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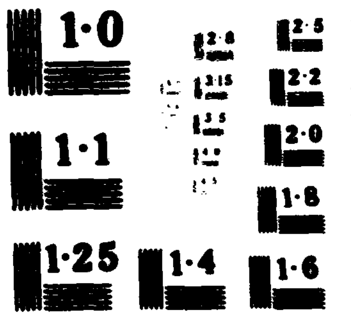
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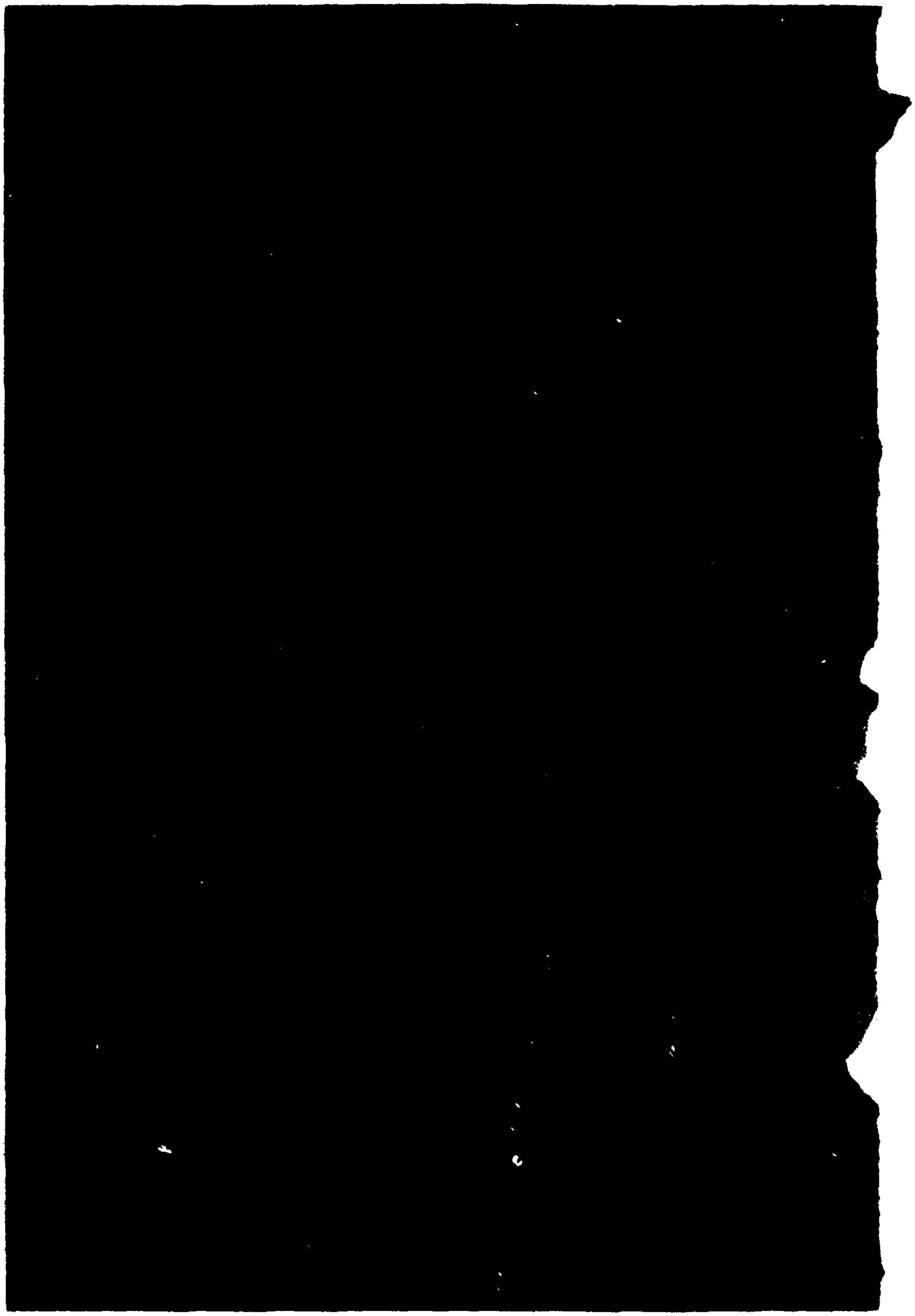

