Measuring Military Readiness and Sustainability

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Prepared for the
Defense Advisory Group to the
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RAND

PREFACE

Military readiness and sustainability have been subjects of research at RAND and elsewhere for many years. Although important progress has been made, the measures of readiness and sustainability routinely available to high-level defense decisionmakers—at the Office of the Secretary of Defense, in the Joint Staff, and in Congress—have scarcely changed. The value of these measures in support of decisionmaking has been very limited, and contention has arisen over the department's failure to provide better measurements.

This report responds to a Defense Advisory Group[1] request to review the state of the art in readiness and sustainability measurement and to develop a "strategic concept design" for improved measurements that would better serve high-level defense decisionmakers. The document identifies (1) incremental improvements that would raise the value of information derived from current reporting and analysis systems and (2) a new concept for assessing readiness and sustainability that would integrate several existing reporting and analysis approaches.[2]

This study is intended to promulgate ideas for improving the measurement of readiness and sustainability; generate discussion and feedback about these ideas within and from the organizations that would provide data, perform the analyses, or use the results, and foster the coordinated development of improved readiness and sustainability measurement and reporting methods. It should be of interest to planners and budgeters for operations, logistics, and manpower in the Office of the Secretary of Defense, the Joint Staff, the unified and specified commands, and the military services, as well as members of Congress and their staffs. The work here was conducted between April 1988 and March 1989 for the project *Enhancing the Measurement of U.S. Military Readiness and Sustainability*.

This report was prepared within the Acquisition and Support Policy program of the National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Chiefs of Staff. The research reported

[1]The Defense Advisory Group (DAG) oversees the National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Staff.

[2]RAND introduced the integrated assessment concept in a fall 1988 briefing to the DAG.

here was sponsored by the institute's Defense Advisory Group, whose members are as follows:

Director, Defense Research and Engineering (chairman)
Under Secretary of Defense for Policy
Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)
Assistant Secretary of Defense (Force Management and Personnel)
Assistant Secretary of Defense (Production and Logistics)
Assistant Secretary of Defense (Program Analysis and Evaluation)
Assistant Secretary of Defense (Research Affairs)
Director, Defense Advanced Research Projects Agency
Director, Net Assessment
Scientific and Technical Advisor, Force Structure, Resource, and Assessment, Joint Staff

SUMMARY

The "four pillars" of military capability are force structure, modernization, readiness, and sustainability. Peacetime expenditures toward achieving and maintaining readiness and sustainability—e.g., through training, maintenance, and materiel stockpiling—typically use more than half the Department of Defense's (DoD's) budget Readiness and sustainability, which reflect approximately how quickly and for how long forces would be usable, govern the degree to which the other two pillars could be exploited in wartime Although each pillar is a broad subject in its own right, we consider readiness and sustainability together because they interact a great deal, often depending on the same resources

For more than a decade, DoD has sought readily understood measures of readiness and sustainability that relate clearly to funding levels. Progress has been made in several quarters—e.g., in relating weapon system availability to spare parts quantities and aircrew performance to flying experience. But many gaps remain, and the scattered pieces of evidence do not convey a concise or very compelling impression of U.S. military readiness and sustainability posture.

BACKGROUND

High-level decisionmakers—especially in the Office of the Secretary of Defense (OSD), the Joint Chiefs of Staff (JCS), and Congress—need to understand the degree to which U.S military posture can underwrite national security objectives Given the military's size, mix, and technological capabilities, how much could the forces do—and where, how well, how quickly, and for how long? How has their capability changed, and how would it change in the future with different funding patterns? This kind of information—together with information about resource costs and fiscal limitations and perceptions of international political and military circumstances—would help decisionmakers choose funding allocations for readiness and sustainability.

Although other indicators have sometimes arisen, in recent years high-level decisionmakers have considered readiness and sustainability principally in terms of the resources available in individual operating units (e g , battalions, ships, and aircraft squadrons)[1] and in the days of

[1]Under the status of resources and training system (SORTS) sponsored by the JCS, each unit regularly characterizes and reports its current status in five respects equipment and supplies on hand, equipment condition, available personnel, training, and

supply (DOS) represented in stockpiles of different materiel (e.g., ammunition, fuel, and spare parts). This information does little to answer the above questions. Fundamentally, it represents only the percentages of stated requirements that are on hand. Decisionmakers generally find this information poorly behaved and unconvincing in large part because the requirements themselves change, the percentages are reported only in coarse categories, the figures are based on somewhat obscure assumptions, and the summaries embody the judgments of disparate commanders. The information is about military resource *inputs*, not potential *outputs*. Furthermore, it largely ignores the improvements possible through special preparations (e.g., intensified training or redistribution of manpower and materiel) and mobilization that might precede combat operations. And it doesn't show whether units and materiel would be available when needed—e.g., whether engineering, supply, maintenance, or medical units and materiel would be available in sequence with combat units, whether units that should be partners in combat would be available simultaneously, or whether the availability of units and materiel that must come from the United States is consistent with the deployment and distribution systems that must transport, handle and store them en route

Figure S.1 summarizes the flow of information through the status of resources and training system (SORTS) and S-rating reporting system.[2] The resulting tabulations are extensive and detailed, but they provide little insight into the mutual consistency of the status and availability of different types of units and materiel—that is, abilities of U.S. forces to undertake and sustain operations of different types in different locations

Our discussions in the DoD (including all the services, the JCS, and the OSD), with the congressional staff, and in the research community suggested eight characteristics readiness and sustainability assessment methods would ideally possess. They would

- Reflect what units and forces can do, not just what they have,
- Be practical (that is, undisruptive, inexpensive, and understandable);
- Be objective and verifiable (instead of subjective),
- Reveal the robustness of posture across scenarios and under different, somewhat unpredictable conditions within scenarios,

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overall status The overall status rating represents the unit commander's broad assessment of the proportion of assigned wartime mission the unit is prepared to undertake

[2]See Tables 1 and 2 in the text for details regarding unit resource category levels (C-levels) and sustainability ratings (S-levels)

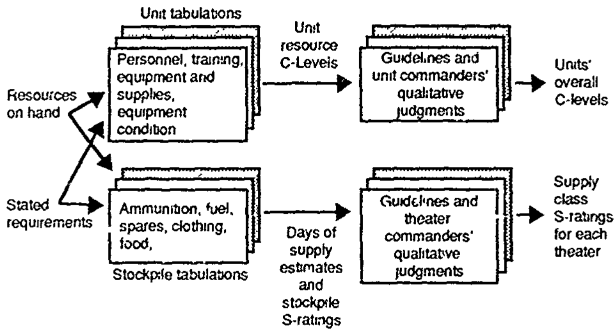

Fig. S.1—Current assessments

- Provide useful feedback to providers of the elemental data;
- Permit comparisons of status from one year to another;
- Reflect the transition from peacetime to wartime; and
- Permit evaluation of tradeoffs (between resource categories or among readiness, sustainability, and force structure)

Probably no assessment method could fulfill all these objectives; indeed, some are conflicting. Nevertheless, they help point the way to improving current methods and designing new ones.

IMPROVING CURRENT ASSESSMENT METHODS

The DoD already has data, analysis, and exercise/testing systems that address different aspects of readiness, sustainability, and the transition from peacetime to wartime. Each serves a different purpose, has its own organizational constituency, and is extensive and complex. Several systems are not especially oriented toward readiness or sustainability assessment, but all could undergo alteration to enhance their contribution to such assessment. We consider these methods in seven "families." Three families deal primarily with military units:

- *Asset reporting—compiling the quantities and condition of the equipment, supplies, and people in individual units* Here, we recommend increased and consistent emphasis on estimating the lengths of time required to achieve specified performance standards and on maintaining only the resources necessary to train up to those standards—that is, we favor emphasizing "training readiness." Higher organizational levels would consider possible redistributions of manpower and materiel among units (also calling on equipment stockpiles) and compare the numbers of "whole, trained-up units" that could become available over time with deployment schedules established for different illustrative contingencies
- *Unit modeling—simulating the mission activity levels achievable with specified sets of resources* These methods could become more practical through streamlining of their extensive data and computational requirements and more useful through treatment of the interdependencies of different units
- *Functional testing—measuring the abilities of individuals and units to perform (proxies of) their wartime tasks and operations.* Here, the needs are for shorter advance notice, more realistic (limited) equipage and preparatory training, greater uncertainty about test content, and test evaluation by instrumented means and outsiders

The four other families deal primarily with forces:

- *Stockpile reporting—compiling the quantities and condition of the equipment, supplies, and people outside of individual units* These compilations would be improved by accounting for more of the resources available (e g., from production or repair pipelines, or left behind by deploying units), by explicitly reporting the forces and operating assumptions that would draw down stockpiles, and by emphasizing the quantities of different mission activity levels achievable
- *Mobilization planning—determining the steps and schedules for assembling and organizing military forces and for accelerating production of military goods and services* On the force mobilization side, valuable improvement would accrue from identifying the times required to assemble different types of units and to train them up to specified performance standards and then examining the integrity (the internal consistency) of the resulting forces that could be marshaled for deployment. On the industrial mobilization side, there is a need for greater depth

and accuracy in specifying wartime's time-phased materiel needs and for faster, more reliable estimation of time-phased production and service capacities.

- *Deployment/distribution planning—establishing the feasibility of specified force and materiel delivery objectives and determining corresponding movement, storage, and materiel-handling schedules.* Here, too, important benefits would derive from streamlining data and analysis tools and broadening the analysis scope—e.g., linking movement in the United States, strategic movement to operating theaters, and movement within theaters. A recent study by the Joint Staff shows how deployment capacity costs could be reduced by increasing the readiness of deploying units, still getting them to combat theaters on time while transporting them by slower means
- *Combat modeling and war gaming—projecting the results of force-on-force conflict in terms of, say, territory gained or forces remaining.* Treatment of readiness and sustainability limitations is embryonic in this arena. Some war games and computerized exercise-aiding systems are beginning to consider sustainability explicitly, although still very coarsely. Improvements will come through greater representation of logistics and manpower constraints, but incorporating these detailed factors threatens to overwhelm already large and very complex activities

In general, these families of methods are disjoint, so the suggested improvements can be undertaken largely independently and in the near term.

AN INTEGRATED ASSESSMENT FRAMEWORK

Some incremental improvements we recommend above would link information across one or more families of methods. What about linking all seven families, using them as building blocks for a comprehensive, integrated assessment system that might have a more desirable combination of the "ideal" measurement characteristics? We believe that the complexities and assumptions of combat modeling and war gaming (e.g., already extensive computer requirements, together with hypotheses about the effectiveness of *both sides'* weapons, strategies, and tactics) will prevent their inclusion in such a framework for some time [3] But a system linking the other families of methods seems at least plausible and might

[3]Nevertheless. we believe ongoing efforts should continue to accord readiness and sustainability greater influence and fidelity in combat models and war games

provide a very powerful, well-behaved, and compelling assessment capability. In concept, it would link information about peacetime operating tempos and training levels (including reserves), forward deployments, and pre-positioned and other materiel stockpiles, as well as information both about capacities and timing for mobilization and deployment and about combat activity, ultimately projecting the levels of activity that could be achieved over time in different mission areas. The services already define limited numbers of mission areas (for instance, in terms of aircraft sortie types, combat ship employment categories, and artillery battalion operations) for which activity levels could be projected. Figure S.2 illustrates the form such assessments might take.

We envision an integrated readiness and sustainability assessment framework that would operate in the following way (see Fig. S.3):

1 Asset and stockpile reports would collectively reflect the quantities of unit and nonunit manpower and materiel resources available, where they are located, and what condition they are in

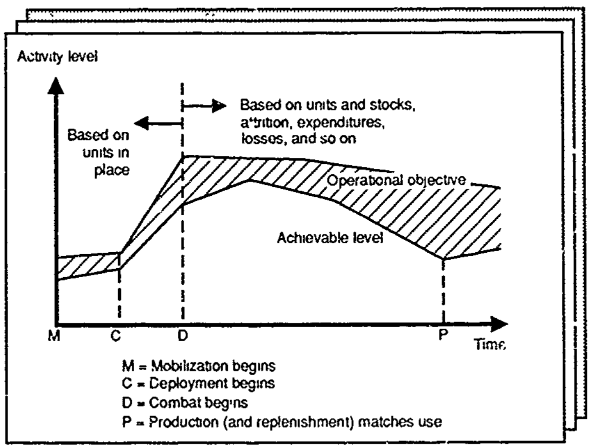

Fig. S.2—Integrated assessment Mission activity levels over time

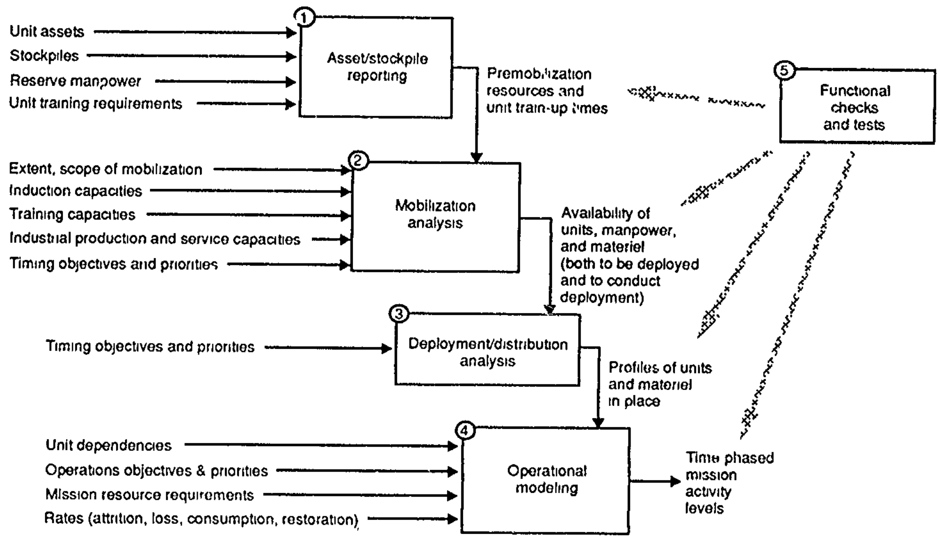

Fig. S 3—Major steps in integrated readiness and sustainability assessment

2. Mobilization analysis would project the numbers of additional units, people, and materiel that could become available over time and the changing levels of unit capability attainable (the latter mainly through "training up").
3. Deployment and distribution analysis would translate information about increasing unit and resource availability (also including increasing lift and handling capacities) into profiles of the increasing numbers of combat and support units and materiel that could be available at appropriate locations in combat theaters.
4. Operational modeling would use assumptions about quantitative mission/engagement objectives—and corresponding expenditure, loss, attrition rates, and so on—to translate the profiles of available units/forces and materiel into profiles of the activity levels achievable over time for different mission areas.[4]
5. Functional checks and tests would be employed to the maximum practical degree to estimate—or at least verify—the input-output and time-capability relationships used in the other steps of the assessment process

Presented in such operational terms, readiness and sustainability assessments should be easily understandable to high-level decisionmakers and be comparable from one year to another. Further, such assessments should reveal any inconsistencies among force elements and resources, identifying the bottlenecks (and corresponding structural or resource shortfalls) that restrict mission activity levels This framework would permit estimation of the effects of eliminating such bottlenecks/shortfalls, allowing comparisons of these effects with corresponding cost estimates Finally, such assessments would provide information much more relevant to high-level decisionmakers' questions about the consistency between the military's readiness and sustainability and the nation's security interests, objectives and commitments.

