Command (USARAK) continues to expand on large-scale exercises such as Arctic Warrior. However, comments from the after-action review of 2020's multi-national joint exercises are similar comments to exercises conducted decades before. The movement and maneuver sections call for solutions to overcome the constraints of the environment.[15] To counter the proliferation of multi-domain sensors and long-range fires, Arctic units continue to express an urgency to develop improvements to Arctic mobility. While similar concerns are expressed throughout the joint force, the Arctic's uniqueness precludes many bulk solution applications in the operational environment. Issues of Arctic mobility instead require special considerations.

The Arctic operational environment is not often considered among potential conflict zones like the South China Sea or Eastern Europe. However, the relevance of the Arctic is only increasing. And the short history of the Arctic warfare shows that the

[14] Department of the Army, *Army Multi-Domain Transformation: Ready to Win in Competition and Conflict,* Chief of Staff Paper #1 (Washington, DC: Headquarters, Department of the Army, March 2021).

[15] LTC Ralphael Jimenez, CPT Alexander Banks, and CWO 4 Brian Cox, "Arctic Winter Conditions Effects on Tactical Field Maintenance," *Army Sustainment* (Spring 2022): 64-67.

environmental constraints will not deter great powers from committing their military above the Arctic Circle. As Dr. Omond Solandt, the head of the Canadian Defense Research Board, said in 1948, "everybody knows it's impossible to fight a war in the Arctic, but we have to prepare for the man who doesn't know it's impossible."[16]

Summary

From the onset of Arctic exploration to great power competition in the Arctic, the stakes have been high. The loss of entire exploration parties proved a risk worth taking for a claim to the great north. Now, with the waters warming and landscapes changing, scientists, capitalists and soldiers seek to further exploit the region. Still, the classic considerations faced by Plaisted's team in 1969 remain. Today, they are interwoven with the new challenges faced elsewhere across the globe. With the ice melting and technology advancing, rapid, efficient, and decisive mobility on land is critical.

[16] "Canada: The Services: Churchill Chills," *Time Magazine* 51, no. 23 (June 1948), https://content.time.com/time/subscriber/article/0,33009,854386,00.html.

CHAPTER 2

LITERATURE REVIEW

Introduction

Experts across disciplines provided much insight on the Arctic's geo-political and physical landscape in 2021. Flush with strategic conjecture, the intellectual space was flooded with research on the motives of the Arctic actors. The study questions, however, targeted challenges faced at the operational and tactical level. These questions are:

1. How do US Army Forces in the Arctic maintain tactical mobility, given the unique environment and potential threats?
2. What unique challenges does the Arctic present to mobility?
3. What new challenges does the changing environment present to Arctic mobility?
4. What doctrinal solutions and training solutions improve mobility?

These questions served as the structure of the research. Many of the sources used offered varying degrees of answers to these questions. Rather than structure this chapter on the study questions, it first aims to establish the operational environment, present the case studies, and then introduce the current US strategy. This structure is important for framing the case studies. After these are presented, official US policies, and on-going approach to Arctic warfare will be reviewed. Chapter 3 will establish the methodology used to synthesize the information from the subsequent literature.

The Operational Environment

US joint doctrinal publications define the operational environment as the conditions, circumstances and influences that affect the employment of capabilities.[17] This section presents the literature used to understand the operational environment. Much like intelligence preparation of the battlefield, the section first explores the changing environment itself followed by the primary threat. The environment is organized by domain – maritime, air, land, information, cyberspace, and space.

Data on the Arctic maritime domain proved abundant given the global implications of a melting Arctic. Inter-governmental organizations, non-governmental organizations, the US, and other nations have heavily resourced Arctic research over the last ten years. Since its inception in 1982, the National Snow and Ice Data Center (NSIDC) regularly published research from global collaborative efforts. In a 2019 paper published in the journal *Climate*, NSIDC researchers projected 2054 as the likely first year the Arctic could be ice-free.[18] Their models, however, varied with this mark coming as early as 2023 or as late as 2100. The trends later reflected in NOAA's *Arctic Report Card 2020*, which marked the summer ice-extent at its second lowest since 1985.[19]

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[17] Office of the Chairman of the Joint Chiefs of Staff (CJCS), Joint Publication (JP) 2-0, *Joint Intelligence* (Washington, DC: Joint Chiefs of Staff, 2013), Ch. 1.

[18] Ge Peng, Jessica L. Matthews, Muyin Wang, Russell Vose, and Liqiang Sun, "What Do Global Climate Models Tell Us About Future Arctic Sea Ice Coverage Changes?" *Climate* 8, no. 1 (January 2020): 15, https://doi.org/10.3390/cli8010015.

[19] W. N. Meier, D. Perovich, S. Farrell, C. Haas, S. Hendricks, A. A. Petty, M. Webster et al., "Sea Ice," in *Arctic Report Card 2021*, ed. T. A. Moon, M. L. Druckenmiller, and R. L. Thoman (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2021), 32, https://arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard_full_report2021.pdf.

The models all point to continued ice-melt, and thus subsequently increased access to northern trade routes. Currently, the two primary sea routes are the Northwest Passage (NWP) and the Northern Sea Route (NSR). The World Economic Forum estimated Europe to Asia shipping times would be reduced by as much as 40% by using the NSR. Utilizing the NWP passage from New York to Japan could save four days from the Panama Canal route.[20] And as the ice continues to disappear, transpolar sea routes likely become accessible, further reducing shipping times.

Additionally, in 2009 the United States Geological Survey estimated that the Arctic contains roughly 13% of the world's undiscovered oil resources and about 30% of its undiscovered natural gas resources – most being offshore less than 500 meters under water.[21] In their 2018 series on Russia's Energy Extraction, the Arctic Institute cited these figures and noted nearly two thirds of Russia's untapped oil and gas reserves exist in their exclusive economic zone.[22] Arctic waters are notoriously dangerous and further development of sea trade and resource extraction comes with risk.

There was a common theme often noted by the Arctic Institute's experts and other observers – Arctic States are further developing their infrastructure on land to capitalize

[20] "The Final Frontier: How Arctic Ice Melting Is Opening up Trade Opportunities," World Economic Forum, 13 February 2020, https://www.weforum.org/agenda/2020/02/ice-melting-arctic-transport-route-industry/.

[21] US Geological Survey (USGS), "Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle," (USGS Fact Sheet 2008-3049, USGS, US Department of the Interior, Washington, DC, 2008), https://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf.

[22] Pavel Devyatkin, "Russia's Arctic Strategy: Energy Extraction Part III," The Arctic Institute, 20 February 2018, https://www.thearcticinstitute.org/russias-arctic-strategy-energy-extraction-part-three/.

on the trends at sea. The Arctic's land domain was traditionally characterized by sparse geographically isolated populations. Land above the Arctic Circle historically lacked infrastructure beyond sparse lines of communication to these northern indigenous populations or resource nodes. Many expect the economic development from the bourgeoning maritime activity to change this. Arctic projections, such as those provided by Timothy Heleniak though Nordregio International Research Center, predicted a moderate population growth over the next three decades. They also predict increased urbanization in the far north.[23] In 2019, Guggenheim Partners, a US $265 billion global investment and advisory firm, estimated US $1 trillion in infrastructure development was needed in the subsequent15 years to meet the World Economic Forum's (WEF's) principles for responsible development in the Arctic.[24] Billions more in Arctic development will likely fall outside of the WEF's principles. Much of the future development, according to the Arctic Institute experts, will take the form of extended road and rail networks, deep water ports, oil and gas pipelines, and communication architecture.[25]

Even as the ice recedes, the conditions on land will remain harsh. While NOAA reported alarmingly increased temperatures across the Arctic, the result on land is

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[23] Timothy Heleniak and Dimitry Bogoyavlensky, "Arctic Populations and Migration," in *Arctic Human Development Report: Regional Processes and Global Linkages,* ed. Joan Nymand Larsen and Gail Fondahl (Copenhagen: Nordic Council Ministers, 2014), 53-104.

[24] Guggenheim Partners, *Financing Sustainable Development in the Arctic* (Chicago, IL: Guggenheim Partners, LLC, January 2019).

[25] Pavel Devyatkin, "Chapter 15. Russia and the Arctic," in *Russian Strategic Intentions,* ed. Nicole Peterson (Washington DC: The Arctic Institute, 2019).

dynamic seasonal shifts. NOAA's annual report noted the annual average surface air temperature for the Arctic in 2019 was 35.4 degrees Fahrenheit. However, this area accounts for 8% of the globe. Temperatures have fluctuated across seasons and location. Even so, since 2000 the report established Arctic temperatures have risen about twice as fast as global temperatures, a result of the phenomenon known as Arctic Amplification.[26] Despite this, much of the Arctic landscape is still covered in snow for most of the year.[27] The extent of the warming and snow coverage will be further explored in Chapter 4.

The Arctic terrain is characterized by vast mountain ranges, expansive tundra and grasslands, varying types of forests, swamps, glaciers, and ice fields. NOAA's annual reports highlighted a key takeaway: the Arctic operating environment will drastically change season to season, and possibly year to year. Compounding the varying terrain will be the warmer temperatures and melting permafrost, which will affect infrastructure, vegetation, hydrology and land features.[28]

The US Army's 2021 Arctic strategy, *Regaining Arctic Dominance*, captured the effects of these changes. The strategy noted the strain on the sparse existing infrastructure. The reduction in multiyear ice increases coastal erosion, which threatens to degrade road and rail networks, and port infrastructure. Further inland, infrastructure not

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[26] Ballinger et al., "Surface Air Temperature," 21-27.

[27] L. Mudryk, A. Elias Chreque, R. Brown, C. Derksen, K. Luojus, and B. Decharme, "Terrestrial Snow Cover," in *Arctic Report Card 2020,* ed. R. L. Thoman, J. Richter-Menge, and M. L. Druckenmiller (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2020), 28-34, https://www.arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard_full_report2020.pdf.

[28] Ballinger et al., "Surface Air Temperature," 21.

normally subjected to the freeze-thaw cycles is now subject to these forces. As the report stated, "infrastructure in many austere locations has already deteriorated due to extreme environmental factors. It can also complicate force sustainment operations as roadways, seaports, and airfields are potentially rendered inoperable."[29]

With Arctic populations urbanizing around development as the existing land infrastructure is threatened, the environment is ripe for information warfare. Even with future investment into communication architecture, the information pipeline to Arctic populations is vulnerable to interdiction – either with homegrown propaganda or targeted coercive messaging. Hope Carr published a 2019 report in *Three Swords Magazine* titled "Arctic Sovereignty and Information Warfare," that addressed these dynamics in the Arctic information domain. Her analysis found that Russia is already targeting their own populations and may continue to target additional populations across the Arctic.[30] Carr's findings coincide with Russian infrastructure investment and militarization in the Arctic region.[31]

The transfer of information in the Arctic has been largely facilitated by space-based architecture. The US Army's pamphlet on the future Arctic Environment highlighted the unique geo-spatial characteristics of the Arctic. Most artificial satellites orbiting the globe pass along equatorial routes. This presents a challenge for those

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[29] United States Army, *Regaining Arctic Dominance,* Chief of Staff Paper #3 (Washington, DC: Headquarters, Department of the Army, January 2021).

[30] Hope Carr, "Arctic Sovereignty and Information Warfare," *Three Swords, Magazine,* 83-89.

[31] Devyatkin, "Russia's Arctic Strategy."

navigating with the global positioning system. Triangulating a position in the Arctic relies on overhead, transpolar orbiting satellites, since the curvature of the earth blocks the equatorial traveling satellites.[32] While these challenges relatively affect each actor equally, each Arctic actor's response to the environment varies. For this reason, and for the purposes of understanding Arctic mobility, it is important to explore the primary threat in the Arctic – Russia.

Multiple studies named Russia's militarization as the primary driver of great power competition in the Arctic. In 2018, the Arctic Institute identified the continuous focus on evolving and expanding military capability across different branches as the defining characteristic of Russian military operations in the Arctic.[33] The Carnegie Endowment for International Peace expanded on this idea in March 2021, when they specified three factors driving militarization: preparations for the unlikely, but potentially catastrophic contingency of war in Europe, the need to secure its second-strike nuclear capabilities, and the quest for resources to pay to finance the competition with the west.[34] The Carnegie Report, along with many others, contextualized the militarization as key to advantageous footing against the west in the international arena. The militarization, which has steadily increased over the last ten years, is unlikely to abate. This was further

[32] US Army and Training and Doctrine Command (TRADOC) G-2, *The Arctic Through 2035: An Overview of the Operational Environment and Competitor Strategies for US Army Training, Doctrine, and Capabilities Development* (Fort Leavenworth, KS: TRADOC Operational Environment and Threat Analysis Directorate, July 2020), 18.

[33] Devyatkin, "Russia's Arctic Strategy."

[34] Eugene Rumer, Richard Sokolsky, and Paul Stronski, *Russia in the Arctic – A Critical Examination* (New York: Carnegie Endowment for International Peace, 2021).

explored in a report from the Center for Strategic and International Studies, titled *America's Arctic Moment*, where the authors explained the importance of military development in the north.[35] As evident from the following case studies, Russia maintains a deep connection with the struggle for the Arctic and draws doctrinal lessons from its historical experiences in the Arctic.

This seriousness of Russia's Arctic presence was punctuated in 2014 when Vladimir Putin announced the creation of a new strategic command for the Arctic Zone under the Northern Fleet with the primary land component being the 14th Army Corps. A report from Mathieu Boulègue, published by the NATO Defense College, detailed this structure. In his chapter on Russia's Arctic force structure, Boulègue detailed the two primary arms of the 14th Corps – the 200th Separate Motor-rifle Brigade in Pechenga and the 80th Separate Motor-rifle Brigade in Alakurtti. The 200th, located less than 15 kilometers from the Norwegian Border, serves as a mobile, all-purpose brigade. It is equipped with heavy platforms including three battalions' worth of motorized rifle units and main battle tanks. The 80th is based 60 miles from the Finnish border and further specializes in Arctic warfare with wider-tracked armored personnel carriers, modified snowmobiles, and amphibious-articulated personnel carriers.[36] Both brigades boast expansive support formations and organic capability to operate across multiple

[35] Nikos Tsafos, Ian Williams, Heather A. Conley, and Matthew Melino, *America's Arctic Moment* (Washington, DC: Center for Strategic and International Studies, 30 March 2020), https://www.csis.org/analysis/americas-arctic-moment-great-power-competition-arctic-2050.

[36] Mathieu Boulègue, "Russia's Military Posture in the Arctic: Managing Hard Power in a Low Tension Environment," (Research Paper, Russia and Eurasia Programme, Chatham House, London, June 2019), 16.

domains.[37] These and other forces committed to the Arctic will be explored in the analysis chapter.

Much of Russia's grasp of the north revolves around their integrated A2/AD system across their northern shores. While Russia continues to expand its network of small military bases across the Russian Arctic, *America's Arctic Moment* notes, the primary mission and character of its forces remain primarily focused on A2/AD capabilities.[38] One of the most complete unclassified analyses of this system came out of the US War College in a paper published, again by Mathieu Boulègue and Keir Giles. Beside the heavy investment in trade and resource collection infrastructure, was the construction and modernization of airfields and bases across the Arctic littoral landscape. These facilities, they found, will eventually form a chain of air defense radar stations, early warning basing, and electronic warfare systems. The improvements, they stated, create an extensive and comprehensive network designed to deny NATO naval and air forces from influencing the area.[39]

Like Russia, China named the Arctic as a strategic front. Unlike Russia, however, they have no land claims to the Arctic; instead, China claimed to be a *near-Arctic state*. While they have mostly leveraged the economic arm of the elements of national power, they have signaled an intent to use military power in the region. A Brookings Institute report on China's Arctic ambitions utilized Chinese sources to capture their strategy in

[37] Boulègue, "Russia's Military Posture in the Arctic," 18.

[38] Tsafos et al., *America's Arctic Moment,* 21.

[39] Keir Giles and Mathieu Boulegue, "Russia's A2/AD Capabilities: Real and Imagined," *Parameters* 49, no. 1 (Spring/Summer 2019): 23-24.

the north. One source, a Chinese scholar writing for a political journal, stated controlling the region gives the country “three continents and two oceans’ geographical advantage” over the Northern Hemisphere.[40] Other diplomatic sources argued that China “cannot rule out the possibility of using force,” in the struggle for control of strategic spaces.[41]

In 2018, China published its Arctic Strategy. In it, China justified its presence with humanitarian principles, committing to research. It also acknowledged the pressing economic importance of the Arctic trade routes.[42] Extending the approach from the Belt and Road initiative, China has invested in infrastructure and research projects across the Arctic. This serves to further justify their presence. As the Arctic Institute has pointed out, the militarization of the South China Sea or the establishment of a naval base in Djibouti are potential models to establish a permanent Chinese presence in the Arctic. A 2020 Arctic Institute report by Yun Sun stated, “China’s Arctic infrastructure development has the potential for dual-use facilities, paving the ground to Beijing’s permanent security presence in the region.”[43]

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[40] Guo Peiqing, “Guo Peiqing: China Has No Land in the Arctic, but It Has Benefits,” *Huanqiu Wang*, 29 April 2016, https://opinion.huanqiu.com/article/9CaKrnJV498; Tang Guoqiang, “Arctic Issues and China’s Policies,” *International Studies* (2013): D993.5.

[41] Academy of Military Sciences of the People’s Liberation Army of China, *The Science of Military Strategy 2013* (Beijing: Academy of Military Sciences, 2013), https://fas.org/nuke/guide/china/sms-2013.pdf, 74, 105-106.

[42] The People’s Republic of China, “China’s Arctic Policy,” (White Paper, The State Council Information Office, The People’s Republic of China, Beijing, 26 January 2018), ii-iii, http://english.www.gov.cn/archive/white_paper/2018/01/26/content_281476026660336.htm.

[43] Yun Sun, “Defining the Chinese Threat in the Arctic,” The Arctic Institute, 7 April 2020, https://www.thearcticinstitute.org/defining-the-chinese-threat-in-the-arctic/.

Even as China surges its Arctic efforts, most sources agreed that Russia will continue to be the dominant actor in the region. However, most of these assessments occurred before President Vladimir Putin’s 2022 invasion of Ukraine. Undoubtedly, the attrition of its forces and the economic blowback will affect their approach to the Arctic. Still, Russia’s extensive claim to the Arctic through their coasts and continental shelf, and the environmental changes continue to present them diplomatic and economic opportunities. There is general agreement that massive environmental change is coming to the land domain of the Arctic. The change is captured across extensive research on temperature, permafrost reduction, precipitation, permafrost, precipitation, infrastructure, and vegetation. Again, this research will be thoroughly explored in Chapter 4 to answer the second secondary research question.

Case Studies on Arctic Warfare

Historically, Arctic warfare has been rare. This is because relatively few people live above 66° 33' Northing. As R. J. Sutherland stated in “The Strategic Significance of the Canadian Arctic,” it “offers no place to go from a military point of view and nothing to do when you get there.”[44] At the onset of World War II, however, national interests brought modern warfare into the Arctic Circle. As nations increased their ability to project combat power, the very nature of the globe compelled some to operate further north in Arctic conditions. The history of these operations provides this study with a relatively condensed list of historical examples. From this short list, three examples best

[44] R. J. Sutherland, “The Strategic Significance of the Canadian Arctic,” in *The Arctic Frontier,* ed. R. St. J. MacDonald (Toronto: University of Toronto Press, 1966), 256-278.

inform this study of Arctic mobility. These were the Battle of Suomussalmi, the Petsamo-Kirkenes Operation, and Canadian training from 1945 to 1955.

Case Study: Battle of Suomussalmi

Lasting 105 days beginning on 30 November 1939, the Winter War was characterized in the West as a "David vs. Goliath" struggle, as the Soviet Union – the largest military power at that time – failed to decisively overcome the under-resourced and numerically inferior Finns.[45] The Soviets bought modest geographic gains with staggering losses of men and equipment from their incursion. At the onset of the conflict, they achieved strategic surprise at numerous points across the 900-mile Finnish border. All the while they maintained a marked advantage in armor, artillery, aircraft, and manpower. "But on these most favorable terms," Nikita Khrushchev later lamented, "we could only win through huge difficulties and incredibly great losses. In fact, this victory was a moral defeat."[46] William R. Trotter, in his capstone historical work, *A Frozen Hell: The Russo-Finnish Winter War of 1939-1940*, attributed Finnish successes to their knowledge of the environment and operational flexibility.[47] Throughout *A Frozen Hell*, Trotter's assessments capped an in-depth telling of the Winter War, presenting mobility

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[45] Evgeniĭ Nikolaevich Kul′kov, Oleg Aleksandrovich Rzheshevskii, and Harold Shukman, eds., *Stalin and the Soviet-Finnish War, 1939-1940* (New York: Routledge, 2014).

[46] Mikhail Heller and Alexandr Nyekrics, *Russian History I and II: History of the Russian Empire/History of the Soviet Union* (Budapest, Hungary: Osiris Publishing, 2003), 320.

[47] William R. Trotter, *Frozen Hell; The Russo-Finnish War of 1939-1940* (New York: Workman Publishing, 1991), 263-266.

considerations in context to the broader war. Dr. Allen F. Chew's case study published through the Combat Studies Institute's Leavenworth Papers specifically targeted lessons from the Battle of Suomussalmi. Chew, through his examination of the destruction of the Soviets' 44th Motorized Rifle Division, pinpointed lessons from the battle through a tactical and operational lens.[48]

The Battle of Suomussalmi, which occurred between the December 7, 1939 and January 8, 1940, proved a seminal moment in the war. The Soviet objective was to advance though Suomussalmi to seize the Finnish city of Oulu, thus severing Finland's lines of communication between the north and the south. Scholars usually divide the battle between the defeat of the Soviet 163rd Rifle Division, which advanced first from the northern approach, and the destruction of the 44th Rifle Division in the south. Early Soviet advances by the 163rd Division stalled at Suomussalmi, as roughly 5,000 irregular Finnish forces held the Soviet division until Finnish regulars arrived to reinforce the area. The Finns then formed an ad hoc division of roughly 12,500 troops, supported by limited artillery, before attacking the 44th Division. As Chew noted, this element proved highly mobile, sporting ski and sled capabilities at the small-unit level, and relying on experience from the Finnish Civil War. These Finnish Forces held the initial Soviet Forces as an unusually cold winter began to set in.[49]

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[48] Allen F. Chew, "The Destruction of the Soviet 44th Motorized Rifle Division," in *Fighting the Russians in Winter: Three Case Studies,* Leavenworth Papers No. 5 (Fort Leavenworth, KS: US Army Command and General Staff College, Combat Studies Institute, December 1981), 17-30.