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This report is based on testimony given by Michael Rich to the House Armed Services Committee's Subcommittee on Readiness in February 1986. It traces the evolution of RAND research on an important defense management problem: How to increase the capability of combat forces by improving the ability of combat commanders, resource managers, and planners to assess readiness and sustainability and to take appropriate action to strengthen both. It describes the general challenge of assessing readiness and sustainability, discusses the present state of the art and its evolution, and finally, considers what the future holds. It reflects a view that readiness and sustainability assessment represents more than a means of looking at past decisions; it is now a required and increasingly important element of day-to-day combat force operations, support system management, and planning for future forces and operations.

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Recent Progress in Assessing the Readiness and Sustainability of Combat Forces

Michael Rich, I. K. Cohen, R. A. Pyles

October 1987

A Project AIR FORCE report
Prepared for the
United States Air Force

RAND

PREFACE

An increasing amount of attention is being directed in the defense community to the problem of assessing the readiness and sustainability of U.S. combat forces. It has been the subject of a recent General Accounting Office study[1] as well as a set of hearings held by the House Armed Services Committee's Subcommittee on Readiness. The problem has also been at the center of much of RAND's recent defense resource management research. Based on testimony given by Michael Rich to the House Armed Services Committee's Subcommittee on Readiness in February 1986, this report traces the evolution of that research and some of the U.S. Air Force actions to implement its products.

In contrast to the testimony, this somewhat more detailed report is addressed to logistics policymakers and senior technical experts. The intent is to describe a comprehensive framework that they could use in conceiving and directing their own organizations' efforts to capitalize on existing capability assessment methods or to extend or improve those methods.

This report was prepared as part of the Project AIR FORCE Resource Management Program study, "Enhancing the Integration and Responsiveness of the Logistics Support System to Meet Wartime and Peacetime Uncertainties." That study is commonly known as the "Uncertainty Project."

[1] U.S. General Accounting Office, *Measures of Military Capabilities: A Discussion of Their Merits, Limitations, and Interrelationships*, NSIAD-85-75, June 13, 1985.

ACKNOWLEDGMENTS

Many individuals and organizations within the Air Force and RAND have made this report possible. Some of them who have written RAND publications are indicated in the references that occur throughout the report. Many versions of Dyna-METRIC were designed, developed, and implemented by Karen Isaacson of RAND—an extraordinary feat. Major John Schade, USAF, while serving on the Air Staff (AF/LEYS), first recognized the potential applicability of Dyna-METRIC to USAF management concerns at a time when the model had been used only to support researchers at RAND.

CONTENTS

I. INTRODUCTION

This report briefly traces the evolution of RAND's research on an important defense resource management problem: How to increase the capability of combat forces by improving the ability of combat commanders, resource managers, and planners to assess readiness and sustainability and to take appropriate action to strengthen both.

By focusing on combat capability, RAND has begun to understand the implications of future enemy threats and wartime operating environments and to adopt a systemwide, or integrated, view to account for the complex interrelationships among the many diverse elements of the logistics system. As shown in Fig. 1, the combat support system provides essential materials (including fuel, munitions, spare parts, test equipment, food, and skilled personnel, among others) and services (principally procurement, inspection, repair, storage, shelter, transportation, and disposal) that maintain the operational forces' peacetime readiness for war and provide a foundation for sustaining their wartime operations. RAND's exploration of improving assessments of this complicated system has concentrated on those portions