The feasibility of developing and operating such an assessment framework is not yet clear. That most of its elements already exist in one or more contexts is encouraging. Because the framework's scope is so broad, involving important interactions among the services, one or

[4]Assessments would be performed for contingencies that differ in size, location, warning, and duration And, within contingencies, evaluations would be performed using different assumptions—e g, about combat intensity, weapon system attrition, personnel casualties, resource consumption, resource losses due to enemy action—that can be predicted only with considerable uncertainty

more offices in OSD or the JCS would have to take responsibility for coordinating the associated data, assumptions, and assessments

CONCLUSIONS

Because the integrated framework may take some time to develop—or may even prove infeasible—we recommend that DoD undertake enhancements in readiness and sustainability assessment in four categories. The first three represent incremental steps in assessing unit readiness, force readiness, and sustainability. The fourth would pursue the integrated assessment framework All can be followed in parallel.

- *Unit readiness.* Specify performance measurement scales and standards for different types of units. Develop systematic means for estimating how long units would take to achieve different levels on those measurement scales. Hold each unit responsible for reporting the resources it needs to maintain its peacetime proficiency and to accomplish its performance upgrade through predeployment training up. Develop and conduct functional tests and (statistical) experimental designs to confirm or refute the train-up time estimates.
- *Force readiness* Build on the performance-based, time-oriented representation of unit readiness. Coordinate databases of (1) induction, individual training, individual and unit processing, and unit training capacities that would provide resources and services to units in contingencies; (2) manpower, equipment, and supplies available to fill out units' resources and training before deployment or employment, and (3) desired schedules for using units within combat theaters (recognizing the functional dependencies among units). Project time profiles of the numbers of units of different types that could be filled out, trained up, and prepared for deployment (if in the United States) or employment (if already in theater). Identify shortfalls from the desired deployment schedules. Perform such assessments for different scenarios—distinguished by scale, region, and warning/preparation, for example. Obtain reviews and comments from theater commanders
- *Sustainability*[5] Use three types of information—about prepositioned stockpiles, resources available in the United States

[5]Sustaining units—for example, maintenance, medical, and supply units—should be tested just like other units to examine unit readiness, emphasizing performance scales and standards and the lengths of time required to achieve performance standards

and the combat theater (including industrial production), and allocations of movement and handling capacity—to project the cumulative quantities of materiel and replacement personnel available in operational theaters. Delineate assumptions (and ranges of uncertainty) for key rates—e.g., weapon system attrition, materiel and personnel losses, and supply consumption—associated with different types of mission activity; use them to draw down the cumulative supply profiles, estimating over time any corresponding shortfalls below mission-area activity-level goals[6] Investigate the sensitivity of the results to these assumptions, and perform assessments for different scenarios Obtain reviews and comments from theater commanders.

- *Overall integration* Explore the feasibility of developing and operating the integrated framework in two ways· (1) linking existing analytic methods and data and (2) designing and building an "ideal" system, unconstrained by the detailed complexities of existing methods. Compare the corresponding advantages and disadvantages and estimate the costs and risks. If one approach or a combination of the two seems sufficiently promising, develop and test it experimentally If the results warrant, proceed with system development and regular application

[6]These recommendations are generally consistent with those presented by the DoD's own Sustainability Assessment Task Force

ACKNOWLEDGMENTS

Instigation and active support for this research came primarily from two offices: the Office of the Assistant Secretary of Defense for Force Management and Personnel, which is interested primarily in readiness measurement, and the Logistics Directorate of the Joint Staff (JS), which is interested primarily in sustainability measurement.

Because of the project's wide scope, an informal advisory committee was established to review its progress and provide counsel and assistance. The committee's members include

Walter B. (Brad) Bergmann, OASD (P&L)
Dr. James Berry, OASD (FM&P)
Lieutenant Colonel Dennis Clausen, JS/J-7
Lieutenant Colonel Richard Dull, OASD(RA)
Commander Donald Geiger, JS/J-4
Dr. John Morgan, OASD(PA&E)
Commander Thomas Schreiber, OASD(P&L)
Lieutenant Colonel Robert Zielinski, JS/J-7

While this research was under way, the Department of Defense (DoD) established an internal, multiservice "sustainability assessment task force" to work toward developing "operationally oriented measures of sustainability." For sharing the deliberations of the task force and its working group and for inviting us to contribute ideas to those deliberations, we are grateful to Major General Merle Freitag (United States Army) and Brad Bergmann, then both of the OASD for production and logistics. Commander Thomas Schreiber (United States Navy) of that office deserves special thanks for his continued interaction with us, especially for the timely provision of his detailed minutes of working group and task-force meetings.

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DEFINITIONS

AFLC	Air Force Logistics Command
AFM	Air Force Manual
AFR	Air Force Regulation
ALA-X	Army Logistics Analysis—Extended
ALO	Authorized level of organization (Army)
AMSAA	Army Materiel and Systems Analysis Agency
ANG	Air National Guard
AR	Army Regulation
ARTEP	Army Training Evaluation Program
ATRIMS	Aviation Training & Readiness Information Management System (Marine Corps)
ASW	Antisubmarine warfare
AURA	Army Unit Readiness Assessment (a RAND model)
BLTM	Battalion-Level Training Model (Army)
BOS	Battlefield Operating System (Army, TRADOC)
CAA	Concepts Analysis Agency (Army)
CAIMS	Conventional Ammunition Information Management System (Navy)
CBS-X	Continuing Balance System—Extended (Army)
CEM	Concepts Evaluation Model (CAA)
CESG	Capability evaluation steering group (OSD & JS)
CFRC	Conventional Forces Readiness Committee (OSD, JS, all Services)
CINC	Commander in chief
CIL	Critical item list (CINCs)
CMTC	Combat Maneuver Training Center
CNA	Center for Naval Analyses
COMPES	Contingency operation mobility planning and execution system (Air Force)
CONOP	Concept of operation
CONPLAN	Conceptual plan (theater CINCs)
CONUS	Continental United States
CPU	Central processing unit
CPX	Command-post exercise
CRAF	Civil Reserve Air Fleet
CRP	Combat readiness percentage (under ATRIMS)
CSPAR	CINC's Preparedness Assessment Report
CSR	Controlled supply rate
C-day	First day of deployment

C-level	Numerical rating of possession of resources under SORTS
C-rating	Numerical rating of possession of resources under UNITREP
C3I	Command, control, communications, and intelligence
DAG	Defense Advisory Group (overseeing NDRI)
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director, Defense Research and Engineering (OSD)
DEFCON	Defense readiness conditions (graduated alert postures)
DEMSTAT	Deployment, Employment, Mobilization Status System (Army)
DG	Defense Guidance (published by OSD), being replaced by DPG
DLA	Defense Logistics Agency
DoD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DOS	Days of supply
DP	Number of dollars of stock on hand plus programmed to provide such stocks
DPG	Defense Planning Guidance (OSD), replacing the DG
DR	Number of dollars required to provide stocks to meet the MTO
DRB	Defense Resources Board (DoD)
Dyna-METRIC	Dynamic Multi-Echelon Technique for Recoverable Item Control (a RAND model, now part of WSMIS)
D-day	First day of conflict/combat
ELCAM	Expected-value-based Logistics Capability Assessment Model (USAF)
ESCAM	Enhanced SORTS Capability Assessment Model (Air Force)
FAD	Feasible arrival date
FEMA	Federal Emergency Management Agency
FFRDC	Federally funded research and development center
FLOGEN	Flow Generator System (MAC)
FLOT	Forward line of own troops
FM	Field Manual (Army)
FM&P	Force Management and Personnel (OSD)
FORCEM	Force Evaluation Model (Army)
FORSCOM	Forces Command (Army)

FYDP	Five-year defense plan
GAO	General Accounting Office
GCC	Graduated combat capability (Air Force)
GMR	Graduated mobilization response
GOCO	Government-owned, contractor-operated
IDA	Institute for Defense Analyses
INBATIM	Integrated Battlefield Interactive Model
INDCON	Industrial condition code (under GMR)
IPL	Integrated priority list
IPS	Illustrative planning scenario (under DG)
IRR	Individual Ready Reserve
JAWS	Joint Analytic Warfare System
JCS	Joint Chiefs of Staff
JDA	Joint Deployment Agency (disestablished, enfolded in USTRANSCOM)
JDS	Joint Deployment System
JDSSC	Joint Data System Support Center
JESS	Joint Exercise Support System
JIMPP	Joint Industrial Mobilization Planning Program
JOPES	Joint Operational Planning and Execution System
JOPS	Joint Operational Planning System
JRTC	Joint Readiness Training Center
JS	Joint Staff
JS/J-3	Operations Directorate, Joint Staff
JS/J-4	Logistics Directorate, Joint Staff
JS/J-7	Operational Plans and Interoperability Directorate, Joint Staff
JS/J-8	Force Structure, Resources, and Assessment Directorate, Joint Staff
JTLS	Joint Theater-Level Simulation (a MAPP model)
LAD	Latest arrival date
MAC	Military Airlift Command (Air Force)
MANPER	Manpower and personnel module (COMPES)
MAPP	Modern Aids to Planning Program (JS and CINCs)
MAPS-II	Mobility Analysis and Planning System (MTMC)
MCCRES	Marine Corps Combat Readiness Evaluation System
MCDC	Mobilization Concepts Development Center (NDU)
MCL	Mobilization Cross-Leveling System (Army)
MEPS	Military enlistment processing stations
METL	Mission-essential task list
MIDAS	Model for Intertheater Deployment by Air and Sea
MILES	Multiple Integrated Laser Engagement System (Army)

MINOTAUR	A simplified, PC-sized intertheater deployment analysis model (PA&E)
MOBERS	Mobilization Equipment Redistribution System (Army)
MOBPERSACS	Mobilization personnel structure and composition system (Army)
MOP	Memorandum of policy (JCS)
MOS	Military occupational specialty (Army and Marine Corps)
MPS	Maritime prepositioned ships (Marine Corps)
MSC	Military Sealift Command (Navy)
MTMC	Military Traffic Management Command (Army)
MTO	Midterm objective (DOS under IPS), being replaced by PPO
M-day	First day of mobilization
NA	Net Assessment (office in OSD)
NATO	North Atlantic Treaty Organization
NAVMOD	Naval Model (JS/J-8)
NDRI	National Defense Research Institute (an FFRDC at RAND)
NDU	National Defense University
NGB	National Guard Bureau
NMIG	National Mobilization Interagency Group, replaced by the Planning Coordinating Committee. Emergency Preparedness/Mobilization Planning
NSC	National Security Council
NSEP SIG	National Security Emergency Planning Senior Interagency Group
NTC	National Training Center (Army)
OASD	Office of the Assistant Secretary of Defense
OCONUS	Other than CONUS
OMB	Office of Management and Budget
OOMS	Operationally oriented measures of sustainability
OPFOR	Opposing force (at NTC)
OPLAN	Operational plan (theater CINCs)
OPORDER	Operational order (theater CINCs)
OPTEMPO	Operating tempo
ORI	Operational Readiness Inspection
OSD	Office of the Secretary of Defense
OUSD(A)	Office of the Under Secretary of Defense for Acquisition
OUSD(P)	Office of the Under Secretary of Defense for Policy
O&M	Operations and maintenance
O&S	Operations and support

PA&E	Program Analysis and Evaluation (OSD)
PBA	Production base analysis
PCS	Permanent change of station
PERSCON	Personnel condition code (under GMR)
POD	Port of debarkation
POE	Port of embarkation
POL	Petroleum, oil, and lubricants
POM	Program objective memorandum (in PPBS)
POMCUS	Pre-positioned overseas materiel configured in unit sets (Army)
PPBS	Planning, programming, and budgeting system
PPI	POM preparation instructions
PPO	Program planning objective
PWRM	Pre-positioned war reserve materiel
P&L	Production and Logistics (OSD)
RA	Reserve Affairs (OSD)
RAPIDSIM	Rapid Intertheater Deployment Simulation Model (JDSSC)
RDD	Required delivery date
REFORGER	Return of Forces to Germany (joint exercise)
RIMS	Revised Intertheater Mobility Study (JS/J-4)
RRF	Ready Reserve Fleet (Navy)
RSAS	RAND Strategy Assessment System
SAC	Strategic Air Command (Air Force)
SATF	Sustainability Assessment Task Force (OSD, JS, and all services)
SEACOP	Strategic Sealift Contingency Planning System (MSC)
SECDEF	Secretary of Defense
SEMATECH	Semiconductor Manufacturing Technology (industrial consortium)
SITREP	Situation report
SORTS	Status of resources and training system
SOTACA	State-of-the-art Contingency Analysis Model (a MAPP model)
SPECTRUM	Simulation Package for the Evaluation by Computer Techniques of Readiness, Utilization, and Maintenance (Navy)
SSS	Selective Service System
STRADS	Strategic Deployment System (will replace MAPS-II at MTMC)
SUMMITS	Scenario Unrestricted Mobility Model for Intratheater Simulation (Mobility Steering Group, OSD)