[49] Chew, "The Destruction of the Soviet 44th Motorized Rifle Division," 17-20.

In a case study published in Nordia Geographical, Dr. Pasi Tuunainen demonstrated how preparation weighs heavily in Arctic operations.[50] Three themes emerged from Tuunainen's analysis. First, the Finnish were mostly composed of men with vast Arctic experience from their peacetime professions. This contrasted with the bulk of the Soviet Forces, who were mostly conscripted from the southern reaches of the Soviet Union. The Finnish advantage allowed their forces to exponentially outrange the Soviets, who lacked basic over-snow capabilities such as skiing. Secondly, the Finnish Forces were winterized, whereas most of the Soviet forces deployed in summer uniforms. Finnish Forces were far better equipped with cold weather attire, appropriate camouflage, and winterized weapons.[51] Thirdly, the Finns trained for the Arctic, the extent of this will be detailed in the case study analysis. These themes were repeated throughout the bulk of the literature.

In late November of 1939, the Soviets dispatched the 44th Motorized Rifle Division. The large mechanized division, with a core of nearly 50 tanks, was manned mostly by Ukrainians unfamiliar with terrain of the far north. Utilizing the fastest avenue of approach for the lumbering mechanized force, the division moved west along a single-tracked road. But on 13 December, an old reconnaissance Finnish aircraft made visual

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[50] Pasi Tuunainen, "New Approaches to the Study of Arctic Warfare," *Nordia Geographical Publications* 43, no. 1 (January 2014): 87-99, https://nordia.journal.fi/article/view/65102.

[51] Tuunainen highlights that the Soviet Forces used petroleum-based lubricants prone to jamming in cold weather, while the Finns used a mixture of alcohol and glycerin or, effectively enough, went without lubricants. They also kept their weapons in the cold, rather than moving back and forth from warming areas, thus preventing the weapons from freezing. Tuunainen, "New Approaches to the Study of Arctic Warfare," 91.

contact with the element. In response, the Finns pressed the isolated 163rd, launching an all-out counterattack that broke the division with the last pockets of Russian resistance eliminated on 30 December. Just 6 miles from the remnants of the 163rd, the 44th Division sat stagnant, unable to break through the Finnish defenses. As the Finns converged on the now strung-out division, the Soviet column began to resemble a string of isolated units as *mottis*—encircled Soviet groups—formed.[52]

Utilizing skis and sleds, the quicker Finnish forces maneuvered beyond the forward Soviet forces to hastily establish a roadblock with abatis. These forward Finnish Forces interdicted the Soviet mechanized formation along its long-exposed flanks throughout the prolonged Arctic nights. Believing they were fighting a larger force, the Soviets halted their advance, and began probing the surrounding area. Beyond their reconnaissance efforts, the Finns bivouacked in the surrounding area. They maintained their operational reach and tempo via their ski and sled teams. Meanwhile, their targeting focused on command and control, ammo depots, isolated security elements, and most notably field kitchens.

While the Soviet dismounted elements attempted to fight through the abatis roadblocks, the Finnish forces were able to quickly maneuver along the Soviet flanks preventing forward progress. The decisive blow came on January 4th, when the Finns massed against the stalled and exposed Soviets. Despite heavy losses in the face of the

[52] Trotter, *Frozen Hell,* 158-163.

mechanized force, the Finns overcame the Soviets, routing them in the frigid Arctic conditions.[53]

This case study applies lessons of Arctic mobility at the tactical level. As Tuunainen stated in his case study, “Mobility was the main tactical principle of winter operations in the Arctic for the Finns.”[54] The Finnish approach to the environment underscored their appreciation of the extreme conditions present during winter operations. For example, this was evident by their use of small, dismounted units with skis and sleds to maximize freedom of maneuver. Finns maintained continuous small-scale raids by cycling troops through two hours of aggressive patrolling, followed by four hours of rest in their field bivouac sites. Every two to three days, Finnish soldiers returned to the rear area where field saunas were set up.[55] Conversely, the Soviets failed to anticipate the effects of the environment in their operational approach or the effect it would have on their troops.

The Soviets turned to the established practice of employing heavy mechanized forces to penetrate canalizing terrain. The effort, however, failed when the Finnish Forces exploited the winter landscape, blocking Soviet avenues of approach using abatis and embanked snow. This left the Soviet formation strewn out and large elements isolated. Whereas the Finns utilized the rural landscape and established unimproved roads by compacting the snow with horse-drawn sleds, the Soviets remained fixed along the

[53] Chew, “The Destruction of the Soviet 44th Motorized Rifle Division,” 29.

[54] Tuunainen, “New Approaches to the Study of Arctic Warfare,” 91.

[55] Trotter, *Frozen Hell,* 166.

degraded road networks.[56] This allowed the Finns to maintain continuous contact. Lessons from the Battle of Suomussalmi live on in Russian doctrine and operations today. Strikingly, as noted by Boulègue, today the 80th Separate Motor-rifle Brigade regularly uses local means of transportation for rapid deployment – namely dog and reindeer sleds – to achieve the effects accomplished by the Finns.[57]

Trotter, Chew and Tuunainen all present the Finns as a model for the effective use of tactical mobility against a larger more cumbersome foe. None, however, presented specific work on Arctic mobility. Instead, their focus was on completing the historical record or identifying an operational approach as uniquely tied to the Arctic environment. Their work provided an important bedrock of context, while offering some specific lessons concerning mobility. Further lessons were gathered from declassified US dispatches from the era and primary sources.

Case Study: The Petsamo-Kirkenes Operation

The Battle of Suomussalmi provides an important example of tactical success in Arctic conditions, but there were two outlying factors with this case. First, the Winter War occurred during an extremely cold winter, one of the coldest on record. Second, as mentioned before, most of the Winter War took place below the Arctic Circle.[58] These

[56] Chew, "The Destruction of the Soviet 44th Motorized Rifle Division," 30.

[57] Trude Pettersen, "Arctic Soldiers Training with Reindeer in Russia," *The Independent Barents Observer,* 1 February 2016, http://www.rcinet.ca/eye-on-the-arctic/2016/02/01/arctic-soldiers-training-with-reindeer-in-russia/.

[58] Suomussalmi is about 150 km. south of the Arctic Circle and the AMAP boundary. It is important to note that this multiple case study commits an arm of the

two points are important, given a common problem with Arctic warfare perspectives: some fail to differentiate Arctic operations from winter operations. Kenneth Eyre, in his extensive review of the Canadian military in the north, captured this misunderstanding, which permeated theorists in the US and Canada after World War II. “The most significant military characteristic of the North, be it mountains, barrens, or boreal forest, is not the cold, but the isolation of these areas,” he offered. “Thus, the development of cross-country mobility is the most important technical problem to be faced by a military force attempting to operate in the North, for mobility is essential both for combat manoeuvre and logistic support.”[59]

Another Soviet operation then presents itself as an ideal case for studying this technical problem: the Petsamo-Kirkenes operation in 1944. The operation stands as the largest battle north of the Arctic Circle and served as a model for large scale operations in the north for Russian planners through the second half of the last century. The Soviet operation began on 7 October and ended 29 October, marking the last of what Joseph Stalin would call the “ten blows” that set conditions for the final offensive to end the war.[60] The massive joint effort of the Karelian Front fused the efforts of 14th Army with the Northern Fleet to deal a crushing blow to the Germans. More than expelling the Wehrmacht from Finland, the far larger Soviet land force – comprised of three rifle corps,

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research to the subarctic case of Suomussalmi because the vastness and harsh conditions mirror that of much of the Arctic.

[59] Kenneth C. Eyre*, Custos Borealis: The Military in the Canadian North 1898-1975*, ed. P. Whitney Lackenbauer (Peterborough, Ontario: Trent University, 2020), 131.

[60] James Lucas, *War on the Eastern Front: The German Soldier in Russia, 1941-1945* (United Kingdom: Greenhill Books, 1998), 20.

augmented with artillery, armor and engineer battalions, and 747 aircraft – aimed to destroy the Wehrmacht forces.[61] While controlling the resource-rich terrain was a clear objective, the Soviets intended to destroy the German Force to prevent them from retrograding and reinforcing their eastern front. However, the Germans were able to slow the attack and maintained order during the withdrawal, thus preserving their forces.

Dr. James F. Gebhardt offers the most complete and thorough analysis of the Petsamo-Kirkenes Operation in his 1990 study published in the Leavenworth Papers. Earlier English texts on the operation, such as Army Pamphlet No. 20-271, *The German Northern Theatre of Operations, 1940 to 1945*, by Earl F. Ziemke, drew entirely from German sources. Gebhardt, however, utilized a range of Soviet sources in his analysis. Gebhardt's Paper Number 16, focused on the operational and tactical level of war. While not specifically focusing on the mobility, the thorough analysis provided this study important insights on the topic.

A key theme of Gebhardt's case study was the importance of joint efforts in the Arctic. Even though this paper is limited to Army forces, the requirements of a joint force must be acknowledged. Figure 1 shows the extensive littoral environment in the Petsamo-Kirkenes theater. Even during the winter months of 1944, the sea avenues of approach provided the Soviets maneuver options against German land forces. As Gebhardt established early in the study, the Soviets prepared the operation to be a truly joint venture with the Soviet's Northern Fleet supporting General Golovko's 14th Army.

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[61] James F. Gebhardt, *The Petsamo-Kirkenes Operation: Soviet Breakthrough and Pursuit in the Arctic, October 1944,* Leavenworth Papers Number 17 (Fort Leavenworth, KS: US Army Command and General Staff College, Combat Studies Institute, 1990), 24.

These naval forces conducted deliberate amphibious landings that allowed the Soviets to project combat power beyond the narrow fronts dictated by the terrain.

Another essential theme was that the Arctic tends to exacerbate the natural limitations of land forces. The Soviets had clearly experienced this in the Winter War. To extend their operational reach, the Soviets employed a robust task organization with their combat engineers, logisticians, and field artillery facilitating ground maneuver. This combined arms approach proved far more robust than the heavy formations committed to Suomussalmi five years earlier. Gebhardt, in great detail, established the importance of these enablers in sustaining mobility. Despite the greater appreciation for the Arctic conditions, the environment still thwarted Soviet efforts.

The composition of their enablers best highlights the Soviet environmental conditions. The large contingent of engineers, thirty battalions, allowed the Soviets to maintain the early offensive. Their tasks ranged from road and bridge repair and construction to reducing German obstacles, mainly anti-tank ditches, and explosives. Gebhardt's sources provided his study important details about the Soviet mobility operations. In total, they built 15 kilometers of improved roads, 33 kilometers of unimproved roads, and twenty-five bridges.[62] Despite their monumental efforts to maintain the lines of communication, these engineer assets failed to maintain the tempo set by the forward elements. The crux of the operation proved to be the logistics. As the Russian offensive progressed, the distance from the forward units grew from 80-100

[62] Gebhardt, *The Petsamo-Kirkenes Operation,* 166.

kilometers on 7 October to 200 kilometers by 22 October.[63] This expansion strained the offensive allowing the remaining German forces to escape. Gebhardt associated much of this to logistics, ultimately determining the operation demonstrates "that the degree of success or failure of military operations on arctic terrain will, in large part, be determined by the ability of logistic planners and operators to sustain the combat force."[64]

In May 2020, John Dzwonczyk and Joel Radunzel, both Army officers and instructors in West Point's Department of Geography and Environmental Engineering, published a report on future Arctic operations, utilizing the Petsamo-Kirkenes operation as a case study. Noting many of the previous conclusions, they also emphasized the Soviets use of unconventional stratagems such as airborne and special operations to outflank the often superior German positions during the operation.[65] However, the Soviets lacked relative advantage in fires and mobility against the defenders. Thus, the operation was confined to a narrow front, and the Germans granted a controlled withdrawal.

Dzwonczyk and Radunzel also compared the Petsamo-Kirkenes operational environment to the modern Arctic. "The challenges are growing more acute as the climate warms in the far north," they wrote.[66] "Due to the uniquely restrictive terrain,

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[63] Gebhardt, *The Petsamo-Kirkenes Operation,* 125.

[64] Ibid.

[65] John Dzwonczyk and Joel Radunzel, "The Past and Future of Land Warfare in the High North," The Strategy Bridge, 5 May 2020, https://thestrategybridge.org/the-bridge/2020/5/5/the-past-and-future-of-land-warfare-in-the-high-north.

[66] Ibid.

Arctic warfare heavily favors the defense. Road networks remain primitive—the only major east-west road in the Kola Peninsula and northern Norway today is the same one the Soviets used in 1944, and it still crosses the same rivers and fjords."[67] These rivers and fjords are subjected to more rainfall with the changing climate. Shorter winters makes the soil wetter and less trafficable, and seasonal changes are becoming less predictable. As such, "present-day forces will need to employ amphibious and airmobile operations to a greater extent than in other environments to both maneuver and sustain operations, just as the Red Army did in 1944."[68]

Gebhardt's study established the difficulties in large-scale operations north of the Arctic Circle. For the purposes of this study, it demonstrated the challenges the environment presents to large maneuver formations in the Arctic. It also highlights an Arctic operation in the context of a larger campaign and the heavy logistical requirements that come with moving, fighting, and sustaining large-scale formations during the Arctic winter. Dzwonczyk and Radunzel's study further emphasize important lessons warfighting practitioners should consider in the future Arctic operational environment.

Case Study: Canadian Northern Operations in the Post-War Years

Following the end of the war, the Western powers drew from the freshly cast insights of Arctic warfare. The Russo-Finnish War and German Campaigns in the far north had led to serious consideration of the Arctic as a potential theater of operation.

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[67] Dzwonczyk and Radunzel, "The Past and Future of Land Warfare in the High North."

[68] Ibid.

During the War, the Canadians had led the Allies in the development of specialized winter equipment and techniques for winter warfare.[69] Even as appreciation for Arctic warfare began to wane in the US and UK, the Canadians continued to test their formations in the far north. After the 1945 exercise Eskimo reported that 83% of Canadian territory was classified as Arctic or Subarctic,[70] it was clear Canada would be the testbed of Arctic warfare during the early years of the Cold War.[71] Following Eskimo, the Canadian Armed Forces spent the next nine years conducting twenty-two northern exercises in an attempt to provide a comprehensive understanding of northern operations.[72] Chief among their goals were solutions to challenges the environment presented to mobility.

The declassified post-exercise reports thoroughly captured the Canadian trials in the far north, their outcomes, and lessons for future operations. The also provided very pointed lessons on mobility at every level. Some reports devoted entire sections to the mobility. Archived by the Canadian military's Directorate of History and Heritage and

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[69] Eyre, *Custos Borealis,* 65-67.

[70] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Eskimo'," in *Lessons in Northern Operations: Canadian Army Documents, 1956-56,* vol. 7, *Lessons in Arctic Operations: The Canadian Army Experience, 1945–1956,* ed. P. Whitney Lackenbauer and Peter Kikkert, Documents on Canadian Arctic Sovereignty and Security (Calgary, AB and Waterloo, ON: University of Calgary and St. Jerome's University, 2016), 3. (Hereafter referred to as Lackenbauer and Kikkert, *Lessons in Northern Operations*, vol. 7.)

[71] P. Whitney Lackenbauer and Peter Kikkert, eds., "Introduction," in Lackenbauer and Kikkert, *Lessons in Northern Operations*, vol. 7, viii-ix.

[72] A comprehensive list of the exercises organized by date is provided in Appendix A.

published *in Documents on Canadian Arctic Sovereignty and Security*, these reports offered this study direct lessons from the observers of the northern exercises. In 1956, the Canadians used these lessons to publish “A Guide to the Planning and Execution of Operations in the North.”[73] The guide served as a poignant summary of nearly a decade of intense study of Arctic and subarctic warfare. In *Canadian Arctic Operations*, P. Whitney Lackenbauer, Peter Kikkert, and Kenneth C. Eyre explored the history of these exercise and their impact on Canadian operations in the far north. This comprehensive analysis provided this study bountiful insight into the Canadian approach to Arctic mobility in the post-war years.

As interest in northern operations waned among the Western Allies, the Canadian exercises were yielding practical operational lessons. Quickly, the differences between winter operations and Arctic operations became evident. However, as stressed in *Canadian Arctic Operations*, the challenges of the Arctic operations extend beyond simply preparing for harsh winter temperatures. While some “fixated on the extreme cold, high level planners began to recognize that the most significant military characteristics of the North for operations in all seasons were isolation, the vast distances involved, the lack of transportation infrastructure, and the limits these variables imposed on military mobility.”[74]

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[73] Department of National Defence (DND), Directorate of History and Heritage (DHH), “A Guide to the Planning and Execution of Operations in the North.” in Lackenbauer and Kikkert, *Lessons in Northern Operations*, vol. 7, 176-230.

[74] Lackenbauer, Kikkert and Eyre, “Lessons in Arctic Warfare,” 51. Before the Japanese captured Attu and Kiska in June 1942, the US were among those that “fixated” on the cold temperatures, “assuming that a mountain trained unit could operate in the cold anywhere.” Lackenbauer and Kikkert, “Introduction,” v.

After Eskimo, observers of Arctic exercises developed "the North African analogy." Referencing lessons from the Libyan Front in World War II, Canadian thinkers proposed that the contrast between North America's Arctic and Subarctic mirrored the contrast between the North African desert and the sub-Saharan desert.[75] Developing a cold-weather approach in Canada would be akin to developing a hot-weather approach to Africa. The expanse of Canada's Arctic demanded improvements to navigation, overland travel, and new approaches to survival.[76] This understanding of the uniqueness of Arctic Operations drove the Canadians to continue the exercises through different seasons and across varying terrain.

For instance, the 1948 exercise*,* Sweetbriar, was conducted during winter conditions along the wooded expanses of the Alaskan Highway. In 1950, Sun Dog One was conducted during the summer around the barrens of Fort Churchill. The Canadian Army later concluded that Sun Dog One marked the first tactical exercise of any kind held in the eastern Arctic region "under conditions which are truly Arctic from the climatic and geographic viewpoint."[77] Through 1954, the exercises were conducted across the Canadian far north and through multiple seasons. While many of these exercises were conducted in Canada's subarctic zones, they still provide applicable

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[75] John Lauder, *Tracks North: The Story of Exercise Muskox,* Arctic Operational History Series, no. 5, ed. P. Whitney Lackenbauer and Peter Kikkert (Antigonish, NS: Mulroney Institute, 2018),

[76] Eyre, *Custos Borealis,* 126.

[77] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sun Dog One'," in Lackenbauer and Kikkert, *Lessons in Northern Operations*, vol. 7, 69.

lessons today especially given the Arctic's warming. Notably missing, however, were exercises beyond the mainland. Such exercises were likely excluded because of the peacetime risks and logistical requirements.[78] Still, the breadth of the lessons provided a menu of solutions for mobility challenges.

US Strategy

In the 2021 *Interim National Security Strategic Guidance* (INSSG), President Joseph Biden laid a groundwork for the US approach to the Arctic. The guidance largely validates the previously released strategies of the US Navy, Air Force and Army. These were established in the 2017 *National Security Strategy* signed by Former President Donald J. Trump. The US Army's Strategy, *Regaining Arctic Dominance*, signed by General James C. McConville and Secretary Ryan D. McCarthy, and released in January 2021, provides the framework for ongoing efforts the US Army is taking today. Key to these efforts, the strategy stated, is employing a calibrated force posture with troops properly trained and equipped to deter adversaries but also project power across the Arctic.[79]

The forces allocated to the Arctic reside at three installations: Fort Wainwright, Joint Base Elmendorf-Richardson (JBER), and Fort Greely. Approximately 11,600 soldiers, between Fort Wainwright and JBER, serve under US Army Alaska (USARAK). They are organized under two brigade combat teams (BCTs), a combat sustainment support battalion, and two aviation battalions. The strategy noted the organizational

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[78] Lackenbauer and Kikkert, "Introduction," xxii.

[79] US Army, *Regaining Arctic Dominance*, 20.

complexity, with these forces assigned to US Indo-Pacific Command (USINDOPACOM) but stationed in US Northern Command (USNORTHCOM). The Alaska National Guard (AKARNG) provides additional capabilities from their 2,000 soldiers, namely engineers, infantry, missile defense, weapons-of-mass-destruction civil support, and aviation. Meanwhile, the US Army Reserve provides an additional 2,000 soldiers across the USAR Theater Support Group, ECC Mortuary Affairs, and Mobilization support elements.[80]

Most of the operational missions are conducted under the authority of USARAK, which provides the executive agent authorities to train and certify units to execute missions in support of Combatant Command requirements across the globe. The Army strategy further called on these units to prepare for specialized Arctic training, noting the "Army currently has some resources to train Arctic-capable soldiers and small units." However, the "ability to conduct effective and extended operations in the Arctic requires far more than just a set of specialized equipment. Units cannot simply be re-purposed or provide add-on capability to be proficient and survive arctic conditions."[81] This highlights the weight the strategy places on specialized Arctic-based units. It further established these units will be joined by a multi-domain task force (MDTF) to meet the demands of the future operational environment. Most importantly, the strategy established a three-pronged approach to future Arctic operations.

[80] US Army, *Regaining Arctic Dominance*, 7.

[81] Ibid., 10.