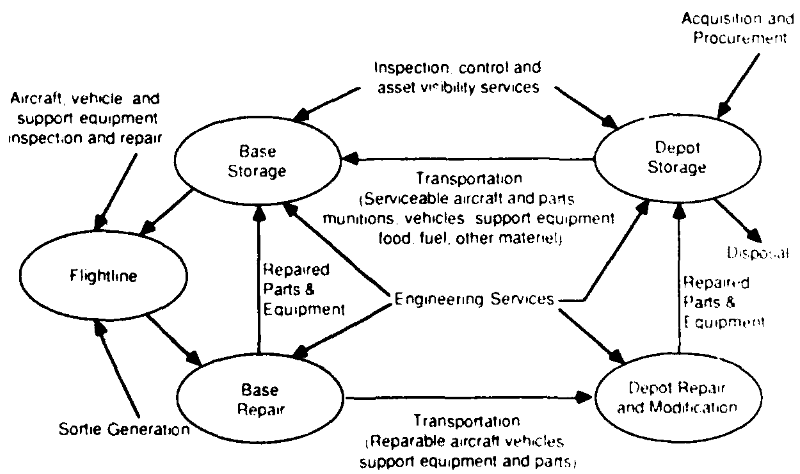

Fig. 1—Simplified combat support system scope and interaction

that provide spare parts for tactical combat aircraft. By keeping the initial scope thus confined, RAND has been able to explore methods to assess and improve combat capability in sufficient depth to assure the method's effectiveness. This report summarizes RAND's research experience, perspectives, and plans, so others can join in exploiting, improving, and extending the military services' abilities to assess their combat readiness and sustainability.

To assess and improve capability RAND has had to conceive and develop *management systems* that embody these interests, that can become part of standard, day-to-day operating practices—first in peacetime, but ultimately in wartime too. The project has been sensitive to distinguishing the different needs of planners, combat units, and support system managers. This research has thus been extended to threat assessment, combat support policy analysis, management system design, and basic model development. Most of the research has been sponsored by the U.S. Air Force,[1] which has consistently reinforced RAND's choice of emphasis and has made good use of its ideas and products.

The following sections describe the general challenge of assessing readiness and sustainability, the present state of the art and its evolution, and finally what the future holds. This brief account will explain why readiness assessment is so important and therefore why many current efforts to improve that capability deserve strong encouragement and support. The reason goes beyond the traditional notions about the purposes and value of such assessment; it reflects a view that *readiness and sustainability assessment represents more than a means of looking at past decisions, it is now a required and increasingly important element of day-to-day combat force operations, support system management, and planning for future forces and operations.*

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[1]Readiness and sustainability complement the other two components of combat capability: force structure and force modernization. Readiness is conceived of as the force's ability to execute its combat mission effectively with little notice; sustainability is the force's ability to pursue that mission for a long period of time.

II. THE GENERAL CHALLENGE

At the heart of the problem is the question, "What must be known?" The answer is that one must know how well the combat support system can meet the operational goals of important warplans. Those plans contain many such goals, of course. In the case of aircraft, RAND has concentrated on sortie generation and aircraft availability, with the number of mission-capable aircraft and combat sorties attainable on each day of specific, rapidly changing war scenarios. These are not the ultimate operational goals that one might prefer, but they are combat-oriented and dynamic, and they underlie those ultimate goals.

The system that enables an aircraft to be ready to fly a combat sortie is large and complex. Each function at each echelon—flight line, base repair and supply, theater repair and supply, and CONUS repair and supply—contributes to weapon system availability and productivity. At RAND we have first emphasized combat-critical recoverable spare parts—or "exchangeables" as they are known—and engines. That encompasses such logistics functions as supply, repair, distribution, transportation, and procurement. Although it is by no means exhaustive, by including all the functions associated with assuring that a serviceable spare part is where it is needed in wartime, this coverage is clearly on the right road.

Logistics managers and planners need to know how many assets that system has, such as spare parts, support equipment (including its condition), maintenance, and manpower. Further, they must know how fast critical steps in each important function (such as repair and transportation actions) are likely to be made. These details are not very meaningful by themselves, however; neither, in the end, are trends in them over time, comparisons across different locations, and so on. What they most need to know is how well the *total system* can meet the operational force's needs. Therefore, they must also understand the relationships among the various resources, functions, and echelons and, most important, how shortages and performance shortfalls in each affect the ability of all the functions and echelons together to "produce" mission capable aircraft and sorties.