S-rating	Numerical rating of possession of PWRM (CINCs)
TACSAGE	Tactical Sequential Analytic Game Evaluator (a RAND model)
TACSIM	Tactical Simulation (used by JESS)
TACWAR	Tactical Warfare Model (JS/J-8)
TFCA	Total Force Capability Analysis (JS/J-8)
TFE	Transportation Feasibility Estimator (in JOPS)
TOCs	Transportation operating commands (under USTRANSCOM)
TO&E	Table of organization and equipment
TIGER	A simulation model for estimating ship system and mission availability (Navy)
TFS	Tactical fighter squadron
TPFDD	Time-phased force deployment data
TPFDL	Time-phased force deployment list
TRADOC	Training and Doctrine Command (Army)
TSAR	Theater Simulation of Airbase Resources (a RAND model)
UNITREP	Unit Status and Identity Report (replaced by SORTS)
USA	United States Army
USAF	United States Air Force
USCENTCOM	United States Central Command
USEUCOM	United States European Command
USLANTCOM	United States Atlantic Command
USMC	United States Marine Corps
USN	United States Navy
USPACOM	United States Pacific Command
USSOCOM	United States Special Operations Command
USSOUTHCOM	United States Southern Command
USPACECOM	United States Space Command
USTRANSCOM	United States Transportation Command
WARMAPS	Wartime Manpower Mobilization Planning System (FM&P)
WRSK	War reserve spares kit (Air Force)
WSMIS	Weapon System Management Information System (Air Force)
WWMCCS	World-Wide Military Command and Control System

I. INTRODUCTION

The DoD defines military capability as "the ability to achieve a specified wartime objective (win a war or battle, destroy a target set)."[1] It regards military capability as comprising four components or "pillars":

- *Force structure.* Numbers, size, and composition of the units that make up U S. defense forces (for example, divisions, ships, air wings).
- *Modernization.* Technical sophistication of forces, units, weapon systems, and equipments.
- *Readiness* The ability of forces, units, weapon systems, or equipments to deliver the outputs for which they were designed (includes the ability to deploy and employ without unacceptable delays)
- *Sustainability.* The "staying power" of U.S. forces, units, weapon systems, and equipments, often measured in numbers of days.[2]

Readiness and sustainability are obviously important. Their clear absence could invite attack, intimidation, or "adventurism" by adversaries.[3] Further, if combat is actually joined, shortfalls in readiness and sustainability risk serious consequences· heavy losses, retreat, capitulation, or escalation (The consequences of shortfalls—e.g., compromised safety and diminished morale—are serious even in peacetime.) Besides being important for deterring and prosecuting war, readiness and sustainability are inherently costly to maintain in peacetime. In recent years, more than half the defense budget has been in accounts generally regarded as supporting readiness and sustainability: operations and maintenance, military pay, and portions of "other

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[1]Joint Chiefs of Staff, 1986a, p 225

[2]The recently revised, complete definition of sustainability is "The ability to maintain the necessary level and duration of operational activity to achieve military objectives Sustainability is a function of providing for and maintaining those levels of ready forces, materiel, and consumables necessary to support military effort" (See Office of the Assistant Secretary of Defense, 1988b, p 12)

[3]There is room for debate about the relative importance of readiness and sustainability as deterrents For illustration, consider this testimony by Major General J D Smith (Director of Operations, Readiness, and Mobilization, Office of the Deputy Chief of Staff for Operations and Plans, U S Army). "We believe that combat divisions, infantry and armor units, deter Truck and materiel handling units do not" (See U S Senate, 1988a, p 453)

procurement" devoted to spare parts and ammunition. Indeed, almost all peacetime military activity is training and practice, both of which are key elements in achieving and maintaining readiness.

Readiness and sustainability are achieved through a wide variety of means, including

- Training and practice,
- Full equipage and manning;
- Spare parts and maintenance;
- Stockpiles of materiels and manpower (reserves) for wartime;
- Force structure mix (e g, providing service units to support combat units),
- If necessary, mobilization to increase force structure and raise military production and services;
- Responsive management of available resources to meet the most pressing needs

It is useful to think of force structure and modernization (together with organization structures and with operational and support doctrines) as establishing a theoretical maximum force potential. They constitute the force design Then readiness and sustainability may be considered as enabling (or constraining) the achievability of that potential—quickly and over the longer term, respectively

Because readiness and sustainability are so important and cost so much, high-level defense decisionmakers (from the President and Congress down through the headquarters of unified and specified commands and the military departments) understandably want to know where these components of military capability stand—whether they are high, low, rising, or falling, and how much, at what costs, and at what risks? Unfortunately, the quantitative indicators or "measures" of readiness and sustainability in prominent use up to now have not provided satisfactory answers to such questions. The primary information high-level decisionmakers routinely receive gives approximate answers to two questions: (1) How much of the military's stated resource requirements are actually filled? and (2) What are the various commanders' assessments of the adequacy of current resource levels? In their current form, these measures don't tell much about the preparedness of U.S. forces to fulfill operational objectives in support of national security interests. They provide little insight into the types, scales, and timing of military operations or activities the forces could mount or into how changes in funding levels for the relevant accounts would affect those operational characteristics. The measures focus on the military's resource inputs, not its potential operational outputs

Specifically, decisionmakers complain about the available measures' lack of change in response to changes in funding levels[4] and about the cogency and integrity of the measures themselves.[5] Continuing pressure has come from Congress and DoD itself to upgrade information about readiness and sustainability.[6] Contributing to the frustration over current measures of readiness and sustainability is a consensus that readiness and sustainability actually change over time. Frequent reference to "the 'hollow' force structure of the late 1970s"[7] has appeared, a time when readiness and sustainability were at a low ebb—when some weapon systems experienced serious shortages of spare parts, munitions, or skilled personnel, for example.

In peacetime, defense decisionmakers inevitably accept limitations in military readiness and sustainability. Money can be saved in the near term with less training, fewer spare parts, smaller stockpiles of ammunition and other supplies, operational responsibilities shifted from active forces to the reserves, and the like But there are countervailing risks: The costs may be very high later if full force and resource postures must be restored, and, probably of greater concern, the forces could do less—either quickly or over an extended interval—if a conflict arose before those postures were restored.

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[4]For example, General Thomas C Richards (deputy commander in chief, United States European Command) testified. "Despite the progress made in improving readiness and sustainability posture, the ratings have remained basically unchanged" (See U S Senate, 1988b) And after an unsuccessful search for statistical relationships between ostensible indicators of readiness and congressional funding of operations and support (O&S) accounts, the Congressional Budget Office could only advance two very simple models attempting to predict the funding necessary for those accounts One model estimates the O&S funding requirement using the number of U S forces (divisions, ships, air wings), the other, using the value of DoD's capital stock (See Pierrot, 1988)

[5]For a related overview, see General Accounting Office, 1986a DoD established a Capability Evaluation Steering Group (CESG) in 1985 to deal with these problems and has subsequently published (classified) military status reports (For indicative results, see testimony by Deputy Secretary of Defense W H Taft IV, U S Senate 1987, pp 642-694) Progress has been made, but frustration remains, Congressman J R Kasich (Ohio) says, "We need benchmarks We're not sure what we can believe, what the good measures are" (See U S House of Representatives, 1988c)

[6]For instance, DoD has had to submit a report to Congress reporting progress in *measuring* readiness, not merely changes in the values derived from measurement Congressman G W Whitehurst (Virginia) says, "we need information that everybody understands When I speak to constituents, if I talk about percentages, it does not mean a doggone thing to them People get lost in numbers" (See U S House of Representatives, 1986, pp 766-767) And OSD's own *Defense Guidance* mandates that each service will "develop operationally oriented measures of sustainability that will better describe the extent to which sustainability resources can be expected to support wartime activity" (See Office of the Assistant Secretary of Defense, 1988b, p iv)

[7]See, for example, Carlucci, 1988, p 15

Decisionmakers must balance present and future costs against risks over a range of conflict types that have different likelihoods and uncertain resource requirements. Unfortunately, the forces and resources needed for any given contingency are not exactly predictable (e.g, because attrition and consumption rates may vary widely from expectations). And even if such "requirements" were known accurately, there are many different types of contingencies, each having a likelihood that can vary over time. Further, decisionmakers may expect (or hope) that signs of impending conflict will be apparent far enough in advance to allow an upgrading of readiness and sustainability. They face the questions, How high should we try to bring our readiness and sustainability for different contingencies, and when? To enable decisionmakers to manage readiness and sustainability deliberately and informedly, they need a yardstick to measure the status of readiness and sustainability—as it has developed over the past, as it stands today, and as it might develop in the future with changes in funding and resource levels.

Readiness and sustainability are often considered separately. While each is a very large subject in its own right, they are considered together here for several important reasons:

- They both count on many of the same resources—e.g, manpower, equipment, and supplies in individual units and in nonunit stockpiles.
- They are both influenced by forward deployment, prepositioning of resources, and support from host nations.
- They both depend on the degree and timing of mobilization
- They share many transport and handling resources.
- Sustainability cannot be evaluated without knowing (or assuming) the locations and activities (and hence the readiness) of forces that must be sustained.

Because the subject is so encompassing and the assessment methods so numerous, this report is somewhat lengthy. Section II provides important background information It outlines the variety of decisionmaking that needs information about readiness and sustainability, it critically reviews the prominent current measures of readiness and sustainability, and it sets out characteristics that measures of readiness and sustainability should ideally exhibit Readers conversant with these matters will want to bypass or only skim this section. Section III takes up seven "conceptual approaches," or families of reporting, planning, or analysis methods in current use that reflect one or more aspects of readiness or sustainability. We describe each approach briefly, cite methods or data systems that exemplify it, and note its advantages and disadvantages, concluding with conceptual recommendations for improving it incrementally. Readers who have special interest in only one or two of these approaches may choose to skip the rest

Section IV outlines a new framework for assessing readiness and sustainability that would integrate data and analyses from most of the families of methods discussed in Sec. III (Hence, readers may find that parts of Sec IV seem familiar, depending on the parts of Sec. III they have read) The integrated approach would focus on the transition from peacetime posture—considering the time it would take units to achieve specified operational performance standards and prepare for deployment, the redistributions of manpower and materiel that would occur in marshaling forces for deployment and employment, the force and industrial mobilization activities, the availability and capacity of movement and handling systems to conduct deployment, and the dependencies of unit operational capabilities on the availability of materiel and of other units (e.g , supporting units or co-combatants)—ultimately projecting time profiles of the quantities of different mission activities that could be generated under different contingencies. Functional tests would be an important element of the integrated framework, ensuring the validity of timing, performance, and capacity estimates used in the analysis of the transition from peacetime footing Neither combat models nor war games are recommended for inclusion in the integrated assessment framework.

Section V concludes by categorizing the recommendations made in Secs. III and IV, addressing unit readiness, force readiness, sustainability, and overall integration

II. BACKGROUND

This section provides context for the subsequent discussions of readiness and sustainability assessment methods. It (1) briefly reviews the decisionmaking at different organizational levels that needs information about readiness and sustainability; (2) summarizes the readiness and sustainability measures in prominent high-level use today, highlighting numerous concerns about them; and (3) outlines several characteristics that would distinguish "ideal" measures of readiness and sustainability.[1] Although some of these desirable features may be in conflict or even unachievable, they point the way toward potential improvements.

DECISIONMAKING THAT REQUIRES INFORMATION ABOUT READINESS AND SUSTAINABILITY

Decisionmaking that requires information about readiness and sustainability occurs essentially in fiscal planning and resource allocation, and contingency/operational planning

Fiscal planning and resource allocation occur within the annual federal budgeting process. This is reflected in the Department of Defense's planning, programming, and budgeting system (PPBS) approximately as follows: The Joint Staff surveys the threat and lays out broad U.S. military strategies for different parts of the world, then OSD publishes the *Defense Planning Guidance* to convey to the services the critical operational and management objectives their programs should fulfill. (The *Defense Planning Guidance* includes an "illustrative planning scenario" (IPS) that the services use to establish their resource requirements and management programs) Given their operational taskings and their financial and other constraints, the services (in a "bottom-up" approach) identify the resources needed and

[1]This research began with a series of interviews on these topics with representatives from (1) OSD (including the following major offices Force Management and Personnel, Production and Logistics, Reserve Affairs, Policy, Acquisition, Comptroller, and Program Analysis and Evaluation), (2) the Joint Staff (including the Directorates for Logistics, Operational Plans and Interoperability, and Force Structure, Resources, and Assessment); (3) operations, logistics, and personnel staffs in the Army, Navy, Air Force, and Marine Corps, (4) congressional staffs (including the Congressional Budget Office and the House Armed Services Committee), and (5) especially well-informed others (from the National Defense University, the Institute for Defense Analyses, the Center for Naval Analyses, and private industry)

the corresponding programs to deliver the required capabilities After review by the Joint Staff and interaction with OSD (and with the Office of Management and Budget), the services' programs and corresponding budgets fold into the president's budget Congress then reviews, revises/negotiates, and authorizes defense programs and appropriates funds for them Finally, OSD and the services allocate the authorizations and appropriated funds to the various programs.[2]

Contingency/operational planning occurs within the Joint Staff and, primarily, within the unified and specified commands in the forms of "deliberate" and "time-sensitive" planning. (Currently, different unified commands are responsible for U S. forces in and contingency plans for Europe, the Atlantic, the Pacific, Southwest Asia, and the Caribbean/Central America.)[3] Following guidance from the Joint Chiefs of Staff (JCS) about national strategies and objectives for their areas of responsibility, the commanders-in-chief (CINCs) of the unified commands develop operational strategies, courses of action, and substantially detailed deployment/resupply schedules for the major contingencies they expect might occur The CINCs are supported in deliberate planning (1) by their in-theater components, which provide intelligence and help establish courses of action and associated unit and resource requirements; (2) by the services, which must identify the specific units and supplies that would be used to fulfill the CINCs' requirements; and (3) by the U S Transportation Command (USTRANSCOM and its components), which would move units and other resources into the theater.[4] The Joint Staff reviews the efficacy and feasibility of each CINC's major plans. The time-sensitive planning process is used to formulate and evaluate alternative courses of action and to develop deployment and resupply schedules in case no applicable "deliberate OPLAN" exists.[5]

Fiscal planning and resource allocation are aimed toward providing enough effective and properly balanced operational forces and supplies

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[2]Whole volumes are written on the PPBS and its constituent processes A concise and convenient synopsis is Armed Forces Staff College, 1986, pp 5-8 through 5-12

[3]There are also unified commands for special operations, transportation, and space The two specified commands are the Forces Command (FORSCOM) and the Strategic Air Command (SAC)

[4]See Armed Forces Staff College, 1986, Ch 6, for a more detailed description of deliberate planning Deliberate planning develops operational plans (OPLANs) so specific that parts of them can be converted immediately to operational orders (OPORDERs), invoking the actual deployment of certain units/resources or military action to achieve certain objectives An important product of deliberate planning is the time-phased force deployment data (TPFDD), a computerized schedule of the loading, movement, and unloading of specified units and materiels from their peacetime locations to the theater of conflict

[5]Ibid , Ch 7

to deter U.S. adversaries and to prevail in conflict if deterrence fails. Contingency/operational planning is aimed toward using whatever forces and supplies are available to the best advantage. Both kinds of decisionmaking need information about readiness and sustainability. In fiscal planning and resource allocation, judgments must be made about whether readiness and sustainability are adequate, consistent with mobilization and deployment capabilities, and in balance with force structure and modernization plans and programs. Further judgments are needed regarding the acceptability of risks inherent in any inadequacies, inconsistencies, or imbalances In contingency/operational planning, individual units and specific resources must be identified to meet specific deployment and employment schedules. Clearly, requirements for early-deploying units and materiels must be met with ready units and existing stockpiles

Fiscal planning and resource allocation are primarily annual, and contingency/operational planning occurs irregularly, whenever plans must be revised or new ones developed Some decisionmaking—usually within the services and mainly associated with identifying needs and allocating resources—occurs more or less constantly and falls within both fiscal planning/resource allocation and contingency/operational planning This decisionmaking feeds into the PPBS process in the quest for additional resources and, in both peacetime and wartime, redirects resources among units and locations to maintain alignment with contingency requirements

Table 1 summarizes the types of decisions faced at the main decisionmaking levels The decisions that occur annually are associated with the PPBS cycle (The change to a biennial budget process instituted in 1986 apparently has not yet changed the annual frequency.) At the highest levels, questions that face decisionmakers annually include, for example

- What are the risks and appropriate national security strategies for each region?[6]
- How capable are our forces of performing the activities required by those regional strategies?
- How are our forces' capabilities changing over time?
- How do funding levels for different accounts affect those capabilities?