1. The Army will be able to project power from within and into the Arctic to conduct and sustain extended operations in competition, crisis, and conflict from a position of advantage.
2. The Army will employ calibrated force posture and multi-domain formations to defend the homeland and pose dilemmas for great power competitors.
3. The Army will engage with and strengthen allies and partners to maintain regional stability.[82]

The strategy identifies three power projection scenarios: deployment from Alaska, deployment to Alaska, and deployment within Alaska. These establish an extreme range of considerations for Arctic mobility. They range from out-the-door employment into the Alaskan frontier to deployment over the icecap (or former icecap) to penetrate the Russian A2/AD bubble.

Aligned with this strategy, is the creation of another element, the 11th Airborne Division. Formed from elements of the 25th Infantry Division, the Arctic Division is specially designed to move and fight in the Arctic. It was activated on June 6, 2022, and will play an integral part in the Army's Arctic strategy.[83] Years of exercises preceded the 11th Airborne, each with valuable insights into the difficulties imposed on operational and tactical mobility across the Arctic operational environment. Lessons from these exercises are as valuable as those from the Soviet, German and Canadian experiences.

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[82] US Army, *Regaining Arctic Dominance*, 22.

[83] "11th Airborne Reactivated in the Alaska," Association of the United States Army, June 7, 2022, https://www.ausa.org/news/11th-airborne-reactivated-alaska.

They also bear weight on the 11th Airborne's operational concepts, and the future of Army operational and tactical mobility in the Arctic.

Summary

The purpose of this thesis was to explore how the US Army should operate in the future Arctic operational environment by exploring mobility from a historical perspective and applying the lessons from history to the new Arctic operational environment. As the case studies establish, these challenges persisted through the short history of military operations in the Arctic. The Canadian armed forces in their exercises were frustrated by similar constraints as the Soviets, during the Petsamo-Kirkenes operations. The Soviets confronted the "Arctic Goblin" after the Finns outmaneuvered and destroyed their life-support.

Changes in the Arctic will not upset many of the findings from these case studies. Compounding the cold which freezes lubrications, stresses mechanical friction points, and permeates soldiers' spirits, are the new problems of a warming Arctic. New problems such as degrading infrastructure, shifting populations, and dynamic warm and cold cycles certainly require creative application to concepts of tactical mobility. This study will compound the lessons from the case studies with perspectives from recent US exercises to rise to the demands of US strategy in the Arctic.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

The purpose of this study was to determine how the US Army, as a component of the joint force, should operate in the emerging Arctic operational environment. It focused on the challenges to mobility both at home and forward deployed in the Arctic. The methodology used for this study generated solutions for how US forces in the Artic can maintain tactical mobility. The methodology addressed the primary study question through the secondary questions, which are:

1. What unique challenges does the Arctic present to mobility (2RQ1)?
2. What new challenges does the changing Arctic present to mobility (2RQ2)?
3. What doctrinal solutions and training solutions improve mobility in the Arctic (2RQ3)?

The outcomes from these questions will lead to the conclusion presented in Chapter 5.

Method

This study followed a qualitative research design utilizing a multiple case studies approach. To answer the 2RQ1, three cases were analyzed: the Battle of Suomussalmi, the Petsamo-Kirkenes Operation, and the Canadian northern exercises from 1945 to 1954.

Applying a single case study to an environment as large and complicated as the Arctic would not present enough applicable data points. The three cases offer data points at the tactical level and operational level. The Battle of Suomussalmi and the Petsamo-

Kirkenes Operation offer perspectives on Arctic warfare from the same region but at different levels of war. This allows for greater cross-study analysis, given the dependent variable of mobility. The Canadian Operations, meanwhile, offer perspective into every level of war, across many multiple physical environments, during multiple seasons. Albeit, these are peacetime exercises, and the friction of actual warfare is removed.

Using mobility as the dependent variable, the cases presented seven factors that operated as independent variables. These are morale, training, mission command, time and space relationships, infrastructure, and mounted and dismounted operations. Morale is a factor because a preponderance of the literature emphasized its importance in Arctic Warfare. Training, because the uniqueness of the environment demanded specialized consideration to growing the skillsets required to operate in the Arctic. Each case presented unique approaches to mission command, thus identifying it as a factor. Time and space relationships significantly characterized each case; consequently, they were identified as a factor. The unique sparseness of the Arctic places importance on another factor, infrastructure. With these factors identified, it is necessary to further delineate solutions between the two categorical factors of mobility – dismounted and mounted. These seven factors will be cross-analyzed across the three case studies in the first section of Chapter 4.

The second section of Chapter 4 will answer 2RQ2, "What new challenges does the changing Arctic present to mobility?" Here, again mobility is the dependent variable. Multiple elements of the future environment will affect the values of the independent variables previously mentioned. Six categories were identified for these elements:

temperature, precipitation, permafrost, infrastructure, vegetation, and threat. The most significant changes to the future Arctic OE are presented within these categories.

Finally, the findings from the previous research questions will be used to answer the 2RQ3, “What doctrinal solutions and training solutions improve mobility in the Arctic?” These doctrinal and training solutions will be in accordance with US strategy and presented in Chapter 5. Most importantly, they will be informed by the past and the expected future. The summation of these study questions answers, in part, the primary study question, “How do US Army forces maintain tactical and operational mobility given the unique environment and potential threats?” This process is detailed in Figure 2.

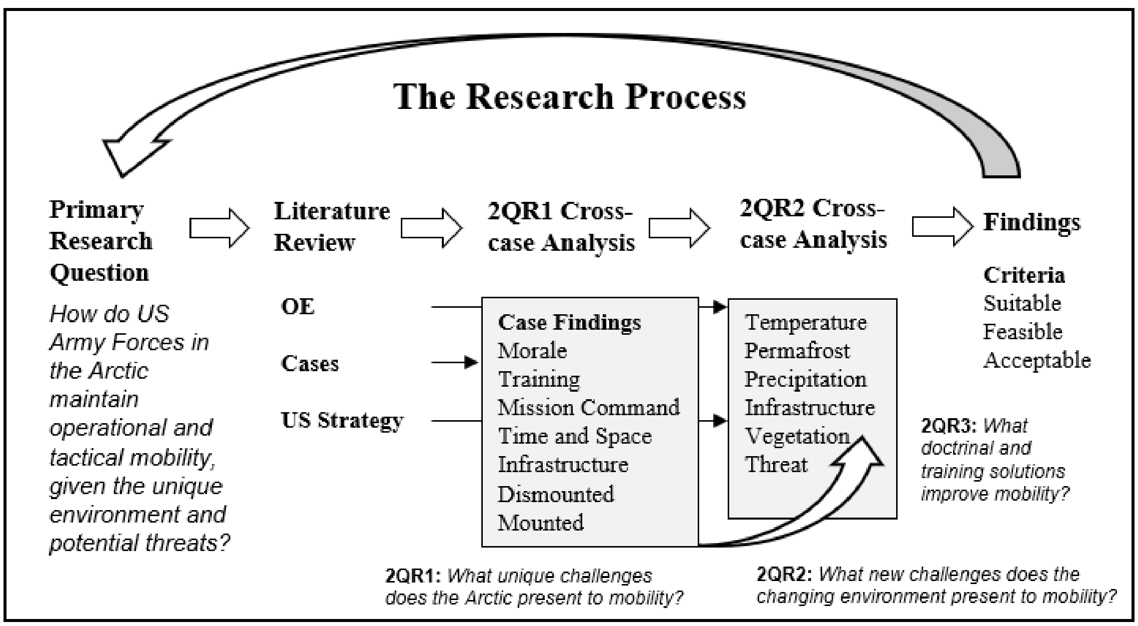

Figure 2. The Research Process

Source: Created by author using information from Robert K. Yin, *Case Study Research and Applications: Design and Methods,* 6th ed. (Thousand Oaks, CA: Sage Publications, 2018); Uwe Flick, *An Introduction to Qualitative Research,* 6th ed. (Thousand Oaks, CA: Sage Publications, 2018).

Data Collection and Analysis

To answer the 2QR1, the study drew from a combination of historical documents, including primary sources and academic studies. These sources yielded a score of insight into each case study. These were aggregated and categorized by major variables. These were reflective of either standards, facts, or practices. The summation of these then answered, in varying capacity, the first and secondary study question.

1. Standards for this case are defined as established rules, norms, or models developed by a case study group specifically for the Arctic operational environment. Often these are developed post de facto and codified in manuals, or unit "standard operating procedures."
2. A relevant fact for this case study is information pertinent for operations in the Arctic operational environment. While there are multiple relevant facts for each case study, facts that will be collated are those that transcend the given case study. For example, while it is important to know that military equipment broke down during a case study, the relevant fact would be that certain lubricants lose their effectiveness in extreme cold.
3. Practices are tactics, techniques or procedures used by an applicable group when operating in the Arctic operational environment. Essentially, these are the "best practices" for Arctic operations. Like standards, these may be found in manuals or through military reviews.

Following this analysis, the current operational environment was analyzed to answer the 2RQ2. The analysis focused on data that defines the effects of the current physical environment. This data mostly arose from research published in reputable scientific journals and military reports, and marked the elements that affect mobility in the future environment. They were organized under the six previously mentioned categories.

The final chapter's conclusion, an analysis of the operational environment, and feasible, acceptable and suitable doctrinal and training solutions, drew from the cross-case study analysis. This data answered the final research question – how US forces in the Artic maintain tactical mobility, given the unique environment and potential threats (Figure 3. The Research Process.)

Summary

The study's methodology, data collection and analysis were designed to land an applicable conclusion to the study questions. Given the purpose, scope, and limitations of the study, this approach opened the aperture to data reception, while narrowing it around an applicable conclusion. The research plan – from the study questions to the literature review to the aggregating the conclusions for analysis – was ultimately designed for coherent application in the following chapters.

CHAPTER 4

ANALYSIS

Introduction

This chapter is arranged according by study questions. Section one presents the findings from the case studies and is organized by the seven factors of morale, specialized training, command and control, time and space, infrastructure, dismounted, and mounted. The following section answers the next secondary study question: "What new challenges does the changing environment present to Arctic mobility?" Together, these two sections will lead to the conclusions that answer the final study question in the next chapter, and ultimately speak to maintaining tactical mobility in the future operational environment.

Section 1: Case Studies

Morale

Through the ancient study of war, great military thinkers and practitioners have placed special emphasis on the intangibles. Sun Tzu advised to attack when an Army is sluggish but avoid it when its "spirit is keen."[84] Both Jomini and Clausewitz set morale as a keystone, the latter describing morale factors as the "ultimate determinant of war." Napoleon once weighed moral power to physical forces as three to one.[85] And as soldiers

[84] Sun Tzu, *Art of War*, trans. Lionel Giles (New York: Allandale Online Publishing, 2000), 28.

[85] Napoleon Bonaparte, *Correspondance de Napoléon Ier publiée par ordre de l'Empereur Napoléon III*, vol. 17 (Paris: *Imprimerie Imperiale* 1868), 471-472.

loaded transports in the lead up to D-Day, Eisenhower declared “Morale is the greatest single factor in successful war.”[86]

The three case studies presented here speak to the symbiotic relationship between morale and mobility in the Arctic. Morale and physical conditions have always been linked. This relationship in the Arctic is *sui generis* because the severity of the environmental can rapidly taper the morale of a ground force. To move from place to place and retain the ability to accomplish the mission requires careful maintenance of the human spirit in the Arctic. The sheer coldness naturally saps humans of physical strength. Combined with the vast stretches of uninhabited terrain and extended periods of darkness, the Arctic landscape and warfare in such an environment isolate, drain, and dishearten those who enter. This was evident through the Battle of Soumussalmi, the Petsamo-Kirkenes Operation, and the post-war Canadian Exercises.

In the Battle of Suomussalmi, the environmental variables wreaked havoc on the spirit of the Soviet soldiers. These soldiers, often collected from more temperate climates and thrust into the ranks, lacked basic winter kit and amenities. Many entered central Finland in the early sub-Arctic winter with summer uniforms. In contrast, the Finns outfitted and operationalized to the conditions. In addition to their lifelong experiences in the Arctic and sub-Arctic, they underwent winter training at the onset of conflict and established support mechanisms to specifically maintain the mental fortitude of their soldiers. Rotating their soldiers from the close areas, they maintained relative luxuries such as hot food service, warming tents, and saunas in their rear area. They also denied

[86] Dwight D. Eisenhower, *Crusade in Europe* (London: William Heinman Limited, 1948), 251.

the Soviets such amenities, reducing their own structures in their home population centers to deny the Soviets reprieve from the conditions. Their targeting, likewise, reflected their grasp of the direct relationship between the environment and morale. Finnish snipers preyed on Soviet soldiers at campfires and strike elements destroyed field kitchens in addition to other sustainment nodes. This deliberate targeting of Soviet life support had a profound effect on the Soviet forces, immobilizing them at the soldier-level. It thus prevented the 163rd Division from breaking out of their positions near Suomussalmi and trapped the 44th in *mottis* after their failed penetration ground to a halt.

While morale would not prove as decisive during the Petsamo-Kirkenes operation, it did effect mobility on both sides. The Germans for instance, already battered from setbacks across the Eastern Front, were particularly affected by the Arctic conditions. In his postwar analysis of the Soviet-German engagements in the north, Dr. Waldemar Erfurth, who served as a high-level German liaison officer with the Finnish, placed the morale of the Germans as a central issue of the Wehrmacht forces. "The endless Finnish Karelian forests had a discomfiting, indeed, a downright sinister effect upon the German soldiers, many of whom had been raised in cities. They were depressed by the apparent limitlessness of the woods."[87] Beyond the forest, the steady operational tempo of the Soviet offensive at Kirkenes compounded with Arctic conditions, battered the already war-weary Germans during the withdrawal. Erfurth noted in his report that only after the casualty reports arrived did the German high command recognize the

[87] Waldermar Erfurth, "Warfare in the Far North," (Manuscript # T-24. Historical Division, Special Staff, US Army, Headquarters US Forces European Theater, October 1947), 9.

weight the trackless terrain, endless forests, and long nights played on the mobility of their soldiers.[88]

Following the end of the Second World War, Canadian researchers reviewed the reports of Scandinavian Arctic and sub-Arctic engagements.[89] Recognizing the shift to Cold War military preparation, the Canadians acknowledged their global position and placed an emphasis on specializing in Arctic warfare. However, as cases out of European Arctic zones highlighted, they had to recognize the effects of Arctic conditions had on the psyche. The Canadians coined Erfurth's description of the effects of the Arctic terrain on the German soldiers as the "Arctic Goblin" – the fear and misconceptions that paralyzed soldiers in the Arctic. The Canadians took to quashing the "Goblin" throughout their ranks.[90]

After the war, the Canadian Army set off to identify personnel who possessed inherent resilience to Arctic conditions and thus could retain mobility throughout operations. Early findings from Canada's post-war exercises, however, suggested managing the morale of Arctic units was far more realistic and practical than pre-establishing it through high recruitment standards. Lessons learned from Exercise *Eskimo* in January and February of 1945 included comments on "man-management," the failure of which would bring "serious results."[91] Similar comments continued through the 1950

[88] Erfurth, "Warfare in the Far North," 19.

[89] Eyre, *Custos Borealis,* 131.

[90] Lackenbauer, Kikkert, and Eyre, "Lessons in Arctic Warfare," 51.

[91] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Eskimo'," 16.

combined US-Canadian exercise Sweetbriar. Up through this exercise, it was evident establishing morale was rarely the challenge in the Arctic, instead failing to maintain morale would limit mobility:

> On arrival in the theatre of operations commanders are faced not with the buildup of morale, but rather with its maintenance under conditions of Arctic warfare. This will depend largely on the facilities for relief which, on the end of a long line communication, will always be limited. Not only is relief required from fatigue but from the squalor of confined tents, tent cooking, and the lack of water for washing. A forward rest area is necessary.[92]

In addition to concepts of life support that were firmly validated by the Finns during the Winter War, other factors were named as critical for maintaining morale – leadership, appropriate equipment, speedy medical evacuation, and optimized soldiers loads (numerous exercises found this to be 45-50 lbs. for dismounted infantry).[93] In addition to these factors, the enemy was seen as a key variable of morale. Later in 1950, Sun Dog One further established morale as a targetable mobility-driving resource. "Great physical and mental effort is required under conditions of extreme cold and high wind chill to remain aggressive. The cold and unusual conditions of life can, if allowed, impose a heavy strain on morale. Every opportunity must be taken to seek out the enemy

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[92] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," in Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 54.

[93] Numerous exercises determined this to be around 45 lbs. "A Guide to Planning and Execution of Operations in the North" acknowledged weights may need to be heavier but heavier loads result in "a marked drop in distance covered, rate of march, fitness to fight, and morale." DND DHH, "A Guide to the Planning and Execution of Operations in the North," 230.

to increase the strain, to deprive him of rest and time to prepare food, and eventually to destroy him."[94]

Throughout the exercises, the Canadians drew correlations between the sustained morale of a force, and thus its mobility, and the level of planning staffs and commanders applied to Arctic operations. Eskimo, the brigade-level training scenario conducted in January and February of 1945, concluded the morale and combat efficacy of a force, and its ability to reach distant objectives was proportional to the time and intelligence devoted to planning.[95] Preventing the collapse of tempo-sustaining morale began with planning, and the subsequent exercises continued to build upon this understanding. As the later sections will note, staffs often lacked an intimate knowledge of the conditions faced by the soldiers in the Arctic. The Canadians predicated their sustainment of morale on staffs and commanders establishing grounded estimates rooted on a solid understanding of their troop's capabilities and the conditions. While the junior leaders sustain their subordinate's morale through strict control measures in the field, the commanders and staffs first enable this through support mechanisms.

Specialized Training

A common thread between the Battle of Suomussalmi and the Petsamo-Kirkenes Operation was the appreciation the victors had of the Arctic conditions, and the preparation to ensure their troops were suited for those conditions. At Suomussalmi, the

[94] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sun Dog One'," 73.

[95] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Eskimo'," 3.

Finns, having the requisite knowledge from day-to-day life in the far north, naturally possessed the skills required to maintain mobility in the harsh conditions. Their developmental procedures were published in *Talvisotakäsikirja: T.S.K.K.* (Winter Warfare Handbook) in 1928.[96] The handbook reflected cumulative knowledge from generations moving across the Arctic landscape and transcribed it to military operations.

The Soviets meanwhile had no inherent tactical knowledge, nor did they distribute references or doctrine to prepare them for the subarctic environment.[97] Without a thorough understanding of the operational environment, pre-operational training stood merely on a base of generalized doctrine. Over-snow travel techniques and navigation were not substantially trained; consequently, they could not move beyond the roads and developed areas. Recorded under a pseudonym nearly ten years after fighting the Soviets in Suomussalmi, Alpo K. Marttinen identified several factors in their defeat, firstly their complete lack of training for the conditions. He said, "One of the basic causes for Russian defeat was their extreme lassitude or negligence in making proper preparations for Arctic warfare. They had apparently failed to comprehend the magnitude of the demands of arctic warfare on specialized training and equipment."[98]

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[96] Tuunainen, "New Approaches to the Study of Arctic Warfare," 90.

[97] On the outset of the war, future Marshall Kirill Meretskov cautioned that serious resistance could be expected. Additionally, the Soviets had produced literature on the difficulties of the environment. The *Finlandiya I ee Armuya* [Finland and its Army] emphasized the natural barriers and Finnish experience in winter warfare. However, the outcomes suggest that these warnings were not heeded. Chew, "The Destruction of the Soviet 44th Motorized Rifle Division," 17.

[98] Victor Suomalainen, as told to Arthur J. Peterson, "The Battle of Suomussalmi," *Military Review* 9, no. 29 (December 1949): 61. Victor Suomalainen is likely Alpo K. Marttinen.

Following the battle, the Finns pilfered the remains of the Russian force. Marttinen later noted his surprise in finding several hundred skis loaded into trucks of the 44th Division. The Finns' constant pressure across the strewn-out Soviets and ability to rapidly reposition across their frontage was in large part thanks to the light infantry's use of skis. These Soviets skis were intended for their scouts. As Marttinen noted "The scouts, however, were not taught how to use them. The Finns found large boxes of new ski instruction manuals, unopened. The inevitable result of this was that in heavy snow the Russians were badly road bound."[99] While the Soviets were tethered to the roads, barely venturing a few hundred meters from them, the Finns strategy revolved around their freedom of movement well beyond the infrastructure. This allowed small units to freely harass the immobile Soviet formations and presented opportunities for wide flanking attacks and envelopments. The success of this strategy was rooted in the experience of its soldiers.

Four years later, the Soviet approach to the Petsamo-Kirkenes Offensive utilized a more deliberate approach to training their soldiers for the conditions in the north. The inability of their formations to breakout from the *mottis* years before pressed the importance of training special troops. These were mainly pulled from the engineer battalions and were assigned under the Karelian Front engineer staff for their support, deployment, and training. These detachments would specialize to conduct reconnaissance, interdiction, counter-mobility, and mobility in the deep, close and rear. This began with a specialized training regimen to ensure these units could achieve the

[99] Suomalainen, "The Battle of Suomussalmi."

same effects leveraged on them in Suomussalmi. The front commander, General Meretskov, emphatically stated that these troops were capable of moving through difficult terrain to the enemy's rear. Special emphasis was placed on their physical and psychological fitness for the difficult operational environment.[100] Their training, specially tailored to the environment, would allow them to effectively navigate the terrain and utilize their unique set of skills and experience. These detachments would improve mobility options for friendly forces, deny mobility corridors for the enemy, and the reconnaissance would pull operations. "From these detachments was gained valuable information, which kept the command informed of changes that were occurring in the enemy's defenses," Meretskov wrote, further detailing their counter mobility efforts. "In addition, the sappers controlled the roads, blew up bridges, and destroyed telephone lines, causing disorder in the work of German rear services."[101]

Most of the emphasis on specialized training focused on the specialized units such as the engineer detachments or the 63rd Naval Infantry Brigade. The bulk of the Soviet land and marine formations relied on their general training and the results were telling. While the infantry would prove mobile in the complicated terrain, their artillery and sustainment struggled to maintain pace. Both tracked and wheeled vehicles struggled in the mud and were highly dependent on the mobility enabling shaping efforts of the special troops. These factors were largely unforeseen by the Soviet planners. The 99th Rifle Corps Commander even admitted that both his staff and he lacked an understanding

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[100] Gebhardt, *The Petsamo-Kirkenes Operation,* 99.