The challenge has yet another dimension: This system performance—described in the combat-related terms referred to earlier—must be known routinely and systemwide in peacetime and wartime. The joint activities of thousands of support managers, personnel, and other resources must be coordinated if readiness and sustainability are to be at their maximum level. Those decisionmakers and actors range from the support planner with lots of lead time, to others with perhaps abundant computational resources, to still others with very little of either. Each must be able to obtain such information in a form and at a frequency that can help identify the need for corrective action, select the appropriate type of action, and ascertain whether it is effective when accomplished.

III. WHERE WE'VE BEEN AND WHERE WE ARE

Assessing readiness and sustainability in this manner is not an easy task. The support system's size, breadth, and diversity mean the Services must use computer models to translate voluminous but relevant system data into meaningful decisionmaking information. Models are necessary for another reason, too: The Services are not especially interested in describing the past and present; they are mainly interested in projecting force capability in the stressful settings defined by their warplans. Moreover, this assessment process must be designed and tailored in ways that make it a central part of the day-to-day activities of those who are responsible for operating U.S. forces, managing the support system elements, and planning for the longer term.

To address these needs, RAND has developed more comprehensive models of the support system, its resources, and its internal processes. These include both event simulation models, prized for representing complex system interactions in fine detail,[1] and analytic (mathematical) models, valued for assessments of large-scale systems and for facilitating searches for cost-effective resource mixes.[2]

Advances in analytic modeling during the last decade have made it possible for current models to reflect the dynamics of combat operations: the changing of force operations and support activities over short periods of time.[3] With those advances, the Logistics community acquired the ability to evaluate large changes in operational force deployment and activity levels, especially in the presence of traumatic support system changes that may make many resources unavailable

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[1]See D. E. Emerson, *An Introduction to the TSAR Simulation Program: Model Features and Logic*, The RAND Corporation, R-2584-AF, February 1982, for a description of a Theater Simulation of Airbase Resources (TSAR). A simulation of airbase attack effects is described in D. E. Emerson, *TSARINA: User's Guide to a Computer Model for Damage Assessment of Complex Airbase Attacks*, The RAND Corporation, N-1460-AF, July 1980.

[2]See R. J. Hillestad, *Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control*, The RAND Corporation, R-2785-AF, July 1982, and R. A. Pyles, *The Dyna-METRIC Readiness Assessment Model: Motivation, Capabilities, and Use*, The RAND Corporation, R-2886-AF, July 1984.

[3]For an excellent discussion of this subject, see S. M. Drezner and R. J. Hillestad, "Logistics Models: Evolution and Future Trends," The RAND Corporation, P-6748, March 1982. The mathematical foundation for that advance is described in R. J. Hillestad and M. J. Carrillo, *Models and Techniques for Recoverable Item Stockage When Demand and the Repair Process are Non-Stationary—Part I: Performance Measurement*, The RAND Corporation, N-1482-AF, May 1980.

during critical force deployment periods (*e.g.*, as critical but bulky and heavy repair equipment is left at peacetime CONUS bases by deploying tactical fighters).

RAND also made great strides using both kinds of models toward achieving a necessary systemwide view. For many years, the combat support community's best and most widely used models fell far short of representing such a view. Although often technically elegant, detailed, and sophisticated, the models were quite narrow in the scope of resources and functions covered and in their outputs, seldom relating the operation of one function to another, and even less often relating those functions to the product of the support system. This situation made comprehensive evaluations of the adequacy of that system and explorations of innovative tradeoffs impossible. Recent modeling efforts have expanded the scope of both simulation and analytic models, thereby enabling us to better relate the support system's various elements to each other and to aircraft availability and sortie generation capability. Thus, recent models have facilitated an "integrated view," which would relate most of the important support functions and echelons to operational force aircraft availability or sorties.[4]