[6]For a discussion that addresses a logical hierarchy and bureaucratic process linking defense resources to national objectives, see Kent (1989), Kent's discussion emphasizes force modernization much more than readiness or sustainability

Table 1

DECISIONMAKING REQUIRING READINESS AND SUSTAINABILITY INFORMATION

Organization Level	Primary Types of Decisionmaking	Approximate Frequency
President and Congress	National security objectives	Annual
	Funding levels for relevant accounts	Annual
	Mobilization/deployment degree/timing	Irregular
	Commitment to military action	Irregular
Secretary of Defense	Funding priorities and requests for corresponding accounts	Annual
	Mobilization activity sequence	Irregular
Joint Chiefs of Staff	Recommendation of national military strategies	Annual
	Apportionment of forces and resources among theaters	Annual/ Constant
	Recommendation of funding priorities to SECDEF, President, Congress	Annual
	Feasibility of Unified & Specified Commands' OPLANs	Irregular
	Alternatives for crisis action	Irregular
Unified and Specified Commands	Identification of "critical items" and "integrated priority lists"	Annual
	Adequacy of services' POMs	Annual
	Concepts of operations for different contingencies	Irregular
	Deployment/movement/reception schedules	Irregular
Service HQs	Funding requests for relevant accounts	Annual
	Priorities and programs for acquiring different materiel and manpower	Constant
	Reprogramming of funds during budget execution	Constant
Service Commands and Theater Components	Employment options and plans	Irregular
	"Source" units and materiels for OPLANs	Irregular
	Mobilization plans	Irregular
	Pre-positioning and resupply needs	Irregular
	Deployment/movement/reception schedules	Irregular
	Equipment, supply, manpower, and facility needs	Constant
	Training needs and plans	Annual
	Reallocations of resources among units/locations	Constant

Note that the questions here are about "capabilities," not just about readiness and/or sustainability. At lower organizational levels, decisionmakers annually face questions more like, for example:

- What additional resources are needed?
- Are budget requests and force plans balanced and justified?

The decisions in Table 1 that occur "constantly" may also be part of the regular PPBS cycle, but they are also part of day-to-day operational decisionmaking in peacetime or wartime They deal primarily with the allocation of available resources:

- Where are additional readiness and sustainability resources needed most? Which resources? How much/many?
- Where should those resources be taken/reallocated from?

The "irregular" decisions in Table 1 are associated with contingency planning, whether in deliberate or time-sensitive planning. They deal with such questions as:

- Which units and materiels should be designated for each use?
- How much can forces do? Where? How quickly? How long?

CURRENT MEASURES OF READINESS AND SUSTAINABILITY

Readiness and sustainability have traditionally been considered distinct, and DoD uses separate mechanisms to collect and summarize data about them Readiness is intended to reflect more or less the initial capability of units and forces; it is represented primarily through reports of the resources that units currently hold—generally compared with specified "requirements" for resources.[7] Although it deliberately avoids use of the term "readiness," the status of resources and training system (SORTS) is generally considered the preeminent reflection of

[7]"Requirement" is ubiquitous in DoD parlance Its meaning ranges from specification of a weapon system's operational characteristics (e g, a new aircraft's speed, range, and payload requirements), to force structure and deployment schedule characterizations (e g, requirements for providing some number of armored divisions within some number of days), to specifications of resource quantities and qualities (e g, requirements for personnel in designated numbers with designated training or for equipment or ammunition, say, of specific types in specific numbers). The common attribute of designated "requirements" is that they are determined through "military judgment," which is generally informed by operational analyses that examine and evaluate options and alternative assumptions

U.S. military readiness.[8] And sustainability, intended to reflect capability over a longer term, is represented primarily in the numbers of "days of supply" (DOS) held in stockpiles The services' Program Objective Memoranda (POMs), submitted during the programming phase of the PPBS cycle, portray readiness and sustainability somewhat differently than do SORTS and the CINCs' sustainability ratings (or "S-ratings," the latter based on DOS calculations).

Readiness Measurement Through SORTS and POM Data

The services submit SORTS reports irregularly (by regulation, within 24 hours of unit status changes or when a forecast date of status change passes) and (at their discretion) periodically to the JCS The reports pertain to individual units.[9] Each service determines the resource "requirements" for each reporting unit on the basis of the unit's planned wartime employment modes (based on approved OPLANs determined through the deliberate planning process) Each reporting unit then reports (through its chain of command up to its component command headquarters, where reports are provided simultaneously to the CINC, the Joint Staff database, and the service headquarters) its holdings or status against those requirements. Both active-duty and reserve units (including the National Guard) submit SORTS reports.[10]

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[8]The SORTS is a minor modification of its predecessor, the Unit Status and Identity Report (UNITREP) system It was modified to more accurately describe the kind of information provided by the system As the name implies, the SORTS reflects the amount and condition of personnel and equipment resources the unit possesses and the status of its training rather than attempting to define a degree of readiness Where UNITREP's "C-ratings" were characterized as reflecting different degrees of "readiness," the (identically determined) "category levels" or "C-levels" in SORTS are characterized as reflecting the proportion of its wartime missions the reporting unit can perform

[9]The Army reports the status of divisions, separate brigades, armored cavalry regiments, and parent-level Table of Organization and Equipment (TO&E) units of company size or larger (on-site air defense and PERSHING battalions report by battery) The Navy reports for ships, squadrons, and major combat service support units The Air Force reports for wings, groups, squadrons, and deployed/deployable detachments And the Marine Corps reports for combat service support battalions and for combat and combat support battalions, squadrons, deployed/deployable companies, batteries, and detachments

[10]The pertinent regulations are JCS Memorandum of Policy (MOP) 11, *Status of Resources and Training System*, 16 March 1990, Army Regulation 220 1, *Unit Status Reporting*, September 1986 Navy Regulation NWP 10-1-11 (Rev A), *Status of Resources and Training System (SORTS)*, September 1987, Air Force Regulation 55-15, *Unit Reporting of Resources and Training Status*, 24 December 1987, Marine Corps Order P-3000 13B, *Marine Corps Status of Resources and Training Standing Operations Procedures*, March 1989

The reports contain scores of data elements—including, for example, several resource counts (both required/authorized and held) and percentage availabilities, reasons for being below C-1 status, and forecast dates of C-level changes As displayed in Table 2, the report for each unit summarizes status in a single C-level for each of four resource categories:

- Personnel, accounting for manning in total, by military occupational specialty (MOS), and (optionally) by pay grade;
- Equipment and supplies on hand, accounting for combat-essential equipment, aircraft (if any), and (other) service-selected end-items, support equipment, and supplies,[11]

Table 2

CRITERIA FOR SORTS RESOURCE CATEGORY C-LEVELS
(Thresholds, percentages of prescribed wartime requirements)

	Personnel[a]		Equipment & Supplies[b]		Equipment Condition[b,c]		Training[d]	
C-1	Total	90	Combat	90	Combat	90	Completed	85
	MOS	85	Aircraft	90	Aircraft	75	Oprtnl Crews	85
	Grade	85	Other	90	End-Items	90	No days required	14
C-2	Total	80	Combat	80	Combat	70	Completed	70
	MOS	75	Aircraft	80	Aircraft	60	Oprtnl Crews	70
	Grade	75	Other	80	End-Items	70	No days required	28
C-3	Total	70	Combat	65	Combat	60	Completed	55
	MOS	65	Aircraft	60	Aircraft	50	Oprtnl Crews	55
	Grade	65	Other	65	End-Items	60	No days required	42
C-4	Lower		Lower		Lower		Lower or longer	
C-5	"Unit not prepared, undergoing service-directed resource action"							

SOURCE JCS, 1986c

[a]The percentage fill by pay grade may be used optionally

[b]The services provide supplemental methods for measuring the status of unique equipment (such as Air Force mobile communications equipment and navigation aids) that is unsuited for measurement by percentages

[c]Equipment must be fully operational within the mission or alert response time or 72 hours, whichever is shorter

[d]Each service designates *one* method of reporting training status for each type of unit

[11]Marine Corps Reserve units base this category level on equipment on hand for training plus equipment held in the stores system

- Equipment condition, accounting for combat-essential equipment and major end-items that are "fully operational . to perform the wartime mission;"
- Training, accounting for the percentage of unit training completed, the percentage of wartime-required aircrews that are formed, available, and fully operational, or the number of days of training required to attain fully trained status.

For example, an aircraft unit that had 64 percent of its aircrews formed, available, and fully operational would report C-3 in training (it passes the C-3 threshold but not the C-2 threshold) Each unit's status is summarized further in an "overall" C-level that reflects the proportion of its wartime mission(s) the unit is prepared to undertake. The alternatives are.

- C-1: Possesses required resources and is trained to undertake the *full* wartime mission for which it is organized or designed,
- C-2: Possesses required resources and has accomplished training necessary to undertake the *bulk* of the wartime mission for which it is organized or designed;
- C-3. Possesses required resources and has accomplished training necessary to undertake *major portions* of the wartime mission for which it is organized or designed,
- C-4: Requires additional resources and/or training to undertake its wartime mission, but if the situation dictates, may be directed to undertake *portions* of its wartime mission with resources on hand,
- C-5: Undergoing service-directed resource action and is *not prepared*, at this time, to undertake the wartime mission for which it is organized or designed.

The overall unit category level is reported as the lowest recorded for any of the four resource areas, unless the unit commander subjectively raises or lowers it.

Clearly, the better a unit is equipped, manned, and trained, the better its constituent category levels and overall SORTS reports can be and, presumably, the more likely its effectiveness in its wartime mission But observers voice numerous serious criticisms about this approach toward "measuring" readiness [12] We summarize the criticisms in five categories.

[12]To be fair, we must emphasize that the SORTS reporting structure was not originally *designed* or *intended* to meet many of these criticisms Fundamentally, SORTS data are intended to reflect only the near-term, almost momentary status of individual units—to assist the commanders of joint forces in choosing operational courses of action, schedules, and participating units Many of these criticisms arise because so many other uses have been attempted with SORTS data

scope of assessment, scenario limitations, requirements orientation, measurement technicalities, and treatment/aggregation of SORTS reports.

Scope of assessment:

- SORTS reports contain information only about units' assets (their "inputs"), not about what they could *do* (their "outputs") with them.
- No account is taken of improvements in resource availability or condition that could be accomplished during a period of predeployment preparation or mobilization
- Resources may exist outside the unit that could be allocated to fill its wartime requirements—e.g., from central repositories or other units.
- SORTS reports may suggest units' ability to undertake operations wherever they're based in peacetime, but they don't reflect their ability to deploy or the availability of external lift resources (land, sea, or air) to move them.
- SORTS data are inappropriate for assessing the mutual consistency of units' status—e.g., for considering whether combat operational units can be deployed and employed at times commensurate with the times for associated support units and other related combat units.

Scenario limitations:

- A unit's requirements are generally based on "the most-demanding OPLAN," so poor or mediocre SORTS reports can conceal strong actual capabilities. For example, an Air Force F-16 squadron that might be well prepared to conduct close-air-support operations in Grenada could be poorly prepared to conduct interdiction or air-to-air operations as part of its most-demanding requirement for a conflict with the Soviets in Europe.
- The time interval within which equipment must be on hand and fully operational may be artificially short. All units must report equipment status as they project it out to at most 72 hours, regardless of whether any OPLAN requires deployment that quickly.[13]

Requirements orientation:

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[13]See JCS, 1990c, pp. B-7, B-9

- The services themselves define the "requirements" in each category judgmentally.[14] There is concern that "requirements" may be lowered in austere times to prevent units from having to submit poor SORTS reports or be raised in periods of increased funding to increase the chances of obtaining desired resources.
- The requirements change legitimately as equipment, employment plans, training doctrine, etc., evolve, often in response to a changing threat. This frustrates the comparison of reported category levels from one time to another. (For example, a new training requirement could drop a unit's SORTS category level from C-2 to C-3, say, but the unit would be no less capable.)

Measurement technicalities:

- The size of "the reporting unit" is widely divergent. An Army heavy infantry division clearly contains greater numbers and diversity of men and equipment than does an Air Force fighter squadron. The larger and more diverse the reporting "unit," the more difficult it is to determine the summary category level for each reporting category (especially the "overall status") and the less that can be inferred about the reporting unit's actual status.[15]
- The category levels themselves are fairly coarse, so that units' holdings could increase or decrease substantially without crossing into a different category level.
- SORTS reports and summaries mix categorical and continuous number scales: The category level for equipment and supply is determined from the percentage of required items the unit holds, the unit's overall category level is determined from the individual category levels (plus the commander's judgment), and SORTS summaries generally tell the percentage of units holding each category level.
- Reporting the category level as the lowest percentage of the requirement held for any resource in the category assumes that all resources in the category are equally important. And the categories themselves are implicitly considered equally impor-

[14]For instance, Air Force units include counts of mobility bags (containing chemical and cold-weather personal gear, for example) in SORTS reports, but these counts are not used in determining the C-level for equipment and supplies on hand or the unit's overall C-level. (See AFR 55-15 (C2), 24 December 1987, p. 24.1.)