[101] Ibid., 107.

of Arctic conditions, planning their employment as if they were on ordinary terrain. Movement timelines in the 99th were drastically off. The lesson, Dr. Gebhart concluded, "is that commanders who are earmarked for Arctic deployment should study Arctic war experience or, even better, conduct terrain walks or staff rides on Arctic terrain."[102]

Before the Soviet's 1944 offensive, the Germans were able to do this with their Finnish partners.[103] The initial thrust into Norway in 1940 proved that the German high command had not appropriately prepared the Germans for Arctic conditions.[104] In fall of 1941, the Germans turned to the Finns to better prepare their forces. Beginning in the winter of 1941-1942, Germany began sending soldiers (mostly officers) to summer and winter courses in Finland. The courses included the conduct of combat patrols, long range-reconnaissance, and long-distance skiing. More applicably, the lessons accounted for conditions unique to the Finnish Arctic and subarctic and were continually aligned with the situation on the Finnish front. This meant by 1944 German officers were able combine the knowledge of both the Winter War and their own success in the region. However, the training was only available to officers and select non-commissioned officers.[105] The experience, which assisted planners and leaders, juxtaposed the Soviet

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[102] Gebhardt, *The Petsamo-Kirkenes Operation,* 118.

[103] During the Continuation War from 1941 to 1945, Finland served as an ally of Germany. Finland, however, maintained its Army outside of German command structure. The Finns would eventually sign the Moscow Armistice before the Petsamo-Kirkenes Operation, which demanded the Finns expel the Germans from Finland.

[104] Erfurth, "Warfare in the Far North," 10.

[105] Ibid., 8-9.

training priorities focused on specially selected troops. Neither approach provided specialized training across the breadth of their formations.

Canadian officials recognized the importance of preparing the depths of their formations for Arctic warfare early in the planning of the post war exercises. Through the 1940s and early 1950s, the Canadians attempted to identify personnel who displayed the necessary resilience required to operating through exacting Arctic conditions. Scientists at the Canadian Defence Research Board (DRB) studied soldiers posted in the Arctic and subarctic. The experiments were conducted during extended exercises and acclimation programs, and included urinalysis, blood pressure measurements, and blood analysis. While the ethics surrounding these experiments proved questionable, they provided important data points to augment the findings from the training exercises. The Canadian military ultimately concluded, "troops need not be hand-picked."[106] Any physically fit soldier could effectively operate in the Arctic with proper training and equipment. The report from the first post-war Canadian exercise went further, claiming that no variations to principles or tactical doctrine need to be imposed, so long as "the force is so equipped and trained that it can attain and retain mobility."[107]

Later exercises like Sweetbriar (see appendix A) agreed with the reports from the war, and Canada further improved on their Arctic training programs to focus on ground mobility. The Selection and Training of Personnel section of the Sweetbriar report stated,

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[106] Matthew S. Wiseman, "The Development of Cold War Soldiery: Acclimitasation Research and Military Indoctrination in the Canadian Arctic, 1947-1953," *Canadian Military History* 24 no. 2 (Summer/Autumn 2015): 152.

[107] DND DHH, "A Guide to the Planning and Execution of Operations in the North," 190.

"Every effort must be made to promote the idea of hard living and self-sufficiency. The need for shelter by civilized men is probably the greatest factor in the loss of mobility in the Arctic."[108] The key to addressing the greatest obstacle to mobility, the report stated, was a robust indoctrination training program. The next exercise Sun Dog One, recommended the minimum period required for acclimatization and indoctrination was at least ten-weeks.[109] It further proposed a minimum of a three-week indoctrination, two weeks of skill training, three weeks of cold-weather familiarization, and two weeks collective training in conditions comparable to the expected theater of operations. The report concluded that these trained and equipped troops, operating with high morale, could operate in extreme cold for periods of 30 days.[110]

Command and Control

Training and equipment are important ingredients to Arctic mobility. Command and control, however, are as important to the mobility formula. During the Battle of Suomussalmi, the Finns organization, philosophy, and strategy facilitated disciplined initiative, allowing small formations to move where they needed to, when they needed to. Meanwhile, the Soviet's rigid hierarchy smothered subordinate commander's initiative throughout echelons. Speaking before the US Army Command and General Staff College in 1960, Marttinen, then a colonel in the United States Army after repatriating from

[108] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," 65.

[109] Wiseman, "The Development of Cold War Soldiery," 24.

[110] Ibid., 150.

Finland, showcased how the Soviet command structure proved immobilizing. “The Russian command initiative was very poor,” he said before the US student officers. “The Russian system of command: follow to the letter, the orders and procedures stated in manuals with no or little reasoning or initiative of their own. It did not work with the complicated situation in which they faced.”[111]

The complication came from the multiple dilemmas the Finns presented, and the unforgiving terrain itself. Writing for the *Military Engineer* in 1940, Colonel Per Zilliacus, the military attaché in Finland, wrote about the unique conditions and described their effects on warfare. Given the frozen swamps and lakes, thick forest, and hemispheric darkness cycles and their natural disruption to lines on communication, he recognized how the terrain demanded disciplined initiative to maintain operational mobility. To ensure control in these difficult conditions, the Finns trained their officers to lead from the front.[112] The Finns also recognized that these conditions required more than forward junior tactical level officers endowed with the trust of their operational level leadership. “The non-commissioned officer, in combat, is the only leader whom the majority of soldiers see and follow and thus, has a direct personal influence upon his men. The result of the battle greatly depends upon the non-commissioned officer's ability

[111] Alpo K. Marttinen, “The Battle of Suomussalmi,” (Lecture, US Army Command and General Staff Officer College, Fort Leavenworth, KS, 1960).

[112] Trotter, *Frozen Hell,* 157.

and skill. Even the individual private must often think and act independently according to the demands of the situation."[113]

It should not be assumed that the Finns empowered subordinates because they lacked the ability to control. Company-level leadership maintained routine radio traffic with their higher headquarters, allowing the Finnish forces to maintain control and readjust to changing conditions.[114] However, built into their concept was the ability for these commanders to move in the absence of mission orders. Inherent in their culture was the trust of their non-commissioned officers to lead small, mobile elements to find, decide, and act against appropriate Soviet targets. This allowed Finns to take advantage of their training and equipment advantages, and apply constant pressure against the immobile Soviets.

Conversely the Soviet leaders at all echelons often failed to act without mission orders. The *mottis*, the isolated Russian elements along primary routes to Suomussalmi, have largely epitomized the Soviet mobility situation during the battle. These *mottis* naturally developed after the Finns established obstacles along the primary roads leading to Suomussalmi. The Soviet rear echelons would halt their movement, leading to fixed positions as they focused on local security. Meanwhile, the dispersed Finns, utilizing exterior lines and following mission orders, were able to reduce these elements and deny the enemy sanctuary. The near continuous pressure they maintained on the enemy would

[113] Per Zilliacus, "Local Conditions in Finland and their Influence on Warfare," *The Military Engineer* 32, no. 181 (January-February 1940): 1-3.

[114] Trotter, *Frozen Hell*, 152.

not have been possible without subordinate leaders empowered to target during their patrols.

The size and scale of the Soviet offensive during Petsamo-Kirkenes was much larger than their efforts during Suomussalmi. It integrated more enabling functions, utilized a more robust sustainment system, and was far more joint. Years of combat operations against the Germans had likewise matured their distinctly Soviet command and control. From the front-level to the division headquarters, a triumvirate of the commander, deputy commander for political affairs, and the chief of staff shared responsibilities. These elements directly communicated horizontally with their higher and subordinate counterparts and laterally through their ranks and each other.[115] Underpinning the complicated system of command were deeply personal relationships since the Front Commander, General Meretskov, was given the flexibility to personally place subordinates in position.[116] This relative freedom, however, was juxtaposed by the fact that all battle plans had to be approved by Stavka, the Soviet high command headed by Joseph Stalin.

Despite the oversight from Stavka, the personal relationships and direct leadership model present in the Soviet formation brought with it considerable advantages. The quick operational tempo meant wired communication was unrealistic and the atmospheric conditions prevented effective radio communication.[117] Commanders then placed

[115] Gebhardt, *The Petsamo-Kirkenes Operation,* 28.

[116] Ibid., 29.

[117] Ibid., 119.

themselves forward with their subordinates' commanders, allowing them to appreciate the difficulties of the terrain. This was especially important given the ineffectiveness of their maps, from which their battle plans developed. The forward presence and diminished communications allowed the Soviet commanders to adapt their plans to the local situation. Ultimately, Gebhardt concluded that the difficulties imposed by the Arctic terrain and weather had not significantly degraded ground operations command and control. "The glue that held the whole system and made it effective was the personal trust of patrons (the Soviet commanders) and clients (their subordinate commanders and staff officers)."[118] While unorthodox, this ad hoc system helped to prevent the operational stagnation that defined the Soviet actions at Suomussalmi.

Such examples of command and control derive as much from the context of their culture and the messy variables of the conflict, as from the environment. The Canadian cases offered sterile training environments to draw more empirical lessons on control and mobility. Through the 1940s, the limitations of physical command and control architecture were thoroughly explored. During Exercise Sigloo in 1948 and 1949, the lead-acid batteries in the radios struggled to hold a charge, while "snow static" auroral blackouts disrupted communications. During Sun Dog One in 1950, the interference of the blowing snow reduced the range of the wireless communication sets by over 75%.[119] Simple solutions such as storing batteries under parkas to extend their running life mirrored the solutions proposed by the Finns during the Winter War. Still, maintaining

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[118] Gebhardt, *The Petsamo-Kirkenes Operation,* 118.

[119] Lackenbauer, Kikkert, and Eyre. "Lessons in Arctic Warfare," 79.

wireless communications proved extraordinarily difficult even through the exercises. After Sun Dog Three in 1952, a report from an Air Force commander summed up the geo-spatial challenges the Arctic presents as the "tenuous nature of wireless communications."[120]

Many of the more artful command solutions to these challenges juxtaposed the Finnish approach. Post-exercise comments from Sweetbriar suggested commanders rigidly manage timetables to maintain unit effectiveness. "In order to maintain morale at the level required for effective performance," the exercise comments stated. "Every item and every minute of the twenty-four hours must be ordered and controlled."[121] In his post exercise comments, Major General Matthew Penhale said details of a soldier's life had to be "timed, ordered, and controlled in all aspects, and in detail, 24-hours a day, else confusion will abound."[122] The Canadians came to exert strict control over patrol timelines during winter exercises, often managing to the minute the patrol timelines of their forward elements.

This strict authoritative approach reflected the viewpoint that morale was a resource to be managed. Like the Finns, the conductors of this control would be the junior leaders. "A Guide to the Planning and Execution of Operations in the North," which largely reflected the summation of lessons from Canada's northern exercises, firmly established their role in controlling their formations, stating "Leadership and

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[120] Lackenbauer, Kikkert, and Eyre. "Lessons in Arctic Warfare," 80.

[121] Ibid., 79.

[122] Lackenbauer and Kikkert, "Introduction," xxiv.

management of a very high order are required, particularly of junior officers and NCOs."[123]

Time and Space in the Arctic

The Battle of Suomussalmi can be characterized as sub-Arctic fighting in the dead of winter. However, the entire character, and likely the outcome would have been different if the battle had occurred outside the confines of deep winter. Even before the increased warming in the Arctic, the differences between the seasons were substantial. Likewise, had the German withdrawal been delayed into the deep winter, the heavy Soviet formations may have been able to envelop and destroy the Germans. While seasonal changes over any region change the nature of military operations, the case studies demonstrate the variables of time and place weigh particularly heavily in Arctic operations.

During the Winter War, sources generally agree that the conditions favored the Finns. Dispatches from European liaison elements to Washington noted this in January 1939. "The winter is the best season for operations, especially for an army with good ski troops," they stated. "Very soon the snow will be so hard and frozen that ski troops can maneuver over it and will not be handicapped by the lack of roads. When the snow begins to melt in the late spring, the north will be also a morass which will be very difficult to pass over."[124] With exception of the north-south running Arctic Highway, the

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[123] DND DHH, "A Guide to the Planning and Execution of Operations in the North," 185.

[124] Military Intelligence Division, War Department, "Soviet Finnish War: Operations from November 30, 1939 to January 7, 1940," Special Bulletin No. 2, G-

dispatches declared the conditions would continue until the ground froze again in the fall. They concluded the Soviets would not be able to conduct operations in the North until the 1st of April. These predictions, written as reports from Suomussalmi were coming in, applied to the Soviet northern front which was above the Arctic Circle. However, given historical hindsight, they also could have applied to the central front and at Suomussalmi.[125]

One of the Soviets' considerations to open the northern front as winter conditions were setting in, was to achieve operational surprise. With a favorable ratio of relative combat power, heavy divisions penetrating along narrow mobility corridors was theoretically sound. Attacking in December meant the frozen ground would be more advantageous to tracked and wheeled vehicles than the thick mud that came in the spring and fall. However, the timing and important terrain details presented unplanned challenges. The two single-track roads through the dense forests required clearing of the deep snow and were susceptible to the harassing actions of the Finns, who had the advantage of mobility through the restrictive terrain in the winter. The extreme cold presented additional unforeseen mobility challenges beyond the morale of the Soviet troops. The equipment of the heavily mechanized Soviet was severely affected. Weapons jammed and lubrication froze, further slowing the Soviet advances.

2/2657-D-1054, in *Special Bulletins from the 1939-1940 Active Campaign in Europe: Lessons 1-10* (Washington, DC: War Department, 1940), 3.

[125] The sources definitions of seasons may not align with the NOAA's as defined in Chapter 1.

Erfurth, writing in 1949 on the lessons the Germans gathered from the Winter War, reached a similar conclusion to those of the 1939 US dispatches. “The peculiarities of terrain and climate in the far north resulted in winters being the more favorable season for offensive campaign, while summer is more suitable for defensive operations.” However, he added the important caveat that although “early and late winter are particularly favorable for attack operations, mid-winter with its deep snow, is not an appropriate time for an offensive warfare.”[126] Melting snow from the winter drastically reduced mobility along the roads that the Soviets were so tied to. Soviet planners were at least partially aware of the costs and benefits of both seasons. This analysis contextualizes the Soviet decision to press the attack: the winter presented advantages of the frozen ground, while a spring offensive may have bogged their formations down in the mud. Without a more accurate understanding of the advantages the deep winter conditions would present to the Finns, the decision in theory is understandable.

In 1944, a question of timing would again befall the Soviets. Although, the considerations would primarily be based on the larger theater strategy and the general political landscape late in the war, General Meretskov, because of the positioning of troops could not begin operations until October. However, the timing of the German withdraw was unknown and Stavka guidance demanded these forces not leave “unpunished.” Merertskov could not wait for the ground to freeze allowing more favorable conditions for cross-country maneuver, the Soviets would have to attack in the

[126] Erfurth, “War in the Far North,” 14.

fall as soon as the troops were positioned.[127] It is difficult to determine if the frozen ground would have facilitated maneuver or allowed more traffic along the supply routes. It is even more difficult to determine if these conditions would have allowed the Soviets to encircle and destroy the Germans.

However, conditions prevented the Soviets from utilizing their relative advantage in tanks and self-propelled artillery. The restrictive terrain, far more restrictive in October, largely prevented these elements from massing against the Germans.[128] The condition of the roads further reduced operational tempo, both because of the small aperture of support the sparse road network allowed, and the condition of the roads themselves. One of Gebhardt's Soviet sources concluded one-third of the Soviet truck fleet underwent some type of repair. In the conclusion of the Leavenworth Papers study, Gebhardt questioned whether winter conditions would have made the terrain more trafficable, given the soil, topography, and clusters of lakes. The survivability and limited visibility of the polar night that plagued the Soviets just three years prior may have further constrained their mobility.

Wide-sweeping claims of seasons favoring the offense or defense have little application to Arctic warfare. As the Suomussalmi and Petsamo-Kirkenes show, they hardly even apply to one operational area (in these cases, northern Finland.) Canadian planners recognized this very early in their post-war analysis of Arctic warfare. They found that a "one size fits all" type model for Arctic and Subarctic operations did not

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[127] Gebhardt, *The Petsamo-Kirkenes Operation,* 115-116.

[128] Ibid., 122.

exist. The special operational environment of Arctic presented a tremendous amount of diversity that would affect mobility across time and space. Operational designs were subject to the unique topographical, climatological, and environmental conditions across a given Arctic operational area.[129]

The Canadian exercise planners did find common attributes across their operational environments – isolation, the vast distances involved, and the lack of infrastructure.[130] Exercises above the Arctic tree line would require massive movements through barren landscape with little infrastructure. However, the location and the time of year, would drastically change the mobility options at the tactical and operational level. "A Guide to the Planning and Execution of Operations in the North" called on control measures to be specifically tailored to the location and season. Planners would have to specifically build an operation's movement tables, rest and refit schedules, sustainment packages, types of mobility platforms, and types of insertion and extraction.[131]

Infrastructure

The more remote an area, the more central a role the limited infrastructure plays. Through each of the case studies, infrastructure – mainly roads and bridges – proved key terrain. That is, the infrastructure demanded action from each belligerent and played a

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[129] Lackenbauer, Kikkert, and Eyre, "Lessons in Arctic Warfare," 71.

[130] Ibid., 50-51.

[131] After Sweetbriar, exercise planners would recommend that "broad planning and provisioning action start from eighteen months to two years before an exercise" of that magnitude. Detailed planning should begin at least six months prior to such an exercise. DND DHH, "A Guide to the Planning and Execution of Operations in the North," 183-184.

crucial role to operational mobility. Both the Finns and the Soviets recognized this early in the Winter War. The Soviet objective at the Battle of Suomussalmi revolved around the control of Oulu and Suomussalmi, which were nodes along the Finnish north-south running roads and rail-lines. Controlling them would effectively sever the Finnish lines of communication in half. The importance of these nodes to operational mobility was recognized during early US dispatches from Finland to Washington in November of 1939. "In the center (the Soviets') objective was apparently the railhead at Oulu, which is the only rail line to Sweden, the only country from which Finland can reasonably expect any supplies."[132]

At the tactical level, the 1939 dispatch noted the mobility advantages owned by the Finns with their superb training, particularly their ability to move off-road on skis. The Soviets, with their large formations of tracked and wheeled vehicles, could not depend on the small poorly maintained east-west running roads. Because of this, the report concluded, "it will also be difficult for the Reds to carry out any extensive operations until spring, unless they first win in the south."[133]

More than difficult, the Soviet road-based operational approach proved fateful, even with success in south. Never having to occupy the roads, the Finns approach centered on fixing the Soviets to the narrow east-west running stretches, while utilizing exterior lines of operations through the sub-Arctic wilderness. Utilizing abatis and mines ahead of, and between, formations the Finns dissected entire columns, preventing their

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[132] Military Intelligence Division, War Department, "Soviet-Finnish War," 4.

[133] Ibid.

support of each other.[134] The sparse infrastructure played a major role in the defeat of the Soviets, but it was the Finnish indirect approach to this limited infrastructure that proved decisive. By simultaneously conducting counter mobility operations on the roads, and maintaining freedom of movement beyond them, they effectively neutralized the Soviets' advantages in strength and firepower. The map of the Soviet-Finish positions from December 1939 highlights the extent to which the battle revolved around the road leading into Suomussalmi (Figure 3).

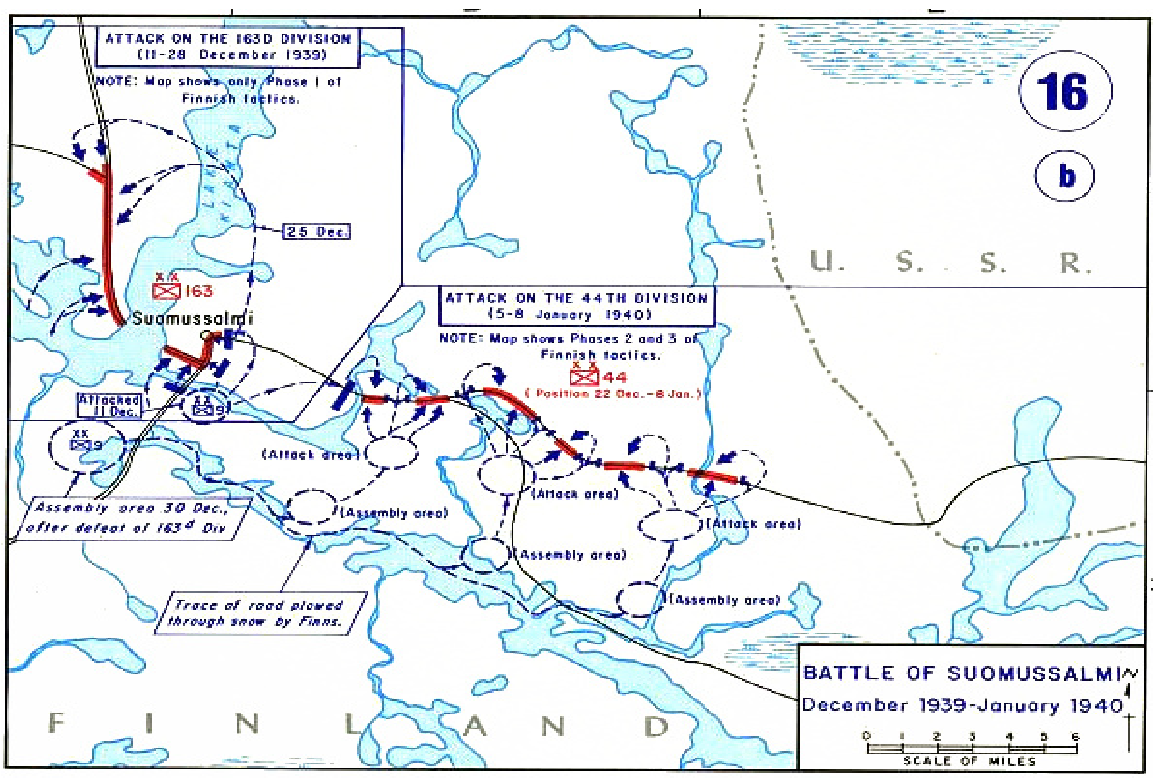

Figure 3. The Battle Lines at the Battle of Suomussalmi

Source: Edward J. Krasnobowski and Frank Martini, "Map of the Battle of Suomussalmi 1939/40," United States Military Academy West Point, accessed March 1, 2022, https://commons.wikimedia.org/wiki/File:Battle_suomussalmi.jpg.