To appreciate the complexity of that "view" and the breadth of the system it covers, consider the component support system encompassed in RAND research on aircraft readiness and sustainability. That system includes several critical logistics functions: supply, repair, distribution, transportation, and procurement. These several functions and activities take place at several levels (or "echelons") and the systemwide view requires joint consideration of each. Thus the most valued models include flightline activities, base component repair and supply, and depot repair, supply, procurement, and disposal activities located mainly in the continental United States.[5] The models that are used to represent this system must therefore reflect asset quantities and performance levels for each of these activities at each of these locations, as well as the functional interconnections among them all. Moreover, they must reflect the rich, complex physical characteristics of the actual equipment involved (such as the fact that different aircraft designs consist partly of unique components that consist of different subcomponents that consist of "bits and pieces") and some important

[4] See Lt. Col. Robert Tripp, USAF, and R. A. Pyles, "Measuring and Managing Readiness: An Old Problem, A New Approach," *Air Force Journal of Logistics*, Spring 1983, for one example of using these models in a systemwide analysis of depot effects on base-level support to operations.

[5] In the Pacific theater, of course, there is yet another level of activity, that of the Pacific Logistics Support Center, which repairs and redistributes a wide range of aircraft components and engines to all the U.S. Air Force forward operating locations from Kadena AB, Okinawa, Japan.

practical details of the actual processes involved (such as the sequence of events in various test and repair operations).

The current generation of readiness assessment models has advanced our ability to understand more about that complex system. As a result, the Logistics analytic community can analyze a wider range of support policies than it could without such models. For example, at RAND we have evaluated the payoffs of different intratheater logistics transportation systems, avionics test and repair strategies, and ways of supporting carrier-based fighter operations.[6] By integrating the effects of the many disparate parts of the overall logistics system, these models have enabled us to measure the payoffs of alternative policies and procedures in terms of the overall system output—numbers of aircraft available for combat and number of possible sorties—given a fairly realistic set of "operating assumptions" (changing flying patterns, phased deployments, etc.). Thus, these new methods greatly strengthened the standard policy analysis approach of assessing current capabilities and comparing those with estimates of the capabilities afforded by alternative policies.

The next step was to exploit these methodological advances in ways that served the main purpose of directly assisting the actual day-to-day system operations. The simple notion that RAND built on was that management should use the same types of assessments that so improved the analysis of proposed policy changes. Management within the services' logistics functions actions ought to be based (to the extent possible) on good estimates of their effects on overall system outputs—available aircraft and sortie generation capability in wartime.

A major development in the early evolution of this notion was the Combat Support Capability Management System (CSCMS), a joint prototype development in the early 1980s involving RAND, the Air Force Logistics Command, and the Pacific Air Forces.[7] This management system used the Dyna-METRIC readiness assessment model in a novel way. It enabled planners responsible for establishing asset requirements (for spare parts and test equipment) and logistics performance standards (such as repair cycle times) to see how their decisions would affect aircraft availability in specific warplans. As important, it improved the ability of combat commanders and support managers to sense and correct conditions that imperil their unit's ability to meet

[6]See Thomas Lippiatt, Richard Hillestad, Lloyd Embry, and John Schank, *Carrier Based Air Logistics Study: Integrated Summary*, The RAND Corporation, R-2853-NAVY, January 1982.

[7]See R. A. Pyles and Lt. Col. Robert Tripp (USAF), *Measuring and Managing Readiness: The Concept and Design of the Combat Support Capability Management System*, The RAND Corporation, N-1840-AF, April 1982.

specific warplan goals. With other systems, commanders were forced to interpret what could be voluminous information about part shortages, repair time trends, and so on, without any decision aids. The CSCMS prototype was designed to integrate that information and "sound alarms" when the combination of all the indicators suggested a system capability falling below that required for a specific operational scenario. Thus, unlike most other extant logistics management systems, it was intended to help managers and commanders detect wartime support problems lurking below the surface in peacetime—problems that appeared only when the changed environment of wartime (stepped-up activity levels etc.) was systematically considered. Moreover, CSCMS contained diagnostic features that pinpointed the particular problem area (the removal rate or "order-and-ship" time for a specific part, for instance) so that appropriate corrective action could be taken quickly.