[15]Although the Navy submits its SORTS reports for large units—mainly for entire ships—the individual units report category levels separately for each pertinent "mission area"—e.g., for antisubmarine warfare vs. strike warfare.

tant if the overall category level is determined as the minimum of the other four category levels. The possibility of substituting one type of resource for another (e.g., compensating for spare parts shortages by using maintenance personnel to "cannibalize" components from other equipment) is ignored.

- If the overall category level (or any of the four resource category levels) is determined subjectively by the unit commander, that commander's motivations could overwhelm the objectivity desired in the reporting system.[16]
- SORTS reporting consumes substantial amounts of time and attention in the reporting units.

Treatment and aggregation of SORTS reports:

- Comparison of reported category levels against scheduled deployment times seems to be sporadic. Comparisons made several years ago by the Office of the Assistant Secretary of Defense for Reserve Affairs revealed serious problems in the preparedness of Army Reserve combat service support units. Such comparisons are important to ascertain whether units can be deployed and used in the proper sequences and with necessary simultaneity.
- In high-level summaries of SORTS information, the scenarios and missions on which the reports are based are seldom distinguished. Statements such as "__% of Army units report category level 3" do not reveal which units, which OPLANs they're reporting against, or which missions they can and cannot perform, and SORTS provides no easy means for identifying more than the units and the shortfalls that place them at their reported category levels.

Finally, the mere existence of SORTS category levels induces commanders to seek the highest level, C-1. But holding all units at the highest levels of resources and training may not even be desirable from a management perspective. Units that do not have rapid deployment requirements should have time in a contingency to upgrade their resources and training. Although we are not aware of estimates of how much greater the cost, it clearly costs more to maintain units at higher

[16]There may be motivations to deflate SORTS reports (e.g., to raise the likelihood of obtaining additional resources or to reduce the likelihood of having to "prove" capability), but motivations to inflate are reportedly far stronger (e.g., to demonstrate the "can-do" attitude, to look good in a superior's eyes, and to be available for the occasional real operational opportunity). Conventional wisdom holds that superiors consider SORTS reports when preparing formal performance evaluations of their subordinates, although that violates DoD policy.

C-levels. Thus, defense managers should endeavor to align units' resources and training with realistic deployment schedules Units that deploy earlier should be maintained at higher C-levels, unless the time required to upgrade them is shorter.[17] Only the Army, in its "authorized level of organization" (ALO) mechanism,[18] seems to recognize this explicitly in its reporting mechanisms. Because funding always seems inadequate to support full resourcing, the Army authorizes selectively reduced levels of resources for selected units Thus, unit commanders can be less concerned about not having all the resources and training required to achieve SORTS level C-1 [19]

SORTS is intended to reflect the ability of units to undertake their wartime missions nearly instantaneously The services and Joint Chiefs of Staff should be able to use SORTS to help select units to employ on short notice in specific contingencies. But several different indicators of "readiness" are used in the PPBS process· (a) weapon system mission-capable rates, (b) peacetime operating tempos (OPTEMPOs) and resources (operating rates, crew ratios, depot maintenance, weapon system alteration, etc), and (c) acquisition logistics and operations and support (O&S) funding for selected weapon systems [20] The Defense Resources Board (DRB) prescribes formats the services use for projecting such data (a total of eight years) until and through the Five-Year Defense Plan (FYDP) period [21] Unfortunately, there is a dearth of information on how these indicators—especially OPTEMPO and O&S funding—might affect warfighting capability. Moreover, mission-capable rates are extremely difficult to predict (because they depend on component failure rates, spare parts inventories, and repair requirements and capabilities that cannot be predicted accurately), and expediting actions (e.g , repair pipeline

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[17]The importance of maintaining balance between units' availability for deployment and the strategic lift capacity (for moving units and supplies to foreign operational theaters) was illustrated in DoD's "Revised Inter-theater Mobility Study (RIMS)" (see Smartt, 1986) More rapid availability for deployment can enable movement by slower (and cheaper) means, but there is no value in achieving availabilities for deployment that precede the availability of lift capacity

[18]Army Regulation 220-1, *Unit Status Reporting*, 16 September 1986, p 3

[19]In the context of spare parts maintenance and distribution, the Air Force is beginning to set differential goals for units' aircraft availability rates, depending on the units' scheduled deployment times But this is not yet reflected in differential specification of requirements in the SORTS reporting system.

[20]Office of the Executive Secretary to the Defense Resources Board, 1987, pp 75–78 This POM Preparation Instruction (PPI) began requiring more detailed data from the services about readiness and sustainability (Sec V) The increase was offset by reductions elsewhere (e g , in manpower formats, in the number of nonmajor systems reported in detail, and in project-level detail on construction)

[21]Ibid , pp 82–113

compression) can be used to raise mission-capable rates if conflict looks imminent.

Sustainability Measurement by S-Ratings and POM Data

As noted, sustainability is currently measured primarily in terms of DOS. Unified and specified commands assemble data and report in biennial "CINC's Preparedness Assessment Reports" (CSPARs) on the percentages of the "objective DOS" represented in theater war reserve stocks (whether pre-positioned in the theater or not). For each of nine classes of supply, the objective is determined based on the "most-demanding OPLAN" for each theater[22] Somewhat paralleling the SORTS category levels, this sustainability reporting system conveys a categorical "sustainability rating (or S-rating)" for each class of supply. An S-rating reflects the percentage on hand of a designated requirement for that item; the requirement is stated in terms of an objective number of days of supply. Table 3 summarizes the criteria for the various S-ratings.

The commander reviews the data contributing to each S-rating and may adjust the rating commensurate with his subjective assessment, also reporting in his CSPAR reasons for adjustments and clarifying any especially serious materiel shortfalls. Maldistribution of existing resources is also of considerable concern to commanders (e g., allocated stocks that are outside the theater)

Increased stockpiling of resources clearly tends to increase commands' S-ratings But, again, many conceptual criticisms apply to this measurement method.[23] We group them into two categories: scope of assessment and measurement technicalities

Scope of assessment:

- Like SORTS' C-ratings, S ratings primarily reflect military assets ("inputs"), not the operational activities ("outputs") they could enable
- S-ratings convey negligible information about the adequacy of supplies for contingencies other than the most demanding one anticipated.
- No account is taken of potential resupply from unapportioned central stockpiles (e g., from the Defense Logistics Agency, DLA) or from new industrial production. Sustainability, too, could be upgraded during a period of mobilization.

[22]Joint Chiefs of Staff, 1986b More recently the objective is derived from the "base case" of the Global War Family OPLAN for individual theaters

[23]Just as for SORTS, some of these criticisms reflect limitations in the usefulness of S-ratings beyond the ratings' original intent

Table 3

CRITERIA FOR MILITARY CAPABILITY REPORT SUSTAINABILITY RATINGS

Sustainability Rating	Percentage of Pre-positioning DOS Objective Available[a]
S-1	90–100
S-2	75–89
S-3	50–74
S-4	0–49

SOURCE: JCS, 1986b

[a]For supply classes I (rations) and III (fuels, lubricants), the S-rating is determined by percentage of fill For example, 78 percent of required rations dictates an S-2 rating For other supply classes (II–individual equipment, IV–construction materials, V–ammunition, VI–personal items, VII–major end-items, VIII–medical supplies, IX–repair parts), the aggregate rating is taken as the S-rating containing the 90th percentile of constituent line items' S-ratings For example, if 50 percent of the items in the class are S-1, 30 percent are S-2, 15 percent are S-3, and 5 percent are S-4, then the aggregate S-rating would be S-3.

- No account is taken of the relationship of stockpiles to allies' requirements, stockpiles, or production potential. For instance, our European allies reportedly provide their forces with less sustainability than does the United States. How much support could we provide each other in actual contingencies, and what would be the resulting sustainability of our combined forces?

Measurement technicalities:

- The precise quantities of some kinds of items are unknown. In these cases the commands may determine their S-ratings on the basis of coarse measures of quantity—e.g., estimated tonnages or dollar values.
- The underlying assumptions about time-varying materiel supply expenditure and loss rates are missing. In fact, these rates can be estimated only with considerable uncertainty (Assumptions are implicit about combat scale and intensity, and even about the enemy's sustainability.) Yet S-ratings *look* definitive

- As combat doctrine, equipment, and munitions change over time, so can the estimated requirements and, consequently, the S-ratings Thus, just as for SORTS data, it is difficult to make comparisons from one year to the next.
- The meaning of a DOS figure is unclear. For example, if a unified command has 100 percent of the pre-positioned stock estimated to be required for 30 days, say, does it also have 100 percent of the stock to enable operations at a 15 percent slower tempo for 15 percent longer? For spare parts, the interpretation of DOS is especially difficult. Predictions of the demands for spare parts are notoriously inaccurate even in peacetime, and even if wartime demands could be predicted fairly accurately, shortages often can be met effectively with parts cannibalization and expedited repair. Thus, *some* capability can almost certainly be maintained beyond any arbitrarily defined DOS horizon
- The S-ratings' coarse, categorical nature (e.g , S-2 vs. S-3) permits important "internal" changes in sustainability without reflecting changes in S-ratings
- Shortages of a few items within most supply classes can be quite severe without affecting the S-rating adversely, although the commander is likely to highlight such shortages by either adjusting the S-rating subjectively or describing the situation within his CSPAR
- In aggregating materiel counts across entire commands to determine DOS availability and S-ratings, there is an implicit assumption that materiel distribution within combat theaters will be efficient in keeping resources in the hands of those who will need and use them
- As for SORTS, objectivity is compromised by the fact that the commander can adjust S-ratings subjectively [24]

DoD prominently uses two other indicators of sustainability besides S-ratings. (1) DOS figures submitted by the services to OSD in their Program Objective Memoranda in the PPBS cycle and (2) comparisons of the dynamic demand and supply of specific types of personnel through the Wartime Manpower Mobilization Planning System (WARMAPS) Let us consider each briefly.

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[24]We believe that the theater commanders' incentives for S-ratings work in the opposite direction from CONUS commanders' incentives for C-levels Theater commanders are less likely to overstate their capabilities

For the most part, DOS figures used in the POMs are calculated based on the ratios between "dollars required" and "dollars programmed" That is,

$$DOS = (DP/DR)(PPO)$$

where PPO = program planning objective, the number of days of wartime supply specified for the Illustrative Planning Scenario (IPS) in the Materiel Sustainability portion of the Defense Planning Guidance (DPG)

DR = number of dollars required to provide stocks to meet the PPO

DP = number of dollars of stock on hand (available) plus programmed to provide such stocks.

The services submit such figures only for secondary items, petroleum, and conventional munitions (including tactical missiles).[25] For each aircraft type, the services must also provide projected sortie rates and/or flying hours per aircraft for surge and sustained periods of wartime operations, along with corresponding assumed attrition rates. For ground and naval operations, they "should specify the operationally oriented measure or other parameters used in determining wartime sustainability requirements" The figures submitted are quite coarse—distinguishing secondary items only in retail vs wholesale categories, petroleum stocks and storage capacity only in four geographic areas (CONUS, NATO, Southwest Asia, and "other"), and conventional munitions in war reserve vs training munitions[26] Collective interpretation of these data as submitted—e g., in terms of their representation of operational sustainability in different combat theaters or for different kinds of contingencies—is impossible. A new portion of the POM submission, however, has the potential for addressing such concerns. "Section IX, Unified and Specified Commands" In this section each Service must address (separately by command) each major requirement identified in the integrated priority list (IPL) of each

[25]Office of the Executive Secretary, 1987, pp 78–80 and pp 114–121 (Note The term PPO replaces MTO, the midterm objective, used in previous PPIs)

[26]Submissions for conventional munitions also distinguish annual procurement quantities and inventory levels "for munitions procurement programs for which more than $100 million is programmed over the POM years, programs classified as 'New Starts,' programs to maintain a warm production base, and programs to meet Republic of Korea stockpile shortfalls" Ibid, p 119

commander-in-chief of each unified or specified command.[27] At the CINCs' discretion, the IPL items may emphasize force modernization or readiness as much as (or more than) sustainability.

The services' POM submissions contain negligible information about manpower sustainability Instead, they focus primarily on peacetime personnel plans and programs (e.g , recruiting, training, retention bonuses, and moving costs).[28] Wartime requirements are considered only for medical manpower and then only for one year in the planning horizon (Requirements and "programmed manpower" are tabulated separately for six geographic areas and 12 areas of medical specialization)

But in WARMAPS, DoD considers the dynamic demand and supply of military and civilian manpower in considerable detail [29] The services use WARMAPS to identify shortfalls that would develop in the manning of occupational groups (aggregations of specialties) at different points in the DPG's IPS. (In principle, WARMAPS could also be used to compare manpower demands and supplies for the CINCs' various OPLANs) WARMAPS summaries compare—within occupational group, theater, and manpower component, for each service, and for each 10-day increment after mobilization—the number of people available with the number required by mobilization, deployment, and workload plans. The requirement (the demand stream) is determined considering, for example, reserve unit mobilization, active and reserve unit augmentation, lift capability, equipment pre-positioning, wartime equipment attrition and workload changes, and personnel casualties. Personnel availability (the supply stream) is determined considering, for example, all active and reserve personnel, military retirees, recruits available through the Selective Service System (SSS) and military training, civilian reassignment, full-time hiring of part-time and intermittent peacetime workers, host-nation support, and additional use of contractors. Although some of the assumptions required to enable WARMAPS operation—especially casualty and medical restoration rates—are probably very uncertain, WARMAPS is a thoughtful and compelling method of considering personnel sustainability. It considers all manpower resources, wartime demands, and the transition from

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[27]Ibid , p 161 Note CINCs prepare critical items lists (CILs) for compilation into IPLs to be forwarded to the services for use in the PPBS A critical item is "an essential item which is in short supply or expected to be in short supply for an extended period " Joint Chiefs of Staff, 1986a, p 97

[28]Ibid , Section VII, pp 141–160

[29]See DODI 1100 19, *Wartime Manpower Mobilization Planning Policies and Procedures*, February 20, 1986, DOD 1100 19-H (Handbook), *Wartime Manpower Program Guidance*, August 1982, DOD 1100 19-M (Manual). *Wartime Manpower Planning System ADP System Users Manual*, June 1983

peace to war. The primary criticisms that apply are that it considers military manpower in very broad occupational groups (so it can mask shortages or overages that may exist within individual specialties), and the shortfalls it identifies cannot be interpreted readily in terms of the wartime operational activities that would be diminished[30]

CHARACTERISTICS OF "IDEAL" MEASURES OF READINESS AND SUSTAINABILITY

The quest for improved measures of readiness and sustainability to support decisionmaking at different organization levels is not new, of course. Relevant studies have been conducted at virtually all levels for several years.[31] From RAND's background in these areas, from the body of work by others, and from our interviews with decisionmakers and staff members concerned with these problems, we have distilled eight characteristics that we believe should be present in "ideal" measures of readiness and sustainability