[134] Marttinen, "The Battle of Suomussalmi."

Nearly five years later, Soviet planners would again look to Finnish infrastructure to maintain operational mobility. Remembering the immobilized *mottis* on the roads to Suomussalmi, the Soviets planned to maintain their momentum by building roads and bridges along multiple northern avenues of approach. They brought specially organized division and corps-level detachments to maintain, improve, or construct bridges ahead of advancing columns. By attaching a squad of engineers to every tank platoon, the Soviets would prevent their armored elements being fixed by abatis or natural obstacles along the roads. To overcome the numerous chokepoints presented by the frozen hydrology, pontoon and bridging units, boating elements, and captured heavy and light German bridge sets accompanied the land forces northern advance.[135]

Despite these efforts, the Soviets still failed to envelop the Germans, allowing them to withdraw to Norway. A primary reason was one arm of the encirclement; the 99th Rifle Corps, advanced too slowly in the underdeveloped frozen winterscape. Even with an understanding of the road constraints, mobility again stagnated, although not catastrophically as it had outside of Suomussalmi. While the Soviets maintained forward progress, engineers struggled with the demands presented along the congested unimproved roads. The 14th Army eventually abandoned its ambitious plan to build multiple road networks and consolidated the efforts along one single track through the breakthrough zone. Infantry units, in some cases a division's worth, were used to complete these engineer tasks. This bottlenecking resulted in increased traffic along the

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[135] Gebhardt, *The Petsamo-Kirkenes Operation,* 20-22.

route, increased wear on the vehicles, delayed medical evacuations, and most importantly, supply chain issues.

Without civilian population centers to draw from, the Soviets had to deliver the raw materials for the construction, food, and fuel from deep in their rear area.[136] The result of the constraints imposed by the infrastructure was severely degraded operational mobility. In his closing chapter Gebhardt concluded, "In all phases of the operation, the cumulative effects of physical exhaustion, brought on by continuous movement and combat, and the inability to provide logistic sustainment seriously degraded the combat effectiveness of both light rifle corps."[137]

High level military officials in the Canadian Army recognized the importance infrastructure played in mobility in the Arctic. While participants in early planning fixated on the cold, these planners focused on the three primary military variables of the north, the isolation; vast distances; and limited infrastructure, as well as the limits these placed on mobility.[138] At Suomussalmi and Petsamo-Kirkenes, wheeled and tracked transportation was tied to a dispersed network of small roads. However, in the expansiveness of Canada's far north and through much of the rest of the Arctic, road networks are often more spread out and in need of repair. This demonstrated the primary difference between Arctic warfare and winter warfare. While the cold played a significant

[136] Gebhardt, *The Petsamo-Kirkenes Operation,* 119-124.

[137] Ibid., 121.

[138] Lackenbauer, Kikkert, and Eyre, "Lessons in Arctic Warfare," 51.

role in Operation Barbarossa and the Ardennes Offensive, the frozen terrain was flush with roads, bridges, and dotted with structures.

This presented the Canadians with tactical, operational, and strategic problems as they began their northern military exercises after the war. One poignant tactical lesson learned during Eskimo in 1945 was transcribed verbatim in the 1956 "A Guide to Planning and Execution of Operations in the North." It stated that wheeled vehicles tend to render a force road-bound in winter. Thus, north of the sub-Arctic line,[139] commanders should have options with over-snow vehicles or aerial resupply. "Otherwise his initiative in selecting alternate routes of advance, and in deploying his force, will be seriously restricted. Moreover, his pace would have to conform to that of his engineers and of his road-bound 'tail'."[140] Another lesson learned months later during Polar Bear found that most reconnaissance efforts were limited to route reconnaissance since reaction would be driven by enemy action along the roads and their periphery.[141]

Limited infrastructure, the Canadian exercises established, places engineers as the preeminent maintainers of operational and tactical mobility. During the exercises, their tasks included construction and maintenance of roads; tracks; and airfields, erection of

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[139] The Canadians used the tree line to provide distinction between the Arctic and sub-Arctic. "For military purposes, it is more convenient to use the tree line as the dividing line between the two." The Arctic "skirts the north coast of Labrador, crosses Northern Quebec, and stretches northwest from the coast of Hudson Bay, in the neighbourhood of Churchill, [Manitoba,] to near the mouth of the Mackenzie River." Lackenbauer, Kikkert, and Eyre. "Lessons in Arctic Warfare," 50.

[140] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Polar Bear'," Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 13.

[141] Ibid.

temporary shelters and depots, reinforcing bridging points, and clearing obstacles. Engineers were utilized in nearly every exercise from 1945 to 1955, often performing every one of these tasks. Early, the Canadians recognized the burden Arctic demands placed on the engineers. While the Soviets in the heat of the operation would redirect whole infantry units to take up engineer tasks, the Canadians saw advancements in air movement as an option around the vast distances and limited infrastructure. As early as Eskimo, planners looked to the air for relief. "Owing to the vast distances and lack of roads in the sub-Arctic, it may in [the] future be considered expedient for a striking force to be conveyed to, and to work from, successive airheads."[142]

During Musk Ox in 1946, Canadian planners integrated air operations into the exercises, expanding the operational reach of their dismounted formations. Clearing potential airheads and landing zones of snow presented a challenge. However, engineers proved effective at finding and establishing expedient options on frozen lakes. By Sweetbriar in 1949, when joint US and Canadian Air Force elements were employed, air transportation was fully mobilized to alleviate the constraints of limited infrastructure. That exercise served to prove the concept of airborne assaults in the Arctic with paratroopers. While night insertions were risky, the airborne assaults and follow-on air landing of troops proved successful, paving the way for the airborne mobile strike force concept by 1951.[143]

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[142] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Eskimo'," 4.

[143] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," 51-56.

Sweetbriar also found aerial resupply to “be of paramount importance.” Supplies could be air dropped, brought in by gliders, or air landed, allowing the units to remain mobile through longer durations than previously seen. During the exercise, engineers focused on maintaining main supply routes on established highways, clearing routes of virgin snow, and preparing air strips on frozen lakes, and rivers before air landing troops. The approach drew parallels to the Second World War’s Pacific theater. “Operations will be from an established airbase to secure a new forward base for operations,” lessons from the exercise noted. “In effect, these operations would be similar to the island-hopping tactics of World War II.”[144]

Dismounted Operations

None of the case studies presented a mobility platform capable of operating effectively throughout the year in the Arctic. However, properly trained and supported dismounts can operate in every season. The mobility of dismounted troops, though, is relative only to the conditions the Arctic presents. At Suomussalmi, these conditions presented light infantry elements the gift of an early winter that accumulated snow at three to four feet.[145] The Finns, however, were appropriately calibrated to the conditions through their composition of experienced dismounted troops. Conversely, the Soviet dismounts, in addition to their lack of training and experience, lacked basic kit – appropriate winter outerwear or even boots. And while skis were not issued across

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[144] DND DHH, “Lessons Learned Winter Exercises, 1945-1954: Exercise ‘Sweetbriar’,” 60.

[145] Alpo K. Marttinen, “The Battle of Suomussalmi,” (Lecture, US Army Command and General Staff Officer College, Fort Leavenworth, KS, 1960), 12:05.

formations, snowshoes also were not available. The Soviets had to trudge through deep snow, while the Finns could glide over it. The effect, Maartigen described, opened the maneuver corridors presenting the Finns with near complete freedom of movement beyond the roads. "We never met Russian patrols more than 300 yards from the road," he said, referring the harassment operations of the Soviet 163rd Division. "Everything outside that was ours. We could move regimental size units from to 500 - 1000 yards from the road."[146]

The Finns retained the mobility advantage in the deep, close and rear areas, and even during deliberate operations by the Soviets, such as when Soviets moved to dislodge the 163rd from the *mottis*. When the Soviet 44th Division moved to relieve the 163rd Division, two companies equipped only with their small arms and 81mm mortars, established blocking positions in a valley along the Soviet ingress route. These elements successfully stalled the mounted Soviet Force along the undeveloped roads. The remainder of the regiment moved freely along the flanks conducting small unit attacks. They were only six miles from the remnants of the 163rd and eight miles from the Finnish headquarters where the plans to destroy the isolated 163rd were being developed.[147] Still, these highly mechanized elements with their tanks, artillery, and wheeled supply trains were unable to break through the Finnish obstacles. Nor were they able to successfully prevent the withering harassment from the dismounted Finnish regiments. The Finns would often relocate during the long night; and while movement at

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[146] Marttinen, "The Battle of Suomussalmi," 19:28.

[147] Trotter, *Frozen Hell,* 162; Marttinen, "The Battle of Suomussalmi," 22:44.

night was preferred, movements during the six hours of daylight brought very little interdiction from the Soviet air element. The dense pine and spruce forests camouflaged the small Finnish elements from the air. The elements that were targeted by the artillery often went unscathed from the fires. Many of the rounds failed to arm in the extreme cold, while the deep snow limited the lethality of the rounds that did project.

The combined arms approach of the Soviets, with its armor, air, and mechanized infantry failed in the face of a largely dismounted Finnish formation. In another operational environment, the Soviet formations would have easily broken through the narrow corridors. However, when comparing compositions, the only relative advantage the Finns maintained over Soviets was with their dismounts. The more mobile and adaptable infantry elements completely broke the 163rd and 44th Divisions. The Soviets return to the Finnish north in subsequent years was with more capable light infantry elements.

During the Petsamo-Kirkenes Operation, the effectiveness of the Soviet light infantry was more mixed. While the Soviet forces this time were better prepared, they still lacked the level of expertise of a local force. Before the Soviet-Finnish Armistice, the Germans were the ones to capitalize on that resident knowledge. Still, before the operation the Soviets conducted a limited train-up; this preparation failed to ingrain the navigational skills required to move freely at night. In October, the sun was above the horizon for less than ten hours.[148] Given the light data and their task, night navigation would have proven an invaluable skillset.

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[148] "Guide to Arctic Sunrise and Sunset," Anthropolis, accessed 3 April 2022, http://www.athropolis.com/sun-fr.htm.

In every phase of the operation, the role of the Soviet light infantry was largely the same: move around the German flanks, block their supply routes, and hold until the combined arms main force arrived. They moved with limited supplies, often those that could be carried with their pack animals, to rapidly close on the German positions. The effectiveness of the Light Rifle Corps varied. In some cases, this worked. The 126th Light Rifle Corps, for instance, from 7 to 12 October were able to cut the German 2nd Mountain Division's lines of communication along the Arctic Ocean Highway. The 70th Naval Rifle Brigade proved less effective as they moved over mountainous terrain earlier in the operation. After arriving at their objectives on 12 October, they were too physically exhausted to block the road and had to survive by butchering their pack animals or using captured rations.[149]

Beyond these flank attacks, Soviet infantry had difficulty maintaining pressure on the withdrawing Germans. The Soviet end state required the destruction of these German elements; this, however, was never met. The Soviet Northern Fleet lessons learned from 1945 established several reasons for their inability to encircle and destroy the Germans after they were driven from their battle positions. One reason simply stated "the pursuit of the retreating enemy was not sufficiently energetic."[150] Two reasons for this were the minimal degree of maneuverability of the infantry and their indecisiveness during the long periods of darkness. These, along with the exhaustion from minimally supported

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[149] Gebhardt, *The Petsamo-Kirkenes Operation,* 120.

[150] Directorate of the Naval Press of the People's Commissariat of the Navy of the USSR, *Concerning Unit Actions during the Breakthrough of the Defenses on the Isthmus of Sredniy Peninsula and Pursuit of the Enemy*, trans. James F. Gebhardt (Moscow: Naval Press, 1945).

foot marches, kept them behind pace of the Germans. The Germans meanwhile were defending relatively familiar terrain allowing quicker movements at night. They seeded mines and destroyed bridges during their withdrawal, slowing the advancing light elements and their support trains. Additionally, the wet mountainous terrain proved brutally exhausting for the attackers. Overlaying topography over the order of battle, aligns the most difficult terrain with the infantry elements that were unable to prevent the Germans from withdrawing.

Despite all this, the Soviets prepared their dismounts far better than they did in 1939. The basic soldier was outfitted with winterized clothing; this included sheepskin caps, mittens, insulating underwear, and sleeping bags, and, unlike Suomussalmi, infantry units were outfitted with white-camouflage smocks.[151] Although skis were not used in mass, the Soviets infantry did rely on the use of pack animals to carry their loads. Maintaining the operational tempo would have been impossible without them. These preparations drastically improved the mobility of the basic Soviet ground unit.

Further calibrating the load out of the light infantry soldier to improve their mobility would be a major goal of the Canadian exercises. The effects of the terrain weighed far heavier on the exposed light infantry soldier than anyone else. They were more susceptible to hyperthermia, exhaustion, and the "Arctic Goblin." Data from these exercises further drove force development.

For instance, Lemming sought to measure the effectiveness of dog sleds, snowmobiles, matches, underwear, suspenders, sleeping bags, rucksacks, and even

[151] Gebhardt, *The Petsamo-Kirkenes Operation,* 25.

moccasins, among numerous other equipment items.[152] The results drove the outfitting of soldiers in subsequent exercises. Musk Ox determined that batteries issued to soldiers were insufficient, leaving them stranded in the dark in the winter months when their flashlights gave out.[153] Sigloo found that the winter kit issued to ground soldiers was too bulky, providing an excessive amount of warmth but preventing manual dexterity in the field.[154] Sweetbriar established standards for the use of skis and snowshoes: "Both skis and snowshoes are required for the varying conditions of snow and types of terrain to be traversed. Skis are best in open country, even in soft snow, especially when trail breaking vehicles can precede the infantry. In bush country snowshoes are more suitable."[155] Sweetbriar further explored the use of sleds and toboggans. The former was discouraged because of its relative disadvantage to over-snow vehicles, while the latter proved effective during casualty evacuation. Following the ground attack, these mobility enhancers would be brought forward, because troops will be more susceptible to cold-weather injuries.[156]

[152] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Lemming'," in Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 23-30.

[153] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Musk Ox'," in Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 38.

[154] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sigloo'," in Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 50.

[155] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," 59.

[156] Ibid., 59-60.

Sun Dog One found that three of five men were required to carry group living equipment, leaving 40% of the team to carry weapons, ammunition, or communication equipment. This was deemed unacceptable, given the adequate weight to maintain operational mobility, was no more than 60 pounds.[157] Arctic summer march rates were measured during Shoo Fly One. The exercise found that marsh rates of march were roughly 1.5 miles per hour.[158] Shoo Fly Two, the second Arctic summer exercise, determined that 45-50 pounds was the optimal load for an individual operating over diversified Arctic terrain in the summer.[159] By Sun Dog Three, the organization of a rifle company was recommended for airborne operation into Arctic winter conditions. It included the recommended tents by echelon, and operational load out of fire support (See Table 1).

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[157] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sun Dog One'," 71.

[158] Shoo Fly One also determined summer uniforms in summer Arctic conditions were suitable. The comments recommended winter clothing with the insulating layers removed were sufficient for the Arctic summers. Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Shoo Fly One'," Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 84.

[159] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Shoo Fly Two'," Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 103.

Table 1. Sun Dog Three Recommended Rifle Company Organization

Detail	Offrs	OR	MMG	3″ Mor	2″ Mor	SMC	LMG	Rif	Tents
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(j)	(k)
Coy HQ Comd G	1	9				3	1	6	2
Adm Gp	3	17				11	1	8	4
Sp Gp		25	2	2		3		22	5
Three P1 HQs (each)	1	5			1	3		3	6
Nine Rifle Secs (each)		8				1	1	6	
Total Coy Group	7	138	2	2	3	35	11	99	29

Source P. Whitney Lackenbauer and Peter Kikkert, eds., *Lessons in Northern Operations: Canadian Army Documents, 1956-56,* vol. 7, *Lessons in Arctic Operations: The Canadian Army Experience, 1945–1956,* Documents on Canadian Arctic Sovereignty and Security (Calgary, AB and Waterloo, ON: University of Calgary and St. Jerome's University, 2016), 183-184.

Even as these exercises developed lessons to improve the effectiveness of the dismount in the Arctic, general limitations remained. Primarily, the dismounts can only move so far under their own capacity and are relatively slow, even when paired with over-snow mobility enhancers. Additionally, the exercises found that dismounted soldiers in the Arctic needed to spend nearly 90% of their time just staying alive, leaving 10% to fighting.[160] As established, Arctic dismounted operations required deliberate planning and careful observation to maintain the fighting capability of troops.

The dismounted section of the Movement and Mobility chapter in "A Guide to Planning and Execution of Operations in the North" reinforced this concept. It stated the daily limit of a dismounted force in any season, excluding ski troops in the winter, will

[160] "No Big Arctic War Believed Possible: Extensive Tests Said to Show Weather Prevents Use of Armies or Even Brigades," *New York Times*, 10 May 1949, https://www.nytimes.com/1949/05/10/archives/no-big-arctic-war-believed-possible-extensive-tests-said-to-show.html.

not normally exceed eight to ten miles. Forced marches of 15 to 20 miles per day are possible for trained troops for short periods. Although the same troops can patrol the same distance over a longer period of time, if they carry a lighter load. However, lightening the load proved nearly impossible when most of the weight derived from survival gear. Naturally, the guide concluded, adverse weather condition in winter will "curtail, and sometimes prevent completely, the movement of troops,"[161] (see table 2.)

[161] The movement rates were further delineated by conditions and "men on foot," "men in snowshoes," and "men on skis" (see Table 2). These were then compared the mounted options in the same conditions. DND DHH, "A Guide to the Planning and Execution of Operations in the North," 183-184.

Table 2. Average Movement Rates in the Arctic

SERIAL	TYPE	RATE OF MOVEMENT (mph) THROUGH DEPTH OF SNOW INCHES						REMARKS
		3″	6″	12″	18″	24″	30″	
1	Men on foot	2½	2	1½	1	immobile[x]		These figures are estimated in relation to one day's march.
2	Men on snowshoes	-	2½	2½	2½	2½	2½	
3	Men on skis	3	5	5	5	5	5	
4	Wheeled vehicles	15	10	5	immobile			
5	Animal drawn vehicles	3	2	1	immobile			Animals other than dogs and reindeer.
6	Tracked vehicles (carriers)	15	15	5	immobile			
7	Tanks	15	10	5	5	5	immobile	
8	Tractor trains	6	6	3	1	1	½	
9	Oversnow vehicles	15	15	15	15	15		

Source: P. Whitney Lackenbauer and Peter Kikkert, eds., *Lessons in Northern Operations: Canadian Army Documents, 1956-56,* vol. 7, *Lessons in Arctic Operations: The Canadian Army Experience, 1945–1956,* Documents on Canadian Arctic Sovereignty and Security (Calgary, AB and Waterloo, ON: University of Calgary and St. Jerome's University, 2016), 207.

Mounted Operations

The Battle of Suomussalmi seems to denigrate mounted operations in the high north. However, as previously established, the case highlights how the Soviet operational approach was not suited to the operational environment. The primary lessons of the battle were not that mounted operations in the north during winter are doomed. It merely shows that the terrain and conditions were not suited for the heavy Soviet formations. The unimproved roads limited the maneuver space of the Soviets' two mechanized divisions. While frozen ground would normally benefit an armored element, the thick tree line and heavy snow prevented the tanks from breaking out from the unimproved roads. The Russian dismounts were hardly capable of supporting the tracked or wheeled operations on these roads, as the dismounts themselves were unable to push beyond the confines of the roads.

To determine the effectiveness of mounted mobility in the Arctic, the other two cases provide more applicable lessons. The Petsamo-Kirkenes Operations presented numerous constraints to mounted elements of the 14th Army. Wheeled and tracked vehicles supporting every warfighting function would run into difficulty during the operation. In many cases, the infantry would outrun the supporting artillery, armored, and sustainment vehicles. Numerous obstacles, both manmade and natural, hindered the Soviet mounted advances. Despite mobility enhancers such as pontoon bridges and amphibious vehicles, the mountainous region and web of rivers, streams and creeks slowed the Soviet tracked and wheeled elements. The bridges and passes through these were subsequently laced with German mines and blocking obstacles. These obstacles employed the engineers extensively. Without these specialists, the combined arms formations would have been unable to advance at all. Often the order of battle involved the maneuver of dismounted maneuver elements pressing the attack or flanking through complex terrain. The engineers meanwhile would repair bridges or clear blocking obstacles so artillery support could move forward to support these forces. This would often present the Germans a pause in Soviet tempo during which they could counterattack the infantry elements.

Soviet tanks suffered the same restrictions. They entered combat nearly four days after the infantry entered the close fight. Despite using multiple axes, the terrain prevented the armor elements from massing on the battlefield. Their role was piecemealed, supporting the infantry intermittently with one or two tanks. Despite the Soviets retaining air superiority, armored formations suffered a high percentage of mobility kills from equal parts enemy action and the terrain.[162]

The greatest enemy of the mounted elements remained the conditions. In anticipation of the logistical requirements, the Soviets deployed enough vehicles forward to supply twice their required daily rate of tonnage. However, the road network's capacity limited the effectiveness of the logistical package. The temperatures and ground conditions took their toll on axles, suspensions, and other moving parts. One of Gebhardt's Soviet sources estimated that one third of the trucks underwent some type of repair.[163]

Again, the Soviet mounted operations at first blush would seem ineffective. However, it is important to establish that any operational mobility would have been impossible with the Soviet's expansive fleet. While the roads limited the sustainment potential, the extended lines of communication equally strained operations. Although they did not allow the combined arms elements to meet the strategic end state, they did facilitate an operational victory.