The conceptual design and rudimentary operating features that were validated in the CSCMS experiment are now being embedded in the U.S. Air Force's Weapon System Management Information System (WSMIS),[8] a major Air Force Logistics Command program that will considerably strengthen the fielded combat forces by improving the quality of information available on a routine basis to those responsible for managing the infrastructure that supports them. As intended, the concept has also been used to improve the information available to those who command the combat forces. One example is TAC PACERS, a Tactical Air Command system that enables Wing Commanders to ascertain quickly whether their on-hand war reserve stocks are adequate to meet particular wartime flying goals.[9]

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[8]See *Weapon System Management Information System (WSMIS)—Status-by-Base, Request for Proposal*, Air Force Logistics Command, F3370-83-R-0076, and *Combat Analysis Capability (CAC) Functional Description*, Dynamics Research Corporation, E-8726-U, November 1983, for descriptions of the WSMIS system and its functional capabilities.

[9]For a description of TAC PACERS, see Lt. Col. Ronald Clarke, "Real-Time Unit Level WRSK Capability Assessment System," and Manual Carrillo, "Design and Capabilities of Dyna-TAB," both in *Proceedings, United States Air Force Capability Assessment Symposium* (LOGCAS 82), March 1982.

IV. WHERE WE ARE HEADED

As far and fast as we have come in this important area, there is still a very long way to go. One area for improvement involves the models' ability to represent some aspects of the real world, which affects not only the accuracy of readiness and sustainability assessments, but may affect the nature and effectiveness of managers' and planners' actions in response to those models' assessments. These models now have two important shortcomings: a naive, overoptimistic treatment of inevitable uncertainties of demands for support, and a simple, mechanistic treatment of repair and distribution. Specifically, current analytic techniques do not adequately reflect the likelihood that actual flying patterns may differ sharply from the assumptions in our planning scenarios, that future component removal rates (the frequency at which parts need maintenance attention, often relative to flying hours or sorties) will probably vary (especially during wartime) over time and situation,[1] and that airbase damage and disruption will probably shatter our assumptions about repair and stock resource availabilities.[2]

The current techniques do not adequately capture the complexities of those logistics functions that hold the most promise for being able to cope with those uncertainties, specifically repair and distribution. Said another way, current models are not rich enough in their representation of demand uncertainties (inability to predict removals) and repair bottlenecks on the one hand, and the potential for adaptive management action on the other.

Current work at RAND is tackling these problems with simulation modeling. We have already developed prototype extensions to Dyna-METRIC—our principal readiness assessment model—that will help us better understand the interactions between demand uncertainty and repair bottlenecks management adaptations, and aircraft readiness and sustainment for some class of repair shops. We are trying to markedly improve the degree to which we can assess how flexible and robust our support system is when it is called upon to respond to unplanned demands for support. That capability will be complemented by recent

[1]See Gordon B. Crawford, *Variability in the Demands for Aircraft Spare Parts: Its Magnitude and Implications*, The RAND Corporation, R-3318-AF, 1987.

[2]For a description of how changes in the threat have transformed the combat environments facing our forces in the future and a discussion of the implications for defense resource management policies, see Michael Rich, William Stanley, and Susan Anderson, *Improving U.S. Air Force Readiness and Sustainability*, The RAND Corporation, R-3113/1-AF, April 1984.

upgrades to TSAR and TSARINA[3] that enable us to study the effects of plausible Warsaw Pact attacks (both conventional and chemical) on our support infrastructure and translate the effects of those attacks into estimates of degradation in a theater's ability to generate sorties. Using these simulations to explore alternative support systems' performance under uncertainty, we hope to deepen our understanding of the potential role of flexibility and robustness in repair and distribution. Based on that foundation, we will be in a much stronger position to identify and evaluate promising support policies and procedures for uncertain wartime environments and to extend the analytic models' representation of uncertainty and support management.