- Measurement of outputs, not merely inputs; reflect what units and forces can do, not just what they have This requires distinguishing mission, location, scale, and time dimensions, making clear the "what" in the question· "Readiness and sustainability for what?"[32]
- Practical· undisruptive, inexpensive, understandable—i e, maintain ease in data collection, assembly, and interpretation The job of measurement should stay extremely small compared with the jobs of providing readiness and sustainability And the results of the measurements should carry meanings that decisionmakers can interpret fairly readily

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[30]The services derive their information for WARMAPS from more detailed data and analysis systems that they use internally for manpower mobilization/deployment planning For example, the Air Force uses COMPES/MANPER (see U S Air Force, 1988), and the Army uses its Mobilization Personnel Structure and Composition System, MOBPERSACS (see Pickett et al, 1986)

[31]The most recent and relevant initiatives in DoD are the "Sustainability Assessment Task Force (SATF)" established by the Deputy Secretary of Defense in June 1988, and the "Conventional Forces Readiness Committee" (CFRC) established under DoD Directive 5120 50, July 1989 The SATF's members include operations and logistics leaders from the Army, Navy, Air Force, Marine Corps, and the Joint Staff, plus senior OSD officials representing the Assistant Secretaries of Defense for Production and Logistics, for Program Analysis and Evaluation, and for Force Management and Personnel The SATF was established to enable the development of "operationally oriented measures of sustainability," identifying and removing "roadblocks" to the development by the services of more consistent and meaningful measures than DOS (as mandated by the DPG) See Office of the Assistant Secretary of Defense, 1988a Brand new, the CFRC has met only a few times We summarize its charter briefly in Sec IV

[32]See Komer, 1984, pp 128–131

- Objective, verifiable, not subject to "gaming"—i.e., remove as much subjectivity as possible. Subjective judgments will probably always be necessary in deciding which units should be committed to action, but they diminish the acceptability of assessments used in the PPBS process and in interactions with those outside of DoD
- Reflect robustness—i e., illuminate readiness and sustainability for a range of circumstances, for example, involving unexpected consumption and casualty rates within a contingency, and even different types of contingencies.
- Useful to data providers—i e , give feedback to those who provide the data Simply "feeding in" data, as SORTS and S-rating reporting currently require, is only burdensome at the level of reporting units, especially if little action can be observed in correcting shortfalls.
- Comparable over time—i.e., permit comparisons of readiness and sustainability status from one year to another This is especially important for communications between DoD and Congress, whether they address changes from previous years or those to be made in future years.
- Comprehensive—i e., relate peacetime's people, stocks, and activity to the ability to conduct military operations. This requires considering mobilization and movement—i.e , the transition from peace to war.
- Permit evaluation of tradeoffs—e g., between resource categories (maintenance manpower vs. spare parts, for instance) or even among readiness, sustainability, and force structure

Some of these "ideal" characteristics conflict. For example, the objectives of measuring outputs and including the transition from peacetime would tend to make readiness and sustainability assessments more complex and difficult to construct, working in the opposite direction from keeping measures simple and easily interpretable. Probably no single readiness and sustainability measurement system would possess all these characteristics in high enough degrees to please all observers The diversity of these characteristics helps explain the wide variety of assessment methods summarized in the next section, they serve somewhat different purposes and emphasize these desirable characteristics to different degrees Our challenge is to conceive a readiness and sustainability measurement framework that provides all of these characteristics insofar as possible and strikes an acceptable balance between conflicting characteristics

The fact that today's readiness and sustainability measures do not balance or, in some cases, possess some of these characteristics helps explain why improvements are needed Table 4 summarizes our assessment of how well SORTS' C-levels and the CINCs' S-ratings measure up with respect to these eight characteristics Unfortunately, neither does very well[33] The remainder of this report describes alternative potential approaches for measuring readiness and/or sustainability and considers their strengths and weaknesses with respect to these same "ideal" characteristics.

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[33]The term "implicit" in Table 4 indicates that this underlying information cannot be inferred from the C-level or S-rating

Table 4

C-LEVELS AND S-RATINGS VS "IDEAL" MEASUREMENT CHARACTERISTICS

"Ideal" Measurement Characteristic	Presence Within	
	C-Levels	S-Ratings
1. Measure outputs, not merely inputs		
Mission dimension	Implicit[a]	Implicit
Location dimension (theater)	Absent	High
Scale dimension	Absent	Implicit
Time dimension	Absent[b]	High
2 Practical		
Undisruptive	Medium	Low
Inexpensive	Medium	Medium
Understandable	Low	Low
3 Objective, verifiable	Low[c]	Low
4. Reflect robustness	Low	Low
5. Useful to data providers	Medium	Medium
6 Values comparable over time	Low	Low
7 Comprehensive (transition from peacetime)		
Peacetime manning	High	Absent
Peacetime stocks	Partial	Partial
Peacetime OPTEMPOs	Low	Absent
Mobilization	Low[d]	Absent
Deployment	Absent	Absent
8 Permit evaluation of tradeoffs	Absent	Absent

[a]Each unit's SORTS report is relative to the requirements for one or more "most demanding" wartime missions, but *which* missions are meant is not clear in the report (Navy units do consider separate mission areas)

[b]Army and Marine Corps ground unit SORTS reports *do* contain a time dimension in their training category level

[c]Unit commanders in the Navy may not adjust their "overall" C-levels subjectively

[d]Except in the Army and Marine Corps ground units' treatment of train-up time

III. CONCEPTUAL APPROACHES TO READINESS AND SUSTAINABILITY MEASUREMENT

Numerous systematic approaches do or could contribute to the measurement of one or more aspects of readiness or sustainability. SORTS C-levels and CINCs' S-ratings are specific instances of only two of these approaches. In this section we describe seven approaches generically In each case we note existing examples, summarize the aspects of readiness and/or sustainability that the approach emphasizes, outline the approach's relative advantages and disadvantages with respect to the "ideal" characteristics delineated above, and suggest enhancements that could raise its value in measuring readiness and sustainability.

Although approaches in one category can contribute to measurement in another, it is useful to subdivide the conceptual approaches into two categories: those oriented primarily toward units and those oriented primarily toward forces The former tend more to illuminate readiness (or initial capability), the latter generally bring in sustainability more strongly.

The seven families of methods we describe here are somewhat arbitrarily defined. Some methods do not fit within a single family readily, perhaps because they deal with more than one topic or borrow methods or data closely associated with another family Nevertheless, the families facilitate discussion. They represent reporting, analysis, and/or planning and evaluation approaches that are fairly distinct, admittedly partial in their treatment of readiness and sustainability, and largely complementary in their current and potential contributions to readiness and sustainability measurement.

APPROACHES ORIENTED PRIMARILY TOWARD UNITS

Three families of methods are oriented primarily toward individual units:

- Asset reporting—straightforward compilations of (and/or characterizations of) the resources held by individual units,
- Unit modeling—(usually) Monte Carlo simulations that translate information about available resource quantities into estimates of weapon system availability or mission generation rates;

- Functional testing—examinations of units' operational, deployment, and/or support capabilities through tests and exercises.

Asset Reporting

SORTS C-levels are determined largely on the basis of units' operational "requirements" determined by the services and other, more detailed unit-asset-reporting systems that the services use to keep track of asset distribution and status For instance, the Army uses data from its Continuing Balance System-Extended (CBS-X) in considering property for SORTS reporting, the Navy uses data from its Conventional Ammunition Information Management System (CAIMS) in considering shipboard munitions, and the Air Force uses data from its Equipment Management System Each service (and the Defense Logistics Agency) has developed and maintains specialized data and resource management systems for keeping track of and managing different types of resources—e.g., major equipment items and their condition, spare parts, fuels, personnel, and training SORTS simply draws together data from these disparate data systems, under the watchful eyes of the units that must use those resources in contingencies and that are charged with maintaining them in peacetime SORTS "boils down" the services' massively detailed data about asset counts and conditions by comparing them with "requirements" for each unit's (most demanding) wartime scenario and consolidating the results into the four C-levels, reflecting equipment and supplies, equipment condition, personnel, and training. In fact, units record raw counts of many types of resources in SORTS reports, along with comments about the importance of shortfalls and the steps and schedules identified for correcting them Naturally, when these data are consolidated for decisionmakers at high levels (especially those outside the services), this detail is typically bypassed Summaries generally report only the fractions of units (sometimes segregated by type and/or resource category) reporting at each C-level. Usually, the summaries are based on units' "overall" reported C-levels, the most subjective of all

SORTS data are especially useful at the lower decisionmaking levels: the service commands, the theater components, and up to the service headquarters. First, the data are used here to detect problems (e g , low rates of equipment readiness), to stimulate searches for their causes (e.g., excessively long repair pipelines), to identify needs for additional resources (e g , more funding for a weapon system's spare or repair parts), and to track progress toward goals. These are the levels where management actions can be taken against specific identified problems Second, the decisions about which units to deploy/employ for "no-plan" contingencies[1] are also made at these levels—under guidance, of course, from the unified and specified commands and the Joint Staff SORTS provides a starting point for this decisionmaking too. But different contingencies typically emphasize different capabilities within a unit's repertoire, and units are typically selected only after information is obtained beyond that available through SORTS—e.g., the length of time since an activity has been practiced or the seniority of the leadership in particular functional areas.

But for decisionmakers above the services, unit-asset-reporting data—even, we believe, as they are summarized in SORTS—are not very helpful. These decisionmakers need information about the *consequences* of such data: Which of our national security objectives/obligations are at risk because of readiness or sustainability limitations? What could (or could not) our forces *do*, how quickly, and with what scale? And how much would it cost (or, how much might it save) to change the situation?

Two additional important steps are sometimes taken with unit asset data that go beyond comparisons against wartime asset requirements: estimation of the length of time it would take each unit to achieve appropriate wartime capability (through additional training) and comparison of this time with deployment times scheduled for different potential contingencies.[2] As noted earlier, the Office of the Assistant Secretary of Defense for Reserve Affairs and the General Accounting Office have identified important discrepancies when making such comparisons, especially for Army reserve combat service support units. We believe that the utility of unit asset data would be greatly enhanced—for all levels of decisionmaking, but especially for the higher levels—by incorporation of the "time dimension" for *all* types of units Unit training and performance objectives already exist Consequently, it should be possible to select one or more points in a range of such objectives and to estimate the length(s) of time it would take each unit to achieve them.[3] This should be augmented with corresponding estimates of the lengths of time it would take units to prepare for deployment The availability of such estimates would enable the generation of estimated profiles over time of the numbers of units of each type

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[1]Contingencies are "no-planners" if they must be met with time-sensitive planning because no deliberately developed OPLAN is available

[2]Each OPLAN developed through the "deliberate planning process" includes time-phased force deployment data that contain movement schedules

[3]The steaming days required for Navy combatant ships to advance to adjacent higher C-levels in training readiness are estimated in Follmann, Marcus, and Cavalluzzo, 1986 And the Army has a model that might be extended to serve this purpose (see CACI, Inc., 1987)

that could be brought to desired levels of capability and readied for deployment. These could be compared with corresponding profiles of requirements for units of each type for different contingencies. Decisionmakers could better understand risks and develop their own decision priorities from studying such profile comparisons. This idea is illustrated in Fig. 1.

This modification would place greater emphasis on units "training readiness" than does SORTS. Corresponding estimates might also be provided for the time needed to bring assigned equipment into an

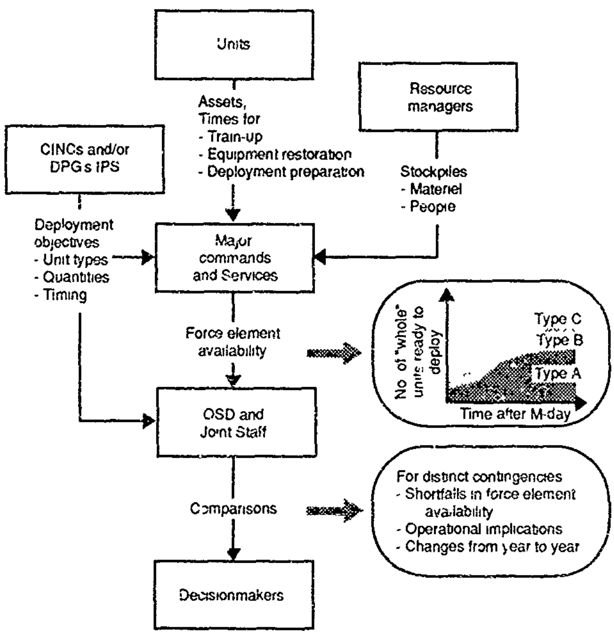

Fig. 1—Estimated unit availabilities vs. requirements

objective condition and to prepare it for deployment.[4] The unit's availability, then, could be determined as the maximum of its "equipment preparation time" or its "people preparation time."

Two other changes would enhance the utility to decisionmakers of unit-asset-reporting mechanisms, overcoming several of the criticisms that apply to SORTS:

- At the unit level, ignore the coarse thresholds that separate category levels, and simply report the counts of available key assets. Higher organizational levels (e.g., major commands or service headquarters) could compare these with the requirements for different contingencies, avoiding the mixing of reports against different contingency requirements that SORTS embodies
- Account for the availability of equipment, supplies, and personnel from other sources—e.g., other units, central stockpiles, or reserves. In emergencies, units' resources are not limited to those initially in their possession.[5] Naturally, this accounting would have to be done at organizational levels higher than the reporting units themselves [6]

All in all, these changes would emphasize *how long* it would take to generate forces of specified sizes and mixes (or, alternatively, what forces could be generated within specified times). Decisionmakers would concentrate on these times, represented on a continuous scale, and the adequacy of the numbers and combinations of force elements that could be generated. Focusing on time would have the dual benefits of relating more clearly to contingency requirements and of emphasizing the lead time needed for force preparation and mobilization

We believe such an extended asset reporting system should be augmented with carefully conceived functional tests to verify or ensure the accuracy of time estimates. These tests would examine the operational, support, and deployment capabilities that different amounts of lead time could actually achieve.