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[162] Gebhardt, *The Petsamo-Kirkenes Operation,* 122-123.

[163] Ibid., 125.

During the war the Canadians developed an early understanding of the effects the Arctic would have on their vehicles. At the winter warfare school in Petawawa, Ontario, they developed kits to "arcticize" their vehicles so they could operate in temperatures as low as negative 40 degrees Fahrenheit. By the end of the war, the Canadians had a substantial body of technical knowledge on vehicle operations in the far north.[164] To expand and operationalize these standards, early post-war exercises tested various combinations of mobility packages against Arctic environments. The 1945 exercises sought to determine the feasibility of the utilizing mounted fleets, measuring, for instance, their reach and ability to operate beyond railheads or roads.

Unsurprisingly, Eskimo found that the vehicles tend to render a force road-bound. Polar Bear offered pack animals as a solution to extending the lines of communication beyond the road. "Pack transport units are almost indispensable once a force moves beyond the vehicle head in terrain such as the Western Coastal region," the post exercise lessons captured.[165] "Even should weather and a change in the situation not interfere with air supply, pack animals are required to move the force tactically and to transport supplies and equipment on the ground."[166]

More applicably, these exercises confirmed the importance of ground state. The frozen ground proved valuable to motorized formations. Even during months with daytime melt, vehicles were limited to periods when the ground was frozen to preserve

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[164] Eyre, *Custos Borealis*, 150-152.

[165] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Polar Bear'," 13.

[166] Ibid.

the state of the movement corridors. Off the road, over-snow vehicles provided the mounted force extended range and operational options. Numerous versions of snow mobiles were tested over the next ten years. Debate over how and where to use these vehicles invoked “the North African analogy.” As the deserts in North Africa differ from its jungles, the Arctic environments varied wildly and thus the Canadian Army needed to develop different over-snow capabilities.

During Lemming, mounted movement over coastal ice was explored, with promising potential for application. Ice potentially offered high speed avenues of approach for vehicular formations. Three main types of ice roads were identified during the course of the exercise as ideal. The first was the coastal marsh or snow-covered beaches. The second was against the icefoot, a natural ice wall that developed at or below the low-water mark and formed because of the rise and fall of the tides and freezing spray. Here the ice proved sticky, allowing for additional grip. The third was land fast, or where ice naturally locked into the land contours. These ice formations, which were observed in the Hudson Bay, allowed for semi-permanent cuts to be drawn, facilitating throughput traffic.[167]

In addition to vehicle capacity, the Canadians explored the operational support structured required to maintain mounted formations in the Arctic. Musk Ox, which represented a series of smaller experimental exercises from February and May of 1946, found that vehicle maintenance points should be located at airbases at 500-mile intervals

[167] DND DHH, “Lessons Learned Winter Exercises, 1945-1954: Exercise ‘Lemming’,” 21.

with intermediate caches and maintenance shelters available.[168] Later exercises found these maintenance shelters required specialized heaters, and the winter lubricants and battery required further development. These experiments produced a series of recommendations not only for the support packages required, but more recommendations on the capabilities and a call for specialized platforms.

By 1947, the Canadians had tested nearly every one of their major chassis in an Arctic environment. During North, the Canadians tested their motorized battalion in a reconnaissance role on the Alaskan Highway. They concluded that the motorized elements, then equipped with armored half-tracks, were best suited to highway defense in the barren north. This autumn exercise, however, included only 33 half-tracks.[169] Two years later, Sweetbriar tested a more combined arms force along a similar stretch of highway in the winter. Air components, engineers, artillery, wheeled and tracked vehicles, as well as over-snow vehicles would all be aligned together against objectives along the highway.

Tracked vehicles proved their worth along the highway during Sweetbriar. Given the reduced mobility of infantry as they close on the objective through heavy snow, fire support in addition to the artillery was needed. "Use of the heavier tanks in support of infantry will give improved offensive power but on the availability of a road line of

[168] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Musk Ox'," 32.

[169] Ibid., 39-42.

communication," the Canadians determined.[170] While the Finns negated the Soviet's tanks along the unimproved narrow corridors of the thick Finnish forest, the Canadians saw a combined arms approach as crucial to accomplishing objectives along northern highways. They determined reconnaissance tasks along the highway also demanded armored support from the road. However, to expand their sensors past the road, the Canadians called for over-snow vehicles. Ultimately, the combined arms exercise proved the role of tracked vehicles could serve; however, it also thoroughly noted the limitations between mobility platforms. "Travel by tracked vehicles and on foot along the frozen streams and lakes is practicable. Wheeled vehicles are usually completely road-bound," Sweetbriar's mobility roundup concluded, further clarifying, "Mobility may be considered the first principle of Arctic or sub-Arctic warfare and true mobility can only be obtained by the possession of over-snow vehicles."[171]

Sun Dog One expanded on integrating over-snow capability. Despite focusing on the requirements for one infantry company, the conclusions again returned to over-snow vehicles. To account for the Arctic's massive distances and life support requirements, dismounted troops needed vehicular support; they could expand their reach in a limited area with dismounted over-snow options such as skis or snowshoes. To expand their reach, however, tracked over-snow vehicles were required during the winter. Enclosed

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[170] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," 57.

[171] Ibid., 57-59.

aluminum-bodied tracked vehicles, such as the Beaver or Wapitis were requested.[172] By the next winter, vehicles like these were testing concepts to expand light infantry range and thus improving their mobility.

During Loup Garou, conducted in 1954, further improved tracked vehicles loaded with soldiers were towing sleds full supplies. This practice allowed light infantry formations to expand beyond the roads, on which conventional wheeled vehicles would have transported them, and delve further into Arctic wilderness. "Further in the gaining contact phase," the exercise report's final note on mobility cautioned, "the towing of sleds by each sub-unit of the forward element, advancing under tactical development, is difficult, slow, and most dangerous."[173]

Section 2: The New Arctic Operational Environment

Temperature

The warming surface temperature is the primary driver of change in the Arctic operational environment. Melting sea ice, increased rain, decreased snow, altered hydrology, permafrost reduction, eroding infrastructure, shifting populations, resource access, bourgeoning maritime trade, and increased militarization all indirectly stem from the increasing temperatures. All these have profound impact on mobility in the future Arctic operational environment. They will be explored in subsequent sections, first the

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[172] DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sun Dog One'," 71.

[173] Department of National Defence (DND), Directorate of History and Heritage (DHH), "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Loup Garou'," in Lackenbauer and Kikkert, *Lessons in Northern Operations,* vol. 7, 169.

extent of the warming will be established. As the subsequent section will show, the degree of warming, and by extension the secondary effects, is far from uniform across the Arctic.

The Arctic has likely warmed twice as fast as the rest of the globe over the past 50 years.[174] This is primarily from a phenomenon known as Arctic amplification, whereby the effects of global warming are intensified in the Arctic.[175] However, land surface air temperatures (LSAT) naturally vary since the domain exists around the Arctic Ocean's periphery. If the goals of the Paris Climate Agreement are fulfilled and global warming levels off around 2 degrees Celsius, the mean Arctic temperature will likely increase by at least 4 degrees Celsius.[176] The mean LSAT would likely follow this trend. Importantly for Arctic planners, the LSAT trends are not homogenous but vary depending on season and location. For instance, the LSAT over Greenland's 66° 33' northing in the winter of 2021 warmed 3-4 degrees Celsius from the 1981 to 2010 means, while temperatures across the same northing in Alaska cooled 1-2 degrees Celsius during the same period. However, when comparing the same locations in autumn of 2020, temperatures rose 1-3

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[174] Ballinger et al., "Surface Air Temperature."

[175] Meredith, M., M. Sommerkorn, S. Cassotta, C. Derksen, A. Ekaykin, A. Hollowed, G. Kofinas, A. Mackintosh, J. Melbourne-Thomas, M.M.C. Muelbert, G. Ottersen, H. Pritchard, and E.A.G. Schuur, "2019: Polar Regions," *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* eds. H. O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N. M. Weyer (Cambridge, UK: Cambridge University Press, 2019).

[176] James Overland, Edward Dunlea, Jason E. Box, Robert Corell, Martin Forsius, Vladimir Kattsov, Morten Skovgård Olsen, Janet Pawlak, Lars-Otto Reiersen, Muyin Wang, "The Urgency of Arctic Change," *Polar Science* 21 (September 2019): 6-13, https://doi.org/10.1016/j.polar.2018.11.008.

degrees in Alaska but warmed less than a degree from the 1981 to 2010 means (Figure 5).[177]

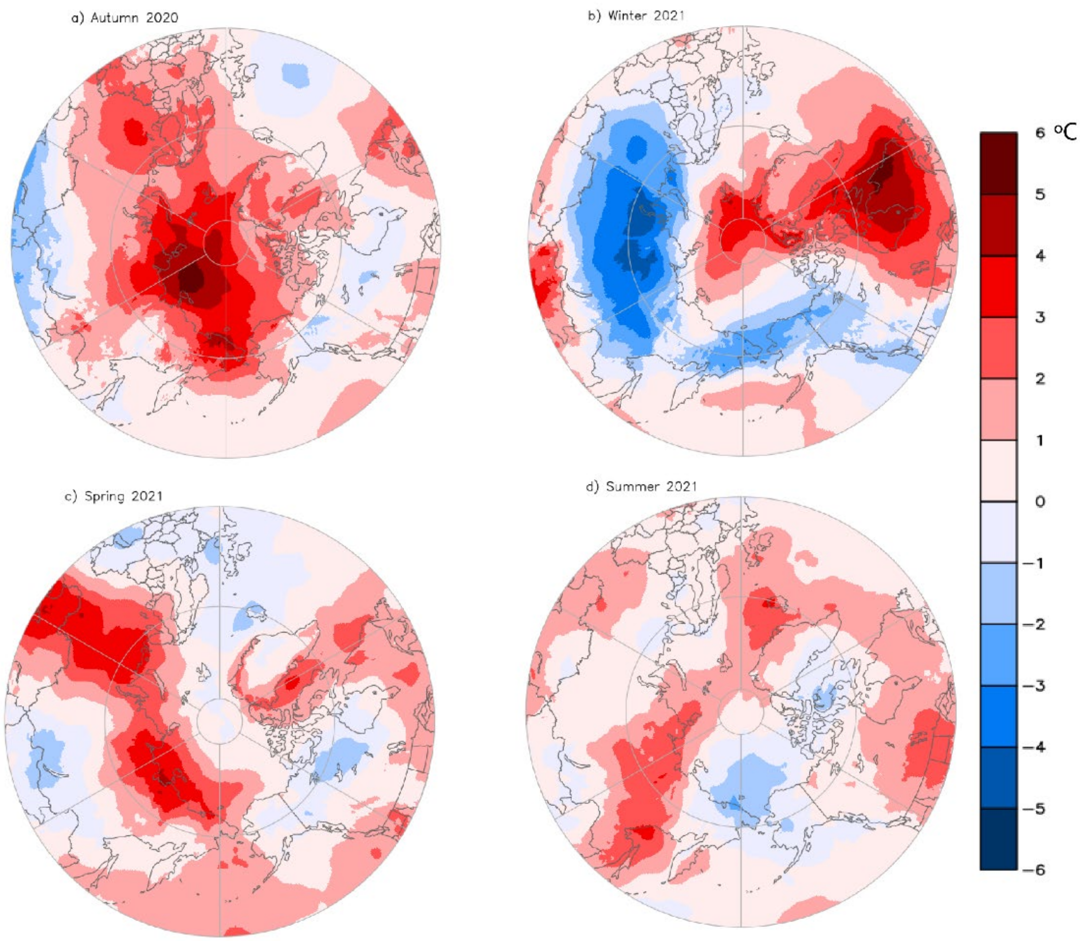

Figure 4. Near Surface Seasonal Air Temperature Anomalies for (a) Autumn 2020, (b) Winter 2021, (c) Spring 2021, (d) Summer 2021

Source: T. J. Ballinger, J. E. Overland, M. Wang, U. S. Bhatt, B. Brettschneider, E. Hanna, I. Hanssen-Bauer, S. J. Kim, R. L. Thoman, and J. E. Walsh, "Surface Air Temperature," in *Arctic Report Card 2021*, ed. T. A. Moon, M. L. Druckenmiller, and R. L. Thoman (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2021), 8-14, https://doi.org/10.25923/53xd-9k68.

177 Ballinger et al., "Surface Air Temperature."

The heat map represented in Figure 6 displays the degree to which the temperature change varies by time and space. General trends are less important than the patterns particular to a given Arctic region. On the extreme end in 2021, temperatures in Russia's Siberian Republic of Sakha experienced a heatwave with temperatures peaking at record of 48 degrees Celsius (118.4 degrees Fahrenheit) in June, the hottest temperature recorded in the Arctic.[178] During the same time, on Greenland's Helheim Glacier was 2 degrees Celsius below the 1981 to 2010 average.[179] When comparing the Sakha Republic's 2021 winter temperatures to NOAA's 1981 to 2010 mean averages, the temperatures cooled in some areas by 3 to 4 degrees Celsius. While some areas may be subject to extreme temperature changes season to season, others may be negligible such as in the Norwegian Arctic.

The US Army divides cold temperatures into five categories: wet cold (+39° F [3.89° C] to +20° F [-6.67° C]), dry cold (+19° F [-7.22° C] to -4° F [-20° C]), intense cold (-5° F [20.56° C] to -25° F [-31.67° C]), extreme cold (-26° F [-32.22° C] to -40° F [-40]), and hazardous cold (below -40° F [-40 C]).[180] Each of these temperature categories is represented in the current Arctic environment. The future Arctic

[178] European Union, Copernicus Sentinel-3 Imagery, "Land Surface Temperature in the Sakha Region," Copernicus, 21 June 2021, https://www.copernicus.eu/en/media/image-day-gallery/land-surface-temperature-sakha-republic.

[179] "Greenland's 2021 Spring: More Snow, Less Melt," National Snow & Ice Data Center, University of Colorado, June 26, 2021, https://nsidc.org/greenland-today/2021/06/.

[180] Headquarters, Department of the Army (HQDA), Army Techniques Publication (ATP) 3-90.97, *Mountain Warfare and Cold Weather Operations* (Washington, DC: Army Publishing Directorate, April 2016), B-1.

environment will likely see less extreme and hazardous cold categories in the northern most regions of the land domain. The data suggests long-term warming. Still, the extent of the warming will remain particular to the region. The effects from limited or intermittent periods of warming, however, will still have impacts on mobility, particularly as the LSAT drives change across the Arctic landmass. The subsequent sections reflect these second order effects and the impacts to mobility.

Permafrost

The case studies demonstrate how the terrestrial layer effects the mobility options at the tactic and operational levels. The state of the ground in Arctic Finland and Canada before 1955 was mostly frozen year-round with an "active layer" that melted seasonally. Permafrost is the ground below the active layer which remains frozen for at least two years. As temperatures spike, the active layer is deepening across the Arctic. In some cases, permafrost is disappearing. This melting will irrevocably change landforms such as pingos, ice-wedges, polygons, and rock glaciers and transform wide swaths of Arctic tundra into bogs, swamps, or saturated plains. By midcentury, the underlying conditions that form the current permafrost landforms may be reduced by at least one fifth or even halved.[181] This will significantly change geo-diversity and hydrology, and thus mobility considerations through both near- and long-term windows.[182]

[181] Olli Karjalainen, Miska Luoto, Juha Aalto, Bernd Etzelmüller, Guido Grosse, Benjamin M Jones, Karianne S Lilleøren and Jan Hjort, "High Potential for Loss of Permafrost Landforms in a Changing Climate," *Environmental Research Letters* 15, no 10 (October 2020): article no. 104065.

[182] G. J. Wolken, A. K. Liljedal, M. Brubaker, J. A. Coe, G. Fiske, H. Hvidtfeldt Christiansen, M. Jacquemart, B. M. Jones, A. Kääb, F. Løvholt, S. Natali, A. C. A. Rudy,

An important way in which permafrost reduction will challenge mobility is through the process of thermokarst. This refers to the loss of structural integrity in landforms held together with permafrost. The subsequent subsistence changes the landscape as base layers shift. While 20% of the northern permafrost areas are considered thermokarst landscapes, most of this area is in the Arctic.[183] The thermokarst process can occur in and alter many different Arctic land formations. For instance, it can increase downhill creeping of rock glaciers. This can expand runoff across wide areas or create tundra ponds, thus drastically reduce avenues of approach or maneuver space. Thermokarst often creates new landforms such as lakes, depressions, thaw slumps, and erosional gullies. These changes can overtake, degrade, or destroy key infrastructure such as airports, rail lines or roads.[184] Such effects can present themselves gradually or manifest rapidly, as subsurface tension reaches a threshold under the sitting landmass.

Melting permafrost also has the potential to change the hydrology of a particular region. A 2021 study found that areas with a deep active layer had increased soil water

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and D. Streletskiy, "Glacier and Permafrost Hazards," in *Arctic Report Card 2021*, ed. T. A. Moon, M. L. Druckenmiller, and R. L. Thoman (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2021), 93-101.

[183] D. Olefeldt, S. Goswami, G. Grosse et al., "Circumpolar Distribution and Carbon Storage of Thermokarst Landscapes," *Natural Communication*, 7 (October 2016): article 13043, https://doi.org/10.1038/ncomms13043.

[184] Dmitry A. Streletskiy, Luis Suter, Nikolay Shiklomanov, Boris N. Porfiriev, and Dmitry O. Eliseev, "Assessment of Climate Change Impacts on Buildings, Structures and Infrastructure in the Russian Regions on Permafrost," *Environmental Research Letters* 14, no. 2 (2019): 025003, https:iopscience.iop.org/article/10.1088/1748-9326/aaf5e6.

storage capacity, which likely leads to increased winter runoff.[185] This can increase the volume and intensity of hydrological features, and the changing landscape from the thermokarst process will likely further change the disposition of these features. The eroding landforms can reroute standing hydrological formations, establish new formations, or in some cases, reduce them. Again, these changes can occur gradually or rapidly. In dramatic cases, large-scale slumping can drain lakes and alter rivers within hours.[186] Hydrological and topographical maps then will have to be constantly reevaluated, and imagery will be increasingly important to reconnoitering routes in the Arctic.

In addition to hydrological formations like rivers, streams, and lakes, the saturated ground will present challenges to tracked and wheeled vehicles operating off-road. As the active layer becomes deeper, the ground will become saturated in areas with poor drainage, reducing its ability to disperse the weight of large military vehicles. Since the active layer may still freeze in the winter months, large swaths of maneuver space may disappear or appear season to season. As temperatures warm, the challenges of the subsequent ground melt will compound with those of precipitations to create new considerations for movement in the north.

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[185] Kang Wang, Tingjun Zhang, Daqing Yang, "Permafrost Dynamics and Their Hydrological Impacts over the Russian Arctic Drainage Basin," *Advances in Climate Change Research* 12, no. 4 (August 2021): 482-498, https://doi.org/10.1016/j.accre.2021.03.014.

[186] Ed Struzik, "How Thawing Permafrost is Beginning to Transform the Arctic," *Yale Environment 360,* 1 January 2020, https://e360.yale.edu/features/how-melting-permafrost-is-beginning-to-transform-the-arctic.

Precipitation

One of the most striking climate predictions is the transition from a snow-dominated to a rain-dominated Arctic. This transition from primarily snow precipitation to rain precipitation will likely occur during the spring, summer, and autumn months. Additionally, the line of year-round snowfall will continue to retreat north as the temperatures pass the freezing threshold from April to October. This is a general trend, and this threshold varies by region.[187]

As consequential to Arctic mobility, overall precipitation will likely increase. The wetter Arctic conditions derive from evaporation of the bourgeoning open water in the Arctic Ocean and the resulting atmospheric dynamics.[188] The precipitation on land then is indirectly linked to the reduction of multi-year ice at sea. As profound as the changes in the maritime domain will be, so too are the derivatives on land. Some models predict as much as a 60% increase of precipitation by the mid-21st century.[189]

The effects of increased precipitation exacerbate the effects of melting permafrost, further changing the landscape.[190] This includes the alteration of rivers and

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[187] R. Bintanja, "The Impact of Arctic Warming on Increased Rainfall," *Scientific Reports* 8 (October 2018): article 16001, https://doi.org/10.1038/s41598-018-34450-3.

[188] R. Bintanja, and F. M. Selten, "Future Increases in Arctic Precipitation Linked to Local Evaporation and Sea-ice Retreat," *Nature* 509 (May 2014): 479-482, doi:10.1038/nature13259.

[189] R. Bintanja, "The Impact of Arctic Warming on Increased Rainfall."

[190] F. J. Wrona, M. Johansson, J. M. Culp, A. Jenkins, J. Mård, I. H. Myers-Smith, T. D. Prowse, W. F. Vincent, and P. A. Wookey, "Transitions in Arctic Ecosystems: Ecological Implications of a Changing Hydrological Regime," *Journal of Geophysical Research: Biogeosciences* 121, no. 3 (March 2016): 650–674, doi:10.1002/2015JG003133121.

stream flow and the metamorphosis of interconnected lakes, along with slumping and erosion. The number of water obstacles and their depth and width will present a significant challenge to both mounted and dismounted Arctic units especially during the warmer months. Like melting permafrost, the ground saturation presents seasonal considerations to mounted forces. Dismounted forces too, suffer constraints from ground saturation as the Canadians discovered during the summer Arctic exercise Cross-country. During the exercise across marshy terrain, they found their Arctic troops could move an average of 1.5 miles per hour or 15 to 20 map miles a day.