But enhancing models is not enough. In light of our new appreciation of the uncertainties and the threat, we have become concerned that the logistics system may need to become more flexible and responsive to changes in the needs of the operational force. Thus, we have begun to develop a new logistics operational concept for more closely Coupling Logistics to Operations to meet Uncertainties and the Threat (CLOUT). This concept urges that decisionmakers at all echelons, and in all support functions, capitalize more fully on their opportunities to reallocate support resources as the needs of the operational force change.

Capability assessments play a key role in that new operational concept. A central element of CLOUT is using assessments of aircraft availability throughout the logistics infrastructure to help prioritize day-to-day actions in support of the force. An extremely important development now being undertaken in concert with the Air Force is one that permits "real time" decisionmaking by each repair and distribution manager to be directly influenced by dynamic aircraft availability and sortie-production goals. Thus, many of the desirable qualities of planning and oversight evaluations would be built into the daily routine decisionmaking process. The eventual result: If a full range of such tools can be developed, managers of each element of the support infrastructure—repair, supply, transportation, distribution, and procurement—would respond in near real time to changing and unexpected force demands for support by using assessments to identify and prioritize those actions that will contribute most to wartime capability.

As this more responsive day-to-day management system evolves, the new evaluation techniques must also be operationalized in planning and oversight functions. As mentioned earlier, the Air Force WSMIS

[3]See D. F. Emerson and L. H. Wegner, *TSAR User's Manual: A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation, Vol. I: Program Features, Logic and Interactions*, The RAND Corporation, N-2241-AF, August 1985, for a description of those models' latest capabilities.

effort has already taken a major step in this direction. Future WSMIS upgrades will incorporate the improved models, so planners and managers can better assess how long- and near-term repair and distribution constraints may limit the support system's ability to respond to unforeseen events. For example, one could use the upgraded WSMIS to evaluate the support system to meet a wide range of uncertainties (including variation in wartime flying programs, unanticipated removal rates, and disruption and damage caused by enemy action).

RAND is also thinking about the path that lies beyond where these ambitious developments lead. No one is satisfied that aircraft availability and sortie measures adequately reflect the contribution of the entire combat support system (including munitions, fuels, personnel, and other resources necessary to carry on combat operations) to combat capabilities. More comprehensive, expressive measures are needed that cover the full range of combat resources and scenarios and that relate available resources to the operational capabilities and flexibilities they provide. Future research should seek such measures, so logistics planners, policymakers, and managers can make integrated assessments of all combat support resources, not just aircraft spares, repair, and flightline support.

The need to make rigorous, systemwide assessments an integral part of routine operations is not merely a challenge for peacetime, although that is the main emphasis of current activities. Those assessments may be needed even more—by the logistics command and control system and by the logistics infrastructure—to guide and execute crisis and wartime support, so that the support system can respond quickly to unexpected, unplanned demands or operational goals. In the future, evolving peacetime assessment systems must be extended to operate under extremely challenging wartime environments where operational goals may change rapidly; demands for support may suddenly exceed the logistics system's capacities; the detailed data may be fragmentary, old, or garbled; the response time requirements may be especially demanding; and rapid, relevant reactions by the logistics system may have the greatest effect.

Most people readily recognize that the ability to make meaningful assessments of the readiness and sustainability of our combat forces is useful for many "retrospective" purposes, such as charting trends and evaluating past investment decisions. Less well understood, however, is how much assessments can improve support to the future peacetime and wartime operations of our combat forces. Those operations will assuredly take place in environments of ever-increasing threat and uncertainty, necessitating a support infrastructure far more responsive and adaptive than today's. The key to great strides and leaps in responsiveness and adaptive capability is to tie specific support function operations and management directly to actual specific deficiencies and shortfalls in readiness and sustainability. The proactive, aggressive use of such information can assure that the support operations' limited resources are directed to the combat forces' greatest needs.