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[4]Unit training and equipment condition are the two elements of SORTS information that units themselves can most nearly control The availabilities of equipment, supplies, and personnel are primarily controlled by "outside" headquarters and support functions

[5]In fact, given the availability of resources from outside, a strong argument can be made that units need possess in peacetime only what they need to accomplish their peacetime training and any additional training required to bring capabilities up to wartime standards

[6]Such systems as the Army's Mobilization Equipment Redistribution System (MOBERS) would be needed to keep track of resources across units and repositories and to identify augmentation and "cross-leveling" that would enable the generation of "whole" units

In summary, we believe that asset-reporting mechanisms would be improved by extending them to provide much more useful information about both unit and force readiness Changes from current mechanisms (principally SORTS) would be as follows:

- Units would report only raw counts (and corresponding "conditions") of available designated equipment, supplies, and personnel
- Units would also report estimates of the lead times needed to bring personnel and equipment up to stated conditions and performance levels and to prepare themselves for deployment. (Train-up times would receive prominent attention, and they might differ depending upon the type of contingency.)
- Higher organization levels would combine information about unit train-up times, unit assets, contingency-specific asset requirements, and stockpiles of assets and manpower available elsewhere to ascertain how many units of different types could be ready to deploy within specified times.
- The numbers and types of units available at different times would be compared with the corresponding numbers required for specified contingencies

The services would still have the important information needed for resource management and budget request development, and they could provide improved unit-specific characterizations to the joint community for use in crisis action planning. But these revisions would provide important new information to high-level decisionmakers about the availability of *forces* for different types of contingencies, information much more useful for their level of decisionmaking.

Several advantages would accrue to such an extended asset-reporting approach:

- Units could more easily provide objective data about the assets on hand.
- Summary indicators would be available for different contingencies, whether illustrative or based on actual OPLANs
- Information would be based on a continuous (time) scale rather than discrete categories.
- Differences through time between the (deployment) requirements for different types of units and their corresponding availabilities would be clarified, illuminating possible inconsistencies among operational requirements, deployment capacities, and unit availabilities.

- The resulting high-level comparisons would be interpreted more readily, and the entire measurement process would remain straightforward

But several disadvantages would also remain:

- Judgments would still be necessary about the "requirements" for unit assets and for the operational capabilities to be achieved through training (Note that many such judgments are already available.)
- Emphasis would still fall on the availability of assets ("inputs"), less on what capabilities ("outputs") would be achievable with them
- Potential tradeoffs (between maintenance personnel and spare parts, for example) would not be addressed
- Negligible information would be provided about sustainability.

Additional efforts clearly would be required initially to implement such an extended asset reporting system. For example, different contingencies would have to be articulated and their requirements determined, some of the services would have to develop means for projecting the amounts of time required for units to train up, and mechanisms would be needed to combine and interpret information about unit assets and about "stockpiles" (of materiel and people) We do not consider such startup efforts as disadvantages in the eventual routine operation of an extended asset reporting system, however.

Unit Modeling

"Unit modeling" represents a family of methods for transforming unit inputs into estimates of unit "outputs." The unit under study is typically a ground force battalion, an aircraft squadron, or a Naval ship. Larger aggregations (e g., divisions rather than battalions) are generally regarded as forces rather than as units and are seldom considered under this approach Unit models typically do not predict "ultimate outputs," such as the number of enemy targets destroyed or the movement in the "forward line of own troops" (FLOT). Instead, they predict intermediate outputs such as the numbers of platoons massed, artillery rounds delivered, or sorties generated

The relationships between inputs and intermediate outputs are most commonly established with Monte Carlo simulation techniques. Multiple model runs are required to estimate the variance as well as the mean of each output measure. Simulation is necessary when the models are too complicated to allow a closed-form analytical solution.[7]

Each service has its own set of unit models. For example, the Air Force uses the Dynamic Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC) Model as part of its Weapon System Management Information System (WSMIS)[8] and is developing the Enhanced SORTS Capability Assessment Model (ESCAM).[9] RAND developed the Army Unit Readiness Assessor (AURA) to model Army units' generation of specific operational capabilities.[10] And the Navy uses the Simulation Package for the Evaluation by Computer Techniques of Readiness, Utilization, and Maintenance (SPECTRUM) (see Perazza and Temkin, 1986) to model carrier airwings, and the TIGER model (see Naval Sea Systems Command, 1987) to model ship system availability

Unit models are "one-sided" rather than "two-sided." Commanders' decisions are not explicitly modeled. Enemy actions are incorporated indirectly through the personnel and equipment attrition rates and through battle damage rates that are applied to friendly forces. Such rates are inputs to unit models. Other model inputs include equipment failure rates, repair rates, and expenditure rates for such commodities as fuel and ordnance All of the inputs may be varied during successive model runs, permitting analysis of the sensitivity of model outputs to input values

Another model input is the set of intermediate output goals For example, models of aircraft squadrons require sortie schedules as objectives for each day of the conflict The models attempt to fly sorties according to schedule, and success is often measured by the number of sorties flown divided by the number of sorties scheduled each day, called the daily success rate.

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[7]A few researchers have attempted to summarize the relationships between input levels and mean output levels using a small number of closed-form regression equations Examples of this approach are Cavalluzzo and Horowitz, 1987, Cedel and Fuchs. 1986, Goldberg, 1986, and Scribner et al, 1986 However, the regression approach has been attempted on a case-study basis only, it is not of wide enough applicability for present purposes

[8]Dyna-METRIC was developed originally at RAND as a closed-form, analytic model (see Hillestad, 1982), but it has evolved into another Monte Carlo simulation (see Isaacson, 1988) WSMIS is described in Dynamics Research Corporation, 1984

[9]See Schubert, 1988 ESCAM is a derivative of RAND's Theater Simulation of Airbase Resources (TSAR) model (see Emerson, 1982)

[10]AURA is another derivative of TSAR (see Shishko and Kamins, 1983, Shishko and Paulson, 1981) After evaluation by the Army Materiel and Systems Analysis Agency (AMSAA), the Army decided not to implement AURA AMSAA determined that AURA required more detailed input data than the Army could supply

Resource inputs are usually restricted to those the unit holds at the outset of the conflict. These resources can include personnel (numbers and skill levels), equipment (numbers and initial operating condition), fuel, ordnance, and spare parts. Some models allow rudimentary forms of resupply and rearward maintenance. This is the extent to which most unit models treat forces, rather than isolated units.[11] However, true force-level modeling would have to consider command and control across units—e g., to reallocate missions and resources—because the output of an entire force cannot generally be expressed as the simple sum of the outputs of its constituent units operating independently.

On the output side, unit models estimate or simulate each output measure during each day of the scenario The time profile of output provides a sense of sustainability as well as readiness. Some models allow the user to specify a set of weights for the output during each day of the scenario. The model then computes the weighted sum of output over the entire scenario, yielding a one-dimensional measure of output.

Unit models can account for flexibility in substitutions among inputs. For example, suppose that an aircraft squadron has a surplus of maintenance technicians but a shortage of spare parts. Unit models might allow for cannibalization, whereby labor is used to consolidate operational parts and thus enhance sortie generation capability

Unit models have both advantages and disadvantages. The advantages are important, though not necessarily more compelling.

- Unit models predict operational capabilities ("outputs," albeit only intermediate outputs).
- Evaluation of predicted performance under different employment scenarios is straightforward Primarily, only the operational objectives (e.g, the desired sortie schedule) need to be changed in the input data.
- Model output values provide information about both readiness and sustainability (although the latter is usually based on only the resources stated as available at the outset of operations).
- Resource tradeoffs can be considered For example, unit models may be used to ascertain whether additional manpower could compensate for materiel shortages or whether more output could be obtained with more end items (e.g., aircraft) vs more spare parts or ammunition
- The outcome of model runs is, ideally, free of subjective judgments on the part of the unit commander (Of course, this

[11]Larger aggregations of forces have been modeled at RAND Shishko and Paulson, 1981, considered a combined arms brigade, and Emerson, 1982, considered a constellation of airbases

ideal would not be realized if the inputs to the model were subject to arbitrary adjustment.)

Some major disadvantages of unit models are:

- They require extensive validation against empirical data.[12] Unfortunately, model validation can be difficult and expensive, and too often it is not accomplished adequately. A positive effort toward model validation can be found in Budde, 1988.[13]
- Unit models generally levy very large data requirements.[14] Perhaps more important, the input data are highly uncertain. Extensive sensitivity analysis is necessary, along multiple dimensions, to account for the simultaneous uncertainty in many or most input parameters
- Unit models may require large amounts of computer time, again depending on the level of detail incorporated. This problem is particularly severe if extensive sensitivity analysis is conducted. However, the cost of computer time is probably small compared with the cost of obtaining measurements by exercising actual units on instrumented ranges
- Unit models typically focus almost exclusively on support units and operations that directly support combat operations. They

[12] Validation can occur at several levels, for example (1) "face validation" (experts agree that the model's internal logic seems valid, and the outputs change in ways that seem reasonable and commensurate with changes in input values), (2) "assumption validation" (empirical data—e g, reflecting the failure rates of individual equipment components—are used to test the accuracy of mathematical assumptions within the model), and (3) "outcome validation" (empirical data—e g, about unit resources, component failures, and repair times—are fed into the model, and its estimated output values—e g, sortie generation rates—are compared with the values actually experienced)

[13] This describes the "Coronet Warrior" exercise for the 94th Tactical Fighter Squadron (TFS) In the exercise, the 94th TFS, located at Langley Air Force Base, flew its 24 F-15Cs at a wartime intensity (up to 3 5 sorties per aircraft per day) over a period of 30 days, using only the resources it would deploy during a real war Dyna-METRIC predicted aircraft availability and sortie generation using this set of inputs In the preliminary analysis, the Dyna-METRIC predictions were much too pessimistic However, further analysis revealed that the actual failure rates were much lower than those used as model inputs, and the actual repair rates were much higher Dyna-METRIC was then run a second tim[illegible]ng the actual failure and repair rates as inputs The results of this excursion were much more favorable Still, the predictive value of the modeling approach (and of peacetime tests themselves) is doubtful if even the inputs cannot be forecast sufficiently accurately (see Hodges, 1985, Goldberg, 1986)

[14] To reiterate, the required data elements typically include initial resource levels (personnel, equipment, fuel, ordnance, spare parts), personnel and equipment attrition rates, battle damage rates, equipment failure and repair rates, resupply and depot repair rates, fuel and ordnance expenditure rates, and a set of output goals The output goals are definitely day-specific, and all other data elements (except initial resource levels) may be day-specific as well Depending on the level of detail in the model, the required data may be quite voluminous

reflect activities that would occur only after mobilization and deployment. They tell nothing about how quickly units could achieve desired levels of capability and be deployed to their operational locations

In light of these disadvantages, we suggest four ways of improving unit models to enhance their potential contribution to the assessment of readiness and/or sustainability:

- Streamline them to simplify their data requirements and to reduce the computational burden.[15] Carried far enough, this could promote their direct use by unit commanders (versus today's nearly exclusive use by analysts and centralized resource managers).
- Integrate multiple-unit considerations—e g.. sharing of repair and materiel between units (mutual support), use of common stockpiles by multiple combat or support units, replenishment of stockpiles through resupply (through transport and handling units) and combined outputs (such as missions that use vehicles from different combat units, or combat unit activity levels as they depend on supporting unit capabilities and resources).
- Extend the models to reflect the process of preparing units for deployment This would include providing additional training,[16] using expeditious means to place equipment in full operational condition, and preparing equipment and personnel for deployment
- Increased effort should be devoted to unit model validation.

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[15]An example of such efforts is the Air Force's development of ELCAM See Rice, 1987, pp 34–37

[16]An early effort that may move in this direction is the Army's BLTM (Battalion-Level Training Model, see CACI, 1987) The BLTM enumerates the training activities required by a battalion to achieve each SORTS training category level and calculates the number of vehicle-miles (or hours of operation) required to achieve each level (Additional modules are available for estimating the cost of transitions between adjacent readiness levels and for scheduling the necessary training) The BLTM can be run for many different battalion configurations, depending upon the unit's TO&E For example, the BLTM can be run separately for an M-1A tank battalion and an M-60 tank battalion, and separately for battalions stationed in CONUS, Europe, and Korea (Although the BLTM is sensitive to a unit's TO&E, it does not include the costs of all resources required to achieve the various readiness levels The only costs included are for fuel and minor spare parts, among the costs excluded are those for ammunition, major component spare parts, and depot-level maintenance.) As noted earlier, Follmann, Marcus, and Cavalluzzo, 1986, have estimated the steaming days required for Navy combatant ships to transit between adjacent C-levels in training readiness

Functional Tests

Functional tests contrast with asset reporting and unit modeling by measuring actual unit outputs; they reflect the demonstrated ability or capacity of the unit to perform the functions that constitute its mission(s). These measures reflect the results of unit and individual training, and often the skill and experience of key members.

During peacetime, armed forces spend most of their time training. Each service has an extensive system for evaluating its training program,[17] as well as incentive systems involving competitions and awards to motivate and demonstrate effective training. Each service conducts tests for individuals, teams, and units; and the tests can address combat, deployment, and/or support operations Hammon and Horowitz, 1987, pp. 18-36, summarize the major types of performance measurement data the services currently generate. Few of the results of these tests and evaluations are reported outside of a service, although the information they provide may be reflected in SORTS: Commanders may make subjective evaluations of their units' readiness based partly on how well the units, crews, and teams meet their training standards.[18]

Since the bulk of U S. military activity in peacetime is devoted to training and exercises, the services already conduct numerous activities closely akin to those that would be needed for readiness-oriented functional testing. Some prominent examples include.

- The Army Training Evaluation Program (ARTEP) is a highly structured and detailed set of evaluation programs, each tailored to a different "branch," such as infantry, armor, and so on Many of its programs are keyed to appropriate soldiers' manuals ARTEP is designed to facilitate decentralized training, to be implemented by unit commanders. For a given specialty, its program lays out what teams, squads, platoons, and so on should be able to do, also reflecting what individuals should know and be able to do. The constituent exercises and drills, including firing and tactical tables, for example, are described in field manuals. Nonunit personnel conduct

[17]For a survey of these, see General Accounting Office, 1986b

[18]Training and testing activities are oriented almost exclusively toward achieving and measuring readiness, not sustainability Field exercises can and occasionally do address aspects of sustainability, however An example is the Air Force's ongoing Coronet Warrior Exercise (see Budde, 1988), which examines the adequacy of war reserve spares kits (WRSKs) (Plans call for each tactical squadron to deploy and sustain itself from its WRSK for the early portion of a contingency.) Even so, the Air Force considers the fill of its WRSKs as an element of unit readiness and reports it through SORTS

ARTEPs for active Army units about every 18 months; reserve units are evaluated about every four years.

- The Army's National Training Center (NTC) conducts simulated battle training for tank-heavy, battalion-sized units selected from divisions and independent brigades. A permanent "opposing force" (OPFOR) is played against the trainee units, and experienced observer-controllers regulate and evaluate the simulated engagements. The NTC uses the Multiple Integrated Laser Engagement System (MILES), which permits simulated weapon firing, recording of target hits, and taking targets out of action when they are hit. (Note that all Army divisions now have and practice with MILES.) Location and event-recording information on most targets and shooters is a unique aspect of the NTC's range instrumentation.