Given the increased precipitation, some Arctic locations will experience increased snowfall during the winter. Overall, however, the areas covered in snow year-round is declining. Snow cover extent, duration, depth, and water stored by the snowpack are declining across the Arctic.[191] Figure 5 shows the extent of the change during the 2020-2021 snow onset (a) and snow melt (b) over the 1999 to 2018 mean. The red areas reflect an increase of snow-free days. Throughout extensive areas of the Eurasian landmass, for example, the duration of the spring snow-free period was 30% to 50% longer than normal. The challenge then for dismounted forces will be maintaining the wider set of skills. While winter mobility options (cross-country skiing, snowshoeing, and sledding) will need to be maintained, their importance in comparison to conventional means of transportation may wane. Mobility platforms will need to be effective over heavy snow and ice, but also the wet ground conditions presented during the spring, summer, and

[191] Rebecca Lindsey and Luann Dahlmann, "Climate Change: Spring Snow Cover," Climate.gov, 14 August 2020, https://www.climate.gov/news-features/understanding-climate/climate-change-spring-snow-cover.

autumn. Overall, Arctic soldiers will need to maintain specialized Arctic skills, alongside more conventional mobility skill sets.

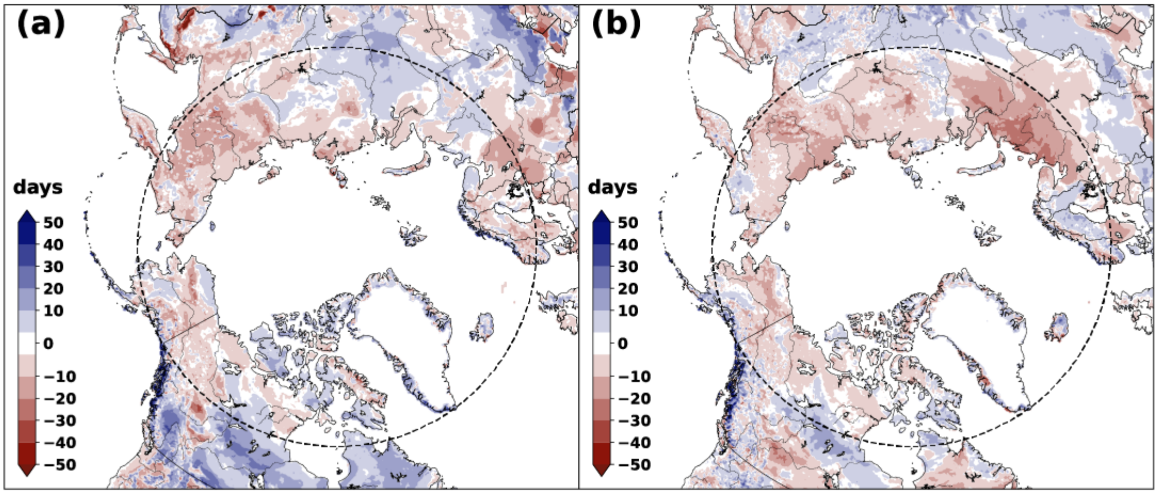

Figure 5. Snow Cover Duration Anomalies (Percent of Difference Relative to Normal Number of Snow-free Days), 2020-2021 Snow Year

Source: L. Mudryk, A. Elias Chreque, R. Brown, C. Derksen, K. Luojus, and B. Decharme, "Terrestrial Snow Cover," in *Arctic Report Card 2020,* ed. R. L. Thoman, J. Richter-Menge, and M. L. Druckenmiller (Silver Spring, MD: National Oceanic and Atmospheric Administration, December 2020), 28-34, https://www.arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard_full_report2020.pdf.

Infrastructure

As the Arctic environment becomes more hospitable to humans and more resource extraction operations commence, the demand for infrastructure will increase. Even as demand increases, the environment will levy the eroding effects on the infrastructure. A 2021 study found that there are 1162 settlements in the Arctic permafrost region that accommodate five million people with one million people living on the coast. The projections suggest that by 2050, 42% of these settlements will see permafrost disappear. Of the remaining settlements, another 42% are settled in high hazard zones where further reduction will have severe effects. That leaves 3.3 million people settled in regions where permafrost will disappear or severely degrade.[192] Many are already affected. In some Russian cities, as many as 80% of buildings already have observed damages from thawing conditions.[193] Across the Arctic, 30% to 50% of critical circumpolar infrastructure will be at high risk.[194]

Much of the infrastructure across the Arctic appeared after the year 2000, primarily in Russia, but in the US and Canada as well. Much of this infrastructure supports the oil and gas industry, specifically pipelines, storage, and processing facilities.[195] Many of these infrastructure nodes are along the coastline, with lines of communication tied to the maritime domain. Because of this, the sustainment of land lines of communication may be lower in priority. Even if inland roads, bridges and rail linkages to industrial nodes are developed at a slower rate than maritime based

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[192] Justine Ramage, Leneisja Jungsberg, Shinan Wang, Sebastian Westermann, Hugues Lantuit, and Timothy Heleniak. "Population Living on Permafrost in the Arctic," *Population and Environment* 43 (January 2021): 22-38, doi:https://www.doi.org/10.1007/s11111-020-00370-6.

[193] Jan Hiort, Dimitry Streletskiy, Guy Doré, Qingbai Wu, Kevin Bjella, and Miska. Luoto, "Impacts of Permafrost Degradation on Infrastructure," *Nature Reviews Earth & Environment* 3 (January 2022): 24–38, https://doi.org/10.1038/s43017-021-00247-8.

[194] Earl Marvin B. De Guzman, Marolo C. Alfaro, Guy Doré, Lukas U. Arenson, and Aron Piamsalee, "Performance of Highway Embankments in the Arctic Constructed under Winter Conditions," *Canadian Geotechnical Journal* 58, no. 5 (May 2021): 722-736, https://doi.org/10.1139/cgj-2019-0121.

[195] Annett Bartsch, Georg Pointner, Ingmar Nitze, Aleksandra Efimova, Dan Jakober, Sarah Ley, Elin Högström, Guido Grosse, and Peter Schweitzer, "Expanding Infrastructure and Growing Anthropogenic Impacts along Arctic Coasts," *Environmental Research Letters* 30, no. 11 (November 2021): 4-7, https://iopscience.iop.org/article/10.1088/1748-9326/ac3176/meta.

infrastructure, the aging infrastructure that connected indigenous populations will be even less prioritized by governments looking to capitalize on the Arctic resource extraction. As indigenous populations move to these industrial areas, the demand to maintain their historic lines of communication will further deteriorate. Preserving this infrastructure will be expensive. New techniques such as convection embankments are promising; however, they are also time consuming, costly, and underdeveloped.

The major road networks connecting the key industrial nodes then will likely receive the bulk of investments and peripheral road networks will suffer the devastating effects of permafrost melting and runoff. The industrial and population centers will likely mark operational objectives with relatively few mounted avenues of approach on the periphery. Long approach march by mounted formations will require extensive road improvements. While engineers can provide such improvements, the scale required to improve these lines of communication will likely not be worth the efforts. Air mobile and amphibious ingress options provide more economical solutions. However, the distance of an offset landing to the objective may in part be determined by the degree of improvement to the roads and the composition of force.

Tactically, limited infrastructure presents limited options to ground commanders. This is especially true for mounted formations. As the Soviets during the Petsamo-Kirkenes operation discovered after planning multiple avenues of approach along several roads, the roads may be far from serviceable. Route reconnaissance for mounted formations, informed by engineers well-versed in conditions of the new Arctic will be necessary to navigating the limited road networks.

Vegetation

As the Arctic Ocean becomes bluer, satellite imagery suggests the Arctic landscape is greening. With the changes to permafrost and earlier snowmelts, the growing seasons have expanded.[196] The Arctic tundra with its expanse of low shrubs, mosses, and grasses are generally shifting north into the Arctic's polar deserts and further south, the boreal forest too is shifting north. The forests, a belt of cold-tolerant conifer trees covering nearly 15 million square kilometers of the North America and Eurasian Arctic, are expected to shift north in the coming decades.[197] The same forests that trapped Soviet armored columns during the Winter War are encroaching northward with new woody growth. One 2013 study suggested that woodland covered areas in the Arctic will increase by as much as 52%.[198] Conversely, a later study that reviewed satellite imagery found that 50% of Arctic vegetation has not changed significantly.[199] That study, along with many others before it, recommended further research into the effects of warming to

[196] Monique M.P.D. Heijmans, Runa Í. Magnússon, and Mark J. Lara, "Tundra Vegetation Change and Impacts on Permafrost," *Nature Reviews Earth & Environment* 3 (January 2022): 68-84, https://doi.org/10.1038/s43017-021-00233-0.

[197] Logan T. Berner and Scott J. Goetz, "New Study Shows that Earth's Coldest Forests are Shifting Northward with Climate Change," *Global Change Biology* 28, no. 10 (May 2022): 3275-3292.

[198] Richard G. Pearson, Steven J. Phillips, Michael M. Loranty, Pieter S. A. Beck, Theodoros Damoulas, Sarah J. Knight, and Scott J. Goetz, "Shifts in Arctic Vegetation and Associated Feedbacks under Climate Change," *Nature* 3 (March 2013): 673-677, DOI: 10.1038/NCLIMATE1858.

[199] Terry V. Callaghan, Roberto Cazzolla Gatti, and Gareth Phoenix, "The Need to Understand the Stability of Arctic Vegetation during Rapid Climate Change: An Assessment of Imbalance in the Literature," *Ambio* 51, no. 4 (April 2022): 1034-1044, https://doi.org/10.1007/s13280-021-01607-w.

accurately model. While the extent of this shift is debated, the current modeling suggests forests will continue to present challenges to mobility in the high north.

The extent of forest shifts into the Arctic tundra is determined by local factors, primarily soil content and permafrost conditions. Areas with limited permafrost ice-content for instance, are likely to see increased woody vegetation, whereas wooded areas experiencing abrupt permafrost thaw in ice-rich lowlands are likely to have woody vegetation replaced with grass-like graminoids.[200] Like other elements in this section, longitude is as important latitude when analyzing these changes. Predicting how vegetation will affect the long-term mobility of a certain area will continue to prove difficult as the Arctic warms. Unlike the potentially rapid changes to the landscape and hydrology resulting from thermokarst, vegetation changes will occur incrementally. The exception to this is wildfires.

The Arctic had not been historically prone to extensive wildfires. However, a 2022 report by the United Nations Environment Programme suggested this will change. The extended growing seasons and vegetation productivity increase fuel availability. Even with the increased precipitation, the Arctic is presenting conditions ripe for extensive fires.[201] The 2020 Siberian heatwave, for instance, resulted in highly publicized wildfires that burned nearly 14 million hectares across Russia's two eastern-most

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[200] Heijmans, Magnusson, and Lara, "Tundra Vegetation Change and Impacts on Permafrost."

[201] United Nations Environment Programme, *Spreading like Wildfire – The Rising Threat of Extraordinary Landscape Fires: A UNEP Rapid Response Assessment* (Nairobi: United Nations Environment Programme, 2022), 50-51.

districts.[202] Given the sparse infrastructure and limited roads through wooded areas, extensive fires may close large swaths of operational space to maneuver forces. The longer-term impacts on mobility go beyond simple reduction of the forest. The roads and rail lines running through impacted areas would be subject to landform unrest as the soil's structure and hydrological characteristics are disrupted.

The Threat: Russia

Russia constitutes the most significant threat in the emergent Arctic operational environment. While it may not be the only threat force in the future Arctic operational environment, Russia's force posture presents the most strategic, operational, and tactical mobility challenges.[203] This section will first analyze Russia strategic disposition in the Arctic. While this presents strategic-level mobility considerations, the environmental elements and the disposition together play out at the tactical and operational levels. Following this layout, the section will focus on Russia's future Arctic force structure and capabilities.[204]

[202] Alexandra Witze, "The Arctic is Burning Like Never Before – and That's Bad News for Climate Change," *Nature* 585 (September 2020): 336-337, https://www.nature.com/articles/d41586-020-02568-y.

[203] As the literature reviewed established, China's Arctic ambitions utilize its diplomatic, economic and information elements of national power. The militarization undertaken by China is an important development. However, the unknown variables of how China would apply the military to tactical and operational problems makes the topic too speculative for this study.

[204] At the time of this analysis, Russian Arctic units have been involved in the War in Ukraine. The events beginning on 24 February 2022 will have effects on the Russian Forces in the Arctic and possibly their strategic approach in the region.

Russia's military capabilities vary between the eastern and western halves of its Arctic territory. Both halves present significant capabilities, although each serve different strategic purposes. The east serves to complete its protective northern dome with military and civilian early warning systems. Military forces in the east primarily serve to control the sea lines of communication, namely the NSR through the Bering Strait. Moving westward presents more integrated military systems designed to prevent incursion into the Russia's key strategic areas by NATO aerial, maritime, or land forces. The west boasts the most modern air defense capabilities across the Russian Arctic coastline with the bulk of its Arctic-specific offensive capabilities under the protective bubble.[205] Barring major repopulation eastward and a shift in development priorities, this general disposition will likely continue into the foreseeable future.

The east to west gradient provides important mobility considerations. Because Russia quarters its primary offensive ground capabilities in the west, large-scale buildup of combat forces in the east requires time. Any ground force buildup in the east would extensively rely on rail lines, airports, and seaports. Future development of key Arctic infrastructure on land would assist Russia in maximizing their extended interior lines of communication in northern Eurasia. As established, this would be expensive. Russia's military posture in the east centers on controlling the sea lines of communication and denying any strategic foothold in the region. Thus, controlling the maritime-based lines of communication along the NSR and future transpolar routes will likely be prioritized.

[205] Matthew Melino and Heather A. Conley, "The Ice Curtain: Russia's Arctic Military Presence," Center for Strategic and International Studies, accessed 29 November 29, 2021, https://www.csis.org/features/ice-curtain-russias-arctic-military-presence.

Two examples of this littoral approach are bases on Wrangel Island and Kotelny Islands. Wrangel, which lies 300 miles from the coast of Alaska, provides a potential radar and long-range fires threat which can extend to the Bering Strait and along the Siberian coast. Kotelny Island, meanwhile, can support combat power projection with continued development of its seaport and air base. Advanced radar and fires platforms on the island also anchor the A2/AD systems in the north.[206] These bases, positioned on large barren islands in the Arctic Ocean, highlight the importance of the littoral environment in the east. With limited lines of communication on the Siberian landmass, these islands would mark key terrain for the US joint force with supporting tactical and operational objectives.[207]

Similar sea bases overwatch NSR and Russia's coastline in the west. Most predominantly, these include bases on Novaya Zemlya and Alexandra Island. Lain across Novaya Zemlya is the Rogachevo Airbase, which houses advanced strategic bombers, fighter aircraft, radars, and electronic warfare capabilities.[208] Alexandra Island hosts Russia's northernmost base. The Nagurskoye Airbase there has been continually improved since its construction to service bombers and fighters year-round despite the extremely cold temperatures. It, too, houses extremely advanced radars and electronic

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[206] Melino and Conley, "The Ice Curtain."

[207] Russia also expressed interest in sending the 82nd Separate Motor Rifle Brigade to the Yamal Peninsula in the east, as a counter to Alaskan-based US formations. While these efforts never materialized, they do indicate desired future intentions. Igor Sutyagin, "The Russian Defence Posture in the Arctic," (Written evidence submitted by request of the House of Commons Defence Select Committee, London, 14 March 2017).

[208] Melino and Conley, "The Ice Curtain."

warfare capabilities. Most importantly, the base's location and air defense capabilities provide strategic denial for NATO incursion. Extending from the Alexandra Island base is the northern ring of concentric circles linking the east and west. These strategic rings provide Russia strategic "over-the-top" A2/AD and allow it to control commercial traffic through the Arctic Ocean.[209]

Russia's Arctic A2/AD system is foundational to its defense. The epicenter of this prickly defense lies on one of its western-most Arctic land-masses – the Kola Peninsula. The densely populated and militarized peninsula serves to both anchor the eastern spanning A2/AD and potentially project power westward. With its western-most corner less than 200 miles northeast of Suomussalmi and jutted up against northern Norway near Kirkenes, the peninsula is the geographical lynchpin of Russia's Arctic strategy. Penetrating from the Barents Sea is Kola Bay and Murmansk, the largest city north of the Arctic Circle. Rail and road networks extend south from the port, which is ice-free year-round.[210] Modernization and infrastructure development have and likely will continue to be prioritized on the peninsula. For this reason, the mobility constraints of the Arctic exist beside those of an urban environment. The advanced technology seen across the northern reaches of the protective dome are found throughout Kola's military nodes, which

[209] The A2/AD bubble prevents attacks from its north, or the "top" of the globe. Joseph S. Bermudez Jr., Heather A. Conley, and Matthew Melino, "Ice Curtain: Hunting for Russia's Newest Military 'Treasures in the Far North'," (Center for Strategic & International Studies, Washington, DC, 27 March 2020).

[210] "Murmansk: The Largest City North of the Arctic Circle," Arctic Russia, 14 January 2020, https://arctic-russia.ru/en/article/murmansk-the-largest-city-north-of-the-arctic-circle/#:~:text=Murmansk%20is%20the%20world's%20largest,Bay%20of%20the%20Barents%20Sea.

include the Severomorsk-1 Airbase, Gadzhiyevo Submarine Base, and ICBM Cosmodromes. Severomorsk is the headquarters of the Northern Fleet, which as of 2014 serves as Russia's Arctic Strategic Command.[211]

As established in Chapter 2, Russia's Arctic ground forces are under the Northern Fleet, this is likely because of the weight on the maritime domain in the Arctic. Organized under the 14th Army Corps, the 80th and the 200th Motor Rifle Brigades serve as its primary Arctic maneuver formations. The 61st "Red Banner" Naval Infantry Brigade also supplements these brigades with Special Forces units.[212] The Northern Fleet also commands the 420th Naval Reconnaissance Spetsnaz Point, a Special Forces battalion with experience across the Greenland-Iceland-United Kingdom gap.[213] The main tasks of the Arctic Brigades are the protection of the Russia's Arctic coastline, facilities, and infrastructure.

The Northern Fleet will integrate these land forces with designated air force and air defense, long-range fires, and electromagnetic warfare capabilities available through the district headquarters. Reflective of the modernization before the Ukrainian war, the Arctic Brigades will be flush with the enabling battalion headquarters to provide the commanders with a greater range of options on the ground. This menu of options is

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[211] Joseph S. Bermudez Jr., Heather A. Conley, and Matthew Melino, "The Ice Curtain: Modernization on the Kola Peninsula," (Center for Strategic & International Studies, Washington, DC, 23 March 2020).

[212] Boulegue, "Russia's Military Posture in the Arctic," 16-17.

[213] Mark Galeotti, "Spetznaz: Operational Intelligence, Political Warfare, and Battlefield Role," George C. Marshall European Center for Security Studies, February 2020, https://www.marshallcenter.org/de/node/1380.

designed to converge effects, frustrate movements, and present multiple dilemmas to adversaries.

The 200th Brigade resides in the Sputnik base in Pechenga, less than 15 kilometers from the Norwegian Border. It operates as an all-purpose and highly mobile formation. Before its recent losses in Ukraine, its four maneuver battalions included three motorized rifle battalions and a tank battalion. Each of these battalions has three motorized rifle companies equipped with MT-LB armored personnel carriers, specially designed for Arctic conditions. The tank battalion sports the Arctic-hardened T-80BVM main battle tanks.[214] Supporting these elements are ADA, anti-tank, reconnaissance, engineer, signal, support, and multi-launch rocket system battalions. Additionally, unmanned aerial vehicles, sniper, electronic warfare, and chemical-biological-radiological-nuclear companies are organic to the 200th Brigade.[215]

Meanwhile, the 80th Brigade sits south of Murmansk, based nearly 60 kilometers from the Finnish border. Like the 200th, the 80th Brigade is designed to be a highly mobile Arctic force with a similar maneuver lineup. However, the 80th was the first Arctic unit to be given organic artillery and it boasts a much wider array of Arctic tailored equipment, including ADA systems such as the SA-15 Gauntlets, and SA-22

[214] Photo and videographic evidence suggest the T-80BVMs from the 200th Brigade were deployed to support the Russian war efforts in Ukraine in February 2022. Stijn Mitzer, "Attack on Europe: Documenting Equipment Losses during the 2022 Russian Invasion of Ukraine," *Oryx*, 4 February 2022, https://www.oryxspioenkop.com/2022/02/attack-on-europe-documenting-equipment.html.

[215] Lester W. Grau and Charles K. Bartles, "Getting to Know the Russian Battalion Tactical Group," accessed 13 August 2022, https://rusi.org/explore-our-research/publications/commentary/getting-know-russian-battalion-tactical-group.

Greyhound. The 80th also maintains its own air support through a small number of Mi-24s attack helicopters, which offer minimal lift capacity for dismounted troops, and Mi-8 rescue helicopters. Unique to its ground forces is the all-terrain Vityaz DT-30, an amphibious articulated track carrier designed for the harsh conditions of the Arctic.[216] For more local means of transportation, the 80th utilizes the TTM-1901 Berkut snowmobile along with dog and reindeer sleds.[217] While the 200th deployed elements in support of both the war in Donbass and in the wider 2022 Ukrainian War, the 80th maintains a more continuous presence near the Norwegian border.[218]

Russia also explored adding an organic airborne battalion to the 200th Brigade. While this never materialized, various airborne and air assault elements received Arctic training and participated in Arctic exercises.[219] Conceptually Russia's airborne assault troops now serve the Arctic brigades as the early response force to set the conditions for the brigades. In support of the concept, most air assault units in Russia must undergo Arctic training, and two divisions – the 76th Guards Air Assault Division and the 98th Guards Airborne Division have been assigned to the Kola Peninsula.[220] These signal

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[216] OE Data Integration Network, "Vityaz DT-30PM Russian All Terrain Carrier," Worldwide Equipment Guide, 2015, https://odin.tradoc.army.mil/WEG/Asset/Vityaz_DT-30PM_Russian_All_Terrain_Carrier.

[217] Boulègue, "Russia's Military Posture in the Arctic," 17.

[218] Thomas Nilsen, "Hundreds of Arctic Troops Killed, Says Ukrainian Advisor," *The Barents Observer,* 26 March 2022, https://thebarentsobserver.com/en/security/2022/03/several-hundred-arctic-troops-killed-says-ukrainian-adviser.

[219] Sutyagin, "The Russian Defence Posture in the Arctic."

[220] Boulègue, "Russia's Military Posture in the Arctic," 18.

Russia's intention to expand its strategic reach through the Arctic with highly deployable force packages.

Despite these developments, warming will strongly affect Russia. Its ability to mass troops with along interior lines of communication will diminish as road and rail-lines are threatened by the melting permafrost and precipitation. Still, Russia is a waning economic power and improving its power projection across its massive mainland requires extensive resources. Given the economic and diplomatic blowback from the most recent war in Ukraine, further development of its infrastructure will likely be constrained without outside support.[221]

Even before the war in Ukraine, modernization efforts have not materialized as planned. There have been varying levels of Arcticization across the 80th and 200th Brigades. To combat these issues, Russia at one point planned to combine the Arctic Brigades into a single division. Given the photos of destroyed Arcticized vehicles from the 200th in Ukraine, regeneration efforts will have to coincide with modernization.[222] Following the outcome of the war, regenerating the losses of men and equipment from the 200th will compete with those from across Russia's combined military force.

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[221] China has signaled an interest in expanding its belt and road initiative in the Arctic through cooperation with Russia. This cooperation involves financing infrastructure development across the Russia's Arctic territory. Matthiew Leiser, "Russia and China to Deepen Cooperation in the Arctic," *The Barents Observer*, 4 February 2022, https://thebarentsobserver.com/en/arctic/2022/02/russia-and-china-deepen-cooperation-arctic.

[222] Stijn Mitzer, "Attack on Europe: Documenting Equipment Losses during the 2022 Russian Invasion of Ukraine," *Oryx,* 4 February 2022, https://www.oryxspioenkop.com/2022/02/attack-on-europe-documenting-equipment.html. *Oryx* confirms destruction of Russian Arcticized vehicles. T-80BVM.

Russia’s strategic disposition creates numerous challenges to the US joint force in the Arctic. Some of these will be passed down in various forms to the tactical and operational level, manifesting in new challenges to mobility. For instance, the Russian A2/AD in the east and west includes extensive electronic warfare capabilities, air defense, and long-range fires. Ground mobility can be frustrated by these assets.

Russia’s network of airports provides ports of entry to build up combat power from the 14th Army Corps or other Russian formations. They also present potential airheads for US troops and building combat power in the Arctic. Just as the Canadians established in 1945 during *Eskimo*, these air bases are critical to sustaining a highly mobile Arctic force.

Even assuming the destruction or suppression of Russia’s strategic fires capabilities, Russia’s Arctic forces possess significant organic fires capabilities in their brigades. Self-propelled howitzers such as the 122mm 2S1 *Gvozdika* or multi-launch rocket systems such as the BM-21 *Grad*, can range between 10 and 20 kilometers if properly modernized and Arcticized.[223] In addition to fires tasks, Russia utilizes artillery as an arm of counter mobility in both the offense and defense. For instance, Russia’s latest remote mining system, the *Zemledeliye* utilizes an MLRS similar to those organic to 14th Army Corps to deliver POM-3 anti-personnel mines across a 5- to 15-kilometer zone.[224] Their organic engineer, reconnaissance, and maneuver troops possess resident

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[223] OE Data Integration Network, “BM-21 Grad, 2S1 Gvozdika,” Worldwide Equipment Guide, accessed 10 June 2022, https://odin.tradoc.army.mil/WEG/Asset/BM-21_ > "Grad"_Russian_122mm_Multiple_Rocket_Launcher_(MRL).

[224] These figures are according to Russian claims. The system was utilized in Ukraine in March. Military Leak Admin, “Russian ISDM Zemledeliye Mine-Laying

knowledge of the Arctic terrain, therefore these elements often work in tandem at counter mobility tasks. Their own history reinforces the weight of such tasks.

Summary

The primary mobility challenges the Arctic environment presented the Finns, Soviets, Germans and Canadians arise from the extreme conditions, vastness, and sparseness. These challenges manifested in the factors of morale, training, command and control, time and space, infrastructure and dismounted and mounted operations. Across these factors were solutions to mobility at the tactical and operational level. Some solutions will be applicable to conditions in the new Arctic OE.

The warming temperatures and their effects on the permafrost, precipitation, infrastructure, and vegetation present an Arctic environment that differs from the environment of the early practitioners of Arctic warfare. Dismounted formations without operational and strategic lift capabilities will struggle against the tyranny of distance. While snow cover will diminish, it will remain a factor, and so will the requirement for over-snow options. Mounted formations will continue to struggle with the scant infrastructure, which will continue to degrade from the effects of melting permafrost. Russia will aim to further limit mobility options both strategically and operationally through its A2/AD capabilities. Tactically, the environmental conditions will always be a challenge. Those who understand the effects of these conditions and adapt will retain the ability to move across the Arctic space.

System Makes Combat Debut in Ukraine," *Military Leak*, 31 March 2022, https://militaryleak.com/2022/03/31/russian-isdm-zemledeliye-mine-laying-system-makes-combat-debut-in-ukraine/.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Many of the Arctic's mobility challenges from the past will persist into the future. The extreme cold and isolation that bogged down the Soviets in Finland, pressed the Germans and challenged the Canadians in the far north will hamper Arctic soldiers on the future battlefield. However, applying their lessons requires a keen perspective of the continuing change in the Arctic environment. The warming will not cast out the "Arctic Goblin" from soldiers not acclimated to the conditions. For this reason, specialized training will be required to temper the fears and misconceptions of the far north. The Arctic's unique geospatial qualities will continue to hamper navigation, and the landscape-altering effects of permafrost, increased rainfall, and shifts in vegetation will continuously require fresh approaches to move effectively. The dynamic environment will test the full spectrum of the command and control system – humans, processes, networks and command posts. The time and space relationships will be critical as the seasonal dynamics change across the diverse landscape. Both dismounted and mounted forces will have to confront these challenges in the face of the Russian posturing. With these realities converging, doctrine and training must keep pace.

Doctrine sets out the fundamental principles used for the conduct of operations and is a guide for the actions of operating forces. One source of doctrine is the experiences of those who have passed before. In the case of the short history of the Arctic, much can be gained from the Finnish, Germans, Russians, and Canadians. While the Finnish models from 1939 may be hard to incorporate given their fundamentally different force structure, their approach to tactical movements are still applicable. Their small-unit swarm tactics in the Arctic boreal forests during the winter months are transferable across every Arctic nation. Despite the change in vegetation, the deep forests will be a distinct feature in the future Arctic environment. While snow may not be a persistent variable, as the annual snow cover duration diminishes across Arctic regions, it will inevitably play an important role at the tactical level. The infrastructure that runs through Finland's backwater Arctic will likely continue to degrade. Future forces may find themselves in a similar position as the Soviets during Petsamo-Kirkenes, where roads planned for ingress, egress and supply routes are untenable through an operation. These tactical mobility problems facing US formations will not be wholly new. Many are addressed in various publications available through the Army Publishing Directorate.

After Bulldog Three and the Canadian exercises closed, the Canadians too found their tactical doctrine accounted for much of the variety experienced throughout the Arctic. They concluded that "no radical changes from accepted combat principles or tactical doctrine are imposed by condition of snow and extreme cold."[225] From their cross-seasonal exercises they maintained that "in the barren lands, desert tactical principles apply virtually without change, while the Yukon and Alaska, jungle and mountain warfare tactics applied."[226] Although the word "Arctic," is presented in ATP 3-21.50, and *Infantry Small-Unit Mountain and Cold Weather Operations*, a mere four times, tactical mobility is thoroughly addressed for Arctic winter operations. Accounting for the drastically warmer temperatures and their effects does not require a new

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[225] DND DHH, "A Guide to the Planning and Execution of Operations in the North," 190.

[226] Lackenbauer and Kikkert, "Introduction," xx.

publication for battalions and below. It does require the end users to review the latest doctrinal manuals, with their mass of experience beyond the short history of Arctic warfare, for guidance.

While much of the tactical mobility challenges have solutions in existing doctrinal sources, the Arctic environment will present operational challenges that demand consideration from doctrine writers. The degradation of existing infrastructure, its development around concentrated resource centers and Russia's extensive A2/AD across the littoral environment present significant challenges to operational mobility. These challenges will weigh heavily on brigade and division staffs. Moving large formations to, from and through this operational environment requires systems for staffs to plan across time and space. The Arctic's vastness and extreme dynamic conditions are unique enough to require doctrinal references to guide Arctic command and staffs. The current FM 3-0 and former *Operations* manuals merely addressed Arctic Operations as a subset of winter operations, ignoring the fact that the Arctic is more dynamic than a cold weather environment.[227] Indeed, it is not always cold, and within a given operation, conditions can change. Formations must deploy, move, maintain, and sustain their subordinate echelons across environments that vary so drastically within limited time and space, an Arctic Operations publication is needed to assist commanders and staffs.

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[227] Gebhardt lamented this in his introduction to his Leavenworth paper. Eyre too highlighted similar misconceptions after WWII in *Custos Borealis*. While the next FM 3-0 is expected to be published soon, the historical tendency has been to leave Arctic Warfare under winter operations. Gebhardt, *The Petsamo-Kirkenes Operation,* xiv; Eyre, *Custos Borealis,* 131.

Doctrine is built on enduring principles. One such enduring principle that must serve as foundational to Arctic Operational Doctrine is the framework of Assured Mobility, which describes the ability of a force to deploy, move and maneuver when and where desired to achieve the commander's intent.[228] Its fundamentals of prediction, detection, prevention, avoidance, neutralization, and protection were evident through the operational successes and failures of the Soviets during the Petsamo-Kirkenes operation. For instance, they predicted the constraints presented by limited infrastructure and employed far more engineers than at Suomussalmi. Their specially trained reconnaissance detachments and dismounted infantry detected forward obstacles and neutralized forward threats. Despite this, the mounted rear artillery and armor support were unable to avoid the natural obstacles, nor were they able to fully protect these formations from the elements. Ultimately, they were unable to prevent desynchronization of the operation as the environment immobilized their rear echelons. Applying the dynamics of the Arctic environment to this framework serves as a checklist for staffs to be captured in Arctic operational doctrine.

Another source of doctrine, in addition to experience and foundational frameworks, is concepts. Concepts are based on proposed new approaches to the conduct of operations or technology. As mentioned, Army Futures Command is developing a concept for a wholly new formation of an Arctic Brigade. Derived from strategic documents and Arctic exercises mentioned in the literature, the concept will be extremely important to establishing the operational standards of the formation. However, doctrine

[228] HQDA, ADP 3-90, 3-11.

writers can draw on another concept to address operational mobility. This is the Marine Corp's concept of Expeditionary Advanced Base Operations (EABO). While fundamentally suited for the littoral environment, EABO offers broader application in the new Arctic operational environment. It focuses on directly confronting the mobility challenges of an integrated A2/AD by utilizing low signature forces to strike adversary naval and air platforms.[229] The Marine concept could be tuned to confront these targets in the Arctic littoral environment, but also confront targets that exist as islands in the isolated Arctic landscape. Applying a naval concept to Arctic operations is not unprecedented. Sweetbriar lessons concluded, "Primarily, operations will be from an established airbase to secure a new forward base for operations. In this effect, these operations would be similar to the island-hopping tactics of World War II."[230] To project forces across the Arctic, the Canadians developed airborne mobile strike force packages. If the US develops airborne or air-mobile Arctic Brigades, then utilizing EABO offers a ready-made joint operational concept to adapt to operational-level Arctic doctrine.

Doctrine and training have a symbiotic relationship. As such, addressing Arctic doctrine requires addressing Arctic training to place doctrine into practice. While the Army doctrine provides solutions to Arctic mobility, there are many more to be gathered from training. For Arctic tactical formations to be fully capable in the future Arctic operational environment, ground-level tactics, techniques, and procedures (TTPs) must

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229 Headquarters, United States Marine Corps (HQMC), *Tentative Manual for Expeditionary Advanced Base Operations* (Washington, DC: Department of the Navy, Headquarters, United States Marine Corps, February 2021), 1-3 – 1-7.

230 DND DHH, "Lessons Learned Winter Exercises, 1945-1954: Exercise 'Sweetbriar'," 58.

be developed. This was well understood through Canada's post-war exercises. Careful reading of the exercise lessons or their offspring in "A Guide to the Planning and Execution of Operations in the North," highlights how Canadian Arctic forces developed TTPs through deliberate training with clearly defined, deliverable training outcomes. They also highlight the wealth of knowledge an Arctic nation can acquire over a decade. Arctic forces in Finland continue to develop their doctrine and refine their TTPs for the new Arctic environment, as do the Norwegian Defense Forces, Danish Joint Arctic Command, Swedish Defense Forces, and British Royal Marines. Partnered training with well-established Arctic forces opens decades of mobility experience to exploitation.

In March 2022, 30,000 troops from 27 countries arrived in Norway for Exercise Cold Response.[231] Massive events like this one offer opportunities to transfer operational solutions to the developing mobility issues of the future. They also offer new environments across seasons to expand the depth of Arctic proficiency. Training across time and space will prove key to preparing for the dynamic environment the Arctic will present. While these events offer cross-pollination of TTPs, they may not always satisfy the Army's requirements to certify a brigade before a deployment. For this reason, a permanent Joint Multinational Readiness Center (JMRC) should be established in the Alaskan Arctic. This would prepare Arctic brigades for mobilization from home station to theaters, certifying the breadth of the formation for the realities of the Arctic. This concept was tested in March 2022 when the Army conducted the first-ever home station

[231] "Exercise Cold Response 2022 – NATO and Partner Forces Face the Freeze in Norway," North Atlantic Treaty Organization, 25 March 2022, https://www.nato.int/cps/en/natohq/news_192351.htm.

combat training center rotation.[232] This event, which was supported by the Joint Multinational Pacific Readiness Center, can serve to prototype such a development.[233] Resourcing another readiness center would be difficult, particularly with manning. To alleviate the burden, other Arctic nations should be leveraged to provide observer controllers (OC) and planners. Permanently assigned OCs, with their keen perspective on the fluctuating Arctic environment can continuously provide important feedback across echelons. With well-informed and conditioned OCs facilitating their training, brigades can avoid the mobility pitfalls of the Soviet staffs during the Finnish campaigns.

Arctic training will remain dangerous and press the limits of the human spirit. The demands of the environment will continue to exact a heavy toll on those unprepared. Preparation requires an understanding of the nuances of Arctic mobility at every level. Resident knowledge from partner training and Arctic JMRC rotations would offer solutions to many of the historical and emerging challenges the Arctic presents. However, to truly facilitate mobility at the operational and tactical level every Arctic soldier must have a base of knowledge. They must be indoctrinated to the environment. Informed by years of deliberate measured training, the Canadians proposed a minimum of three weeks. Three weeks would allow the Arctic soldier to confront the fears and misconceptions that immobilize them psychologically and physically. Confidence arises

[232] Davis Winkie, "CTC on Ice: Army Holds First Arctic Brigade-level Training Rotation," *Army Times,* 9 March 2022, https://www.armytimes.com/news/your-army/2022/03/09/ctc-on-ice-army-holds-first-arctic-brigade-level-training-rotation/.

[233] Jim Verchio, "March Brings Joint Pacific Multi-National Readiness Center Exercises to Fort Greely DTA," US Army, 17 February 2022, https://www.army.mil/article/254080/march_brings_joint_pacific_multi_national_readiness_center_exercise_to_fort_greely_dta.

from developing the skills to prepare, move, navigate, and sustain across the Arctic landscape. Under the current model, all soldiers assigned to USARAK are required to complete Cold Weather Indoctrination Course (CWIC). This training is conducted at the tactical unit level, and when appropriately managed and resourced, largely prepares soldiers for the harshest Arctic conditions.

CWIC is conducted by leaders trained through the Cold Weather Leaders Course (CWLC), while the Cold Weather Orientation Course (CWOC) provides an example of "what right looks like" for CWIC.[234] However, CWOC still focuses instruction on the cold, leaving out staff training of the Arctic's other two unique challenges - isolation and the vast distances involved. To appropriately prepare commanders and staffs for the operational constraints these challenges place on mobility, requires institutional-level training. An "Arctic operational planning course" would seed in Arctic brigades the planning considerations necessary to remain mobile in the Arctic. This course, as well as CWLC, should provide soldiers an additional skill identifier to allow the US Army to appropriately man the breadth of its Arctic forces.

Preparing Arctic formations for the hazards of the far north will remain a continuous evolutionary process. In this environment, the Napoleonic axiom that one 'jumps into the fray, then figures out what to do next,' is folly. Mobility considerations at the tactical and operational levels shift daily, seasonally, and annually. Training must keep pace, and operational doctrine should provide structure and frameworks. Headline-driving anomalies, such as Siberia's Arctic reaching temperatures above one hundred

[234] United States Army Alaska, "Basic Military Mountaineering Course Student Handout," (Northern Warfare Training Center, Black Rapids, AK, 2014), 41.

degrees Fahrenheit in 2021, may tease thoughts of a less hazardous Arctic. However, Finland's December 2021 temperatures mirrored those of the bitterly cold Winter War.[235] These anomalies represent the Arctic's primary challenge to mobility – the wide variation of conditions across a sparse but increasingly important space.

Recommendations for Further Research

After extensive research on Arctic mobility, several topics arose for further research. The first is determining the ideal composition of a combined arms force in the Arctic. Given the warming Arctic and its limited infrastructure, power projection in the Arctic will be difficult. What force packages should be available to Arctic Brigades and Divisions if they should be expected to deploy in the far north? Primarily, does this include armor if the infrastructure in the region will require extensive engineer and sustainment to support? With the future Arctic division and brigades being airborne, the Canadian Mobile Strike Force's performance during the post-war exercises can provide insights into their application to Arctic warfare. Additionally, as infrastructure erodes and populations in the Arctic converge around resource and transportation nodes, they may be isolated both physically and psychologically. Hence, the application of information warfare in the Arctic should be explored in greater depth.

This paper provided several doctrinal recommendations. One was utilizing EABO, which offers joint forces a solution to penetrating Russia's A2/AD in the Arctic. The application of this concept in a joint Arctic force merits further research. Can

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[235] MK, "The First Week of December 2021 the Coldest in Helsinki Since 1937!" MKWeather, December 2021, https://mkweather.com/the-first-week-of-december-2021-the-coldest-in-helsinki-since-1937/.

concept be further refined to specifically guide joint Arctic operations? Another recommendation was the publishing of an Arctic operations manual. Current doctrine seems to conflate Arctic operations with cold weather and mountain operations. However, as the case studies highlighted well before the acceleration of global warming, the Arctic is not always cold and mountains are not its defining geological feature. Why does US doctrine continue reduce the complexity of the Arctic to these two features?

APPENDIX A

CANADIAN NORTHERN EXERCISES, 1945-1955

YEAR	NAME	DATES	LOCATION
1945	Eskimo	16 Jan - 25 Feb 1945	Prince Albert and Lac la Ronge area, Saskatchewan
1945	Polar Bear	Feb - April 1945	Caribou and Coastal Range British Columbia
1945	Lemming	Mar - Apr 1945	Churchill, Manitoba to Padlei, NWT
1946	Musk Ox	Feb - May 1946	Churchill, Manitoba to Edmonton, Alberta via Cambridge Bay, Kugluktuk (Copppermine) and Tulita (Fort Norman)
1946	North	26 Aug - 8 Sep 1946	Alaska Highway
1947-1948	Moccasin	Dec 1947 - Nov 1948	Churchill, Manitoba
1948-1949	Sigloo	Winter 1948 -1949	Churchill, Manitoba
1950	Sweetbriar	13 Feb - 23 Feb 1950	Northwest highway system between Whitehorse, Yukon and Northway, Alaska
1950	Sun Dog I	16 Feb - 15 Mar 1950	Churchill, Manitoba
1950	Cross Country	12 Jul - 24 Aug 1950	Fort Churchill to Cape Chuchill, Manitoba
1950	Shoo Fly I	20 Jul - 2 Aug 1950	Cape Churchill, Manitoba to Duck Lake, Saskatchewan
1951	Sun Dog II	14 Feb - 23 Feb 1951	Fort Churchill and Nunnalla area
1951	Shoo Fly II	15 Aug - 1 Sep 1951	Chuchill, Manitoba
1951-1952	Polestar	Winter 1951 - 1952	Churchill, Manitoba
1952	Sun Dog III	4 Feb - 14 Feb 1952	Kuujjuaq (Fort Chimo)
1952	Deer Fly I	1 Jun - 29 Jun 1952	Fort Churchill and Christmas Lake, Manitoba
1952	Bull Pup	1 Jun - 14 Jun 1952	Calgary to Wainwright Area
1952	Deer Fly II	6 Jul - 3 Aug 1952	Fort Churchill and Christmas Lake, Manitoba
1952	Deer Fly III	10 Aug - 7 Sep 1952	
1952-1953	Eager Beaver	Jan 1952 - Jul 1952	Kluane Lake, Yukon
1952	Prairie Tundra I	12 Nov - 12 Dec 1952	Area north of Fort Churchill, Manitoba
1953	Prairie Tundra II	14 Jan - 15 Feb 1953	Area north of Fort Churchill, Manitoba
1953	Bull Dog I	18 Feb - 1 Nov 1953	Area around Tulita (Fort Norman) and Norman Wells, Northwest Territories
1954	Bull Dog II	1 - 14 Dec 1954	Area around Fort Churchill and Baker Lake
1954	Loup Garou	18 Feb - 1 Mar 1954	Area around Sept Iles, Quebec
1955	Bulldog III	23 Feb - 8 Mar 1955	Yellowknife, Northwest Territories

Source: Lackenbauer, P. Whitney, and Peter Kikkert, eds., *Lessons in Northern Operations: Canadian Army Documents, 1956-56,* vol. 7, *Lessons in Arctic Operations: The Canadian Army Experience, 1945–1956,* Documents on Canadian Arctic Sovereignty and Security (Calgary, AB and Waterloo, ON: University of Calgary and St. Jerome's University, 2016), xxvi-xxvii.

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