  The core of the NTC, however, is the permanent OPFOR and observer-controllers. The OPFOR employs Soviet tactics, and its high competence has a profound effect on trainee units. The observer-controllers provide immediate critique and feedback to trainee units.

  The Army has developed two other NTC-like establishments. The Joint Readiness Training Center (JRTC) at Fort Chaffee, Arkansas, involves both the Army and the Air Force. Here the Army trains airborne and light infantry units that are air-dropped or air-landed into the training area. The Combat Maneuver Training Center (CMTC) at Hohenfels, Germany, like the NTC and JRTC, also has observer-controllers and will have permanent aggressor forces. The JRTC and CMTC both employ MILES.

- The Army's Return of Forces to Germany (REFORGER) exercise has deployed designated units to Europe to participate with forward-deployed NATO units in large-scale maneuvers. Both active and reserve units have participated. A primary purpose of REFORGER has been to exercise strategic deployment capability, including the POMCUS concept.
- The Marine Corps Combat Readiness Evaluation System (MCCRES) resembles the Army's ARTEP, it applies to both ground and air units. Units are evaluated every 18 months or two years by outside evaluators The Marine Corps also operates an Aviation Training and Readiness Information Management System, ATRIMS; it records aircrew training and performance. This information is used to calculate a Combat

Readiness Percentage (CRP). ATRIMS data are kept at the squadron level and cannot be accessed by higher commands.

- The Marine Corps and Navy frequently conduct amphibious and air assault exercises in the United States and overseas.
- The Navy has an extensive program of formal training cycles and competitions. It enjoys an advantage over land-bound military organizations: At sea (where they spend about a third of the time during peace), units can train and exercise (and even shoot) with fewer constraints regarding real estate or complaints from irate civilians

Much of the formal training activity for surface ships centers around ship overhaul. After a ship is overhauled, a (usually) newly constituted crew—some of whose members have taken individual refresher training or training applicable to new shipboard installations—undergoes successive basic and refresher training that covers every ship mission and system. Training concludes with a "battle problem." Performance in each training period is scored numerically and the data go to ship and squadron commanders. Exercises conducted by divisions are reported to the Fleet Training Group, which also retains the data

- Mission (e.g., antisubmarine, mine warfare) exercises and competitions are scored to award the "battle efficiency designator 'E'" to the best ship in a squadron. Awards are also given for such functions as supply, seamanship, and maintenance.
- Naval aviation training of both individuals and units is extensively programmed and evaluated, from individual carrier landings through organization competitions Antisubmarine warfare (ASW) aircraft conduct exercises over instrumented underwater ranges. Units from carrier wings participate in a "top gun" competition held at a Nevada range.[19]
- The Air Force's rough counterpart to the Army's ARTEP is its Operational Readiness Inspection for wings. A unit is given limited advance notice of the inspection. The exercise generally has two phases, one that tests ability to deploy and one that simulates combat activities over about four days.

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[19]The Navy conducts many other inspection and related activities that cover individual training through the condition of specialized technical installations Overarching the latter is the Board of Inspection and Survey, an independent entity that certifies the condition of both new ships and ships completing major overhauls For a description, see Hammon and Horowitz, 1987, pp 23-30

- The Air Force also conducts extensive crew training for both flying and weapons qualification For the latter, gun cameras and simulators are used extensively.
- Finally, the Air Force has such activities as Red Flag (at Nellis Air Force Base) and competitions in air-to-air, air-to-ground, reconnaissance, and troop carrier.[20] Some of these are conducted jointly with allied air forces

We believe the most desirable features of functional testing, considering the best features of examples like those above, are specification of performance standards and corresponding measurement/scoring scales (which promote and enable self-evaluation, comparisons across similar units, and comparisons over time), and scoring by instrumented means or by impartial, outside observers/evaluators. Tests are generally difficult to develop, however, and controversy is always possible over whether tests measure the right things, whether they focus on broad enough composites of activities, or whether they can predict actual operational performance in wartime. Nevertheless, well-designed exercises and corresponding tests and evaluations are the closest proxies available for wartime operations; short of war, they are the only means for capturing information about actual output/performance instead of about inputs or predicted output/performance.

Criticisms of current testing practice suggest flaws that should be avoided if the functional testing approach is to yield the most valuable information possible:

- In most cases, units engaging in exercises and tests receive more notice than they would probably receive in actual contingencies. For example, battalions training at the National Training Center typically know approximately a year in advance of their "appointment." Extended notice lets units plan and execute programs of training so that their performance peaks at the right moment.
- Units typically participate with full sets of equipment, supplies, and manpower Combined with possible extra and specially scheduled training, this usually places units in C-1 condition before they start Although that would clearly be desirable in real-world contingencies, it may be unrealistic to expect
- There is little focus on how long it would take units to achieve higher performance levels. As noted several times above, we

[20]For example, see *Airman*, 1988, pp 18–23, for an account of an international competition in air reconnaissance

believe the time dimension should be central in understanding unit and force readiness.

- There is a tendency to consider a great deal of detail in tests (e g., as in the ARTEP). This has the benefit of making tests comprehensive but the liability of making them extensive, expensive, and somewhat difficult to evaluate in the broad.
- Because many types of exercises and tests are so extensive or expensive, few units can go through them each year. Thus, performance-based data for large numbers of units tend to be out of date

We emphasize that these criticisms do not necessarily apply to current methods of exercising and testing units *for purposes of training*—i.e., for identifying performance areas that need bolstering through further or better training and practice. But these problems do limit the usefulness of many exercise and test results for purposes of readiness measurement

As described in our suggestions for extending and improving unit asset reporting methods, we believe readiness measurement should focus first on how long it takes units to achieve their objective wartime operational capabilities, starting from the variety of states they might be in when they are mobilized or when special preparations begin. The shorter these times, the more ready the units. Second, readiness measurement should concentrate on the numbers of units of each type available for deployment over time, much more nearly reflecting *force* readiness, although based on the availability of constituent units. For some contingencies it is imperative that engineering and supply/transportation management units, for example, be put in place before combat units—e.g., to prepare operating locations and facilities and to manage the forward movement of ammunition, fuel, and other materiel for the combatants Thus, the sequence and numbers of requirements for units of different types are extremely important in illuminating the readiness of forces.

Functional testing can contribute powerfully to readiness measurement (and, although much less, to sustainability measurement) by examining operational performance (especially the length of time required to achieve objective standards) and preparation for deployment (again focusing on the time required) at the unit level. We recommend several conceptual changes or variations in testing practice to enhance its usefulness for these purposes:

- Limit the number of criteria on which units are tested so that tests take less time Units should still be held responsible for performance on a full range of criteria; they simply wouldn't know in advance which criteria they would be tested on This should enable measurement of the performance of more units (For example, adaptations of ARTEP evaluations might check only a sample of 30-50 tasks instead of hundreds)

- Increase the use of instrumented measurement and external evaluation teams. This would enhance the objectivity and credibility of resulting measures and summaries.
- Test units that start with different levels of resources and perceived readiness (e g., as reflected in C-levels) and examine the dependence of operational performance improvements on different amounts of preparation notice.[21]

Naturally, test conditions should be made as similar as possible to wartime conditions, and different types of tests are appropriate for different types of units For example, maintenance unit performance might be measured primarily on the basis of tests of individual members' skills. But combat units' performance should be measured on the basis of, say, collective abilities to locate and hit targets and to execute maneuvers correctly and rapidly Ideally, operational performance would be evaluated only after a unit had conducted any intense training allowed by the preparation interval, had absorbed any additional resources the test allowed (e.g., representing equipment or manpower "cross-leveled" from other units or provided from reserves), and had executed a deployment (even if it only returned to its original location).[22]

At least three major obstacles confront the development and implementation of testing programs that would emphasize readiness measurement:

- There is a natural organizational aversion to external, objective evaluation. For example, the commanding officer's promotion opportunity could be compromised if the unit's performance on any test is less than outstanding. Perhaps more subtle, if units perform well or adequately without all the resources they deem necessary, the missing resources might no longer be accepted as "requirements." Consequently, any dollars that might have gone into acquiring and maintaining those resources would

[21]This could be hard on the unit commanders

[22]As would happen in real mobilizations, some additional manpower and equipment might be available before deployment, but some would come only afterward (note especially the Army's pre-positioned overseas materiel configured in unit sets (POMCUS) and the Marines' maritime prepositioned ships (MPS))

almost certainly go toward resources demonstrated as needed by other units or services.

- It might be difficult to achieve effective confidentiality about testing schedules and content In peacetime, unit training activities and deployments are typically scheduled months in advance, which is necessary for coordinating the use of scarce field ranges, transportation resources, and the like Even under wraps, the more people who know of such schedules and the farther in advance they know, the more likely the units to be tested will find out when their numbers will come up. The same holds true for test content. Unauthorized knowledge of schedules and test activities would improve units' chances of doing well, but it would compromise the utility of the tests for measuring unit performance potential.
- There will be a perception that additional tests will be needed and that they will be costly. We believe, however, that the kinds of changes we suggest could be integrated with current and developing exercise/test programs The readiness-focused information might come at only a moderate marginal cost, and that cost might be met with some combination of additional and reallocated dollars [23]

There are inevitable complaints that practical tests cannot replicate wartime conditions and events. It is hard to argue otherwise, but individuals, units, procedures, equipment, and inventories that perform poorly on well-designed and well-executed tests are also likely to perform poorly in wartime.

We believe that the benefits of readiness-oriented functional testing warrant working out ways to overcome the obstacles Some problems would inevitably remain—e.g., tension in units might increase because of the susceptibility to unexpected tests, and personal plans would be disrupted occasionally by the need to intensify training and deploy [24] But several of the countervailing advantages are compelling:

- The measurements would be based on empirical "output" information, not on voluminous "input" information or on modeling assumptions about how resource inputs affect outputs.

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[23]See unpublished RAND research by Polich et al for a summary and evaluation of the performance measures and background information available from existing and emerging exercise and test programs Specifics for the precise types of tests, sample sizes etc, need to be worked out

[24]Such problems would be especially severe for units employing reservists Nevertheless, we believe the problems should be faced directly, because the reserves and National Guard have become so important in the U S total force structure

- Comparability of status from one year to another would be enhanced, provided the tests themselves were stable and appropriately calibrated
- A great deal more of the innovation and substitution that would be important in actual mobilization and war would be reflected.
- When related to characteristics of personnel in the tested units (e.g., mental aptitudes, individual training, and experience), test performance could provide valuable insights for personnel policy and management

All in all, functional testing tends to focus greater attention on unit training, attempting to ascertain what people can accomplish with the available resources. The availability of manpower and materiel in the right types and quantities obviously affects operational performance, but we believe there is no substitute for actually measuring that performance. If enough test data could be obtained, it would be possible to estimate important statistical relationships projecting, say, how long it would take a unit of a specific type with a specific set of resources and a specific previous operating tempo to come up to a specified performance standard and prepare for deployment And short of that, only tests can provide the necessary verification of performance levels or preparation times that might be estimated on the basis of models or subjective judgments.

APPROACHES ORIENTED PRIMARILY TOWARD FORCES

DoD has numerous information and analysis systems and methods that do not focus on individual units. Rather, they consider collections of units or resources that would be used by collections of units Although some of these methods still address matters of readiness (though at the force level, not for individual units), they generally emphasize sustainability somewhat more than readiness. We will describe four families of force-oriented approaches and offer suggestions for improving their contributions to readiness and sustainability measurement

- Stockpile reporting—conceptually straightforward compilations of materiel and manpower inventories *not* held by operating units, frequently summarized as estimates of how long those inventories would last in wartime.
- Mobilization planning—models, concepts, and data systems that concentrate on either assembling and equipping forces or on marshaling industrial resources for production and service to meet military needs.

- Deployment planning—examinations of the feasibilities of movement, and planning the schedules for movement of units, manpower, and materiels for different contingencies.
- Combat modeling—war gaming and force-on-force modeling techniques typically used to evaluate force structures, strategies, and tactics in opposition to enemy forces.

Stockpile Reporting

Stockpile reporting is the traditional method of characterizing military sustainability in both peacetime and wartime. It simply identifies the inventories of different resources available for use by forces in a geographic area, and it typically converts these figures to estimates of how long the inventories would last. Unfortunately, the constituent information about resource counts and about time-varying consumption and loss rates is often lost at the stage of making time estimates.

In Sec. II we briefly summarized three stockpile-reporting systems. (1) the CINCs' S-rating reporting for all classes of supply with respect to their most-demanding OPLANs; (2) the services' DOS submissions for secondary items, petroleum, and conventional ammunition through POMs in response to the Defense Planning Guidance; and (3) WARMAPS. WARMAPS is unique in conveying both the time-varying demand for and estimated supply of the resources (manpower of different types) it analyzes Stockpile-reporting systems, like unit-asset-reporting systems, depend for their information largely on the services' (and, to a limited extent, DLA's) many data systems that track stocks of the various resources.

The great value of DOS figures, of course, is that, properly determined, they should identify the most constraining resource. At first glance, it seems that marginal dollars should be channeled toward acquiring the resources in shortest supply, those having the lowest DOS. But if war seems unlikely in the near term, decisionmakers may decide to accept the risk inherent in short supplies and plan to augment those supplies quickly if necessary.

Characterization of sustainability in terms of DOS is a useful approach but clearly an "index-oriented" one. It doesn't try to "model the war;" it essentially ignores how combat plans and operations would change when resources come into short supply. To different degrees, of course, forces could simply avoid combat until they received adequate supplies; and they would almost certainly use controlled supply rates to ration limited supplies. Further, the practical meaning of a statement such as "We have 60 days of supply of fuel for theater X" is unclear. Is that the length of time we expect the fuel that is in shortest supply to last? What are the prospects of obtaining more fuel before the current stockpile runs out? How much more? Which operations would we probably curtail to conserve fuel? When? And what is the meaning of 60 DOS of fuel if there are only 45 DOS of ammunition or of some other commodity?

Beyond this difficulty in interpretation, the principal deficiencies of the materiel stockpile information currently available to decisionmakers are summarized as follows.

- The DOS figures are calculated differently. For instance, the Army calculates DOS (for ammunition) on the basis of weight, while the Air Force uses dollar values.[25] And at least for secondary items, the Navy and Army assume fairly constant operating tempos for their deployed forces, the Air Force does not; the Air Force and Navy allow for cannibalization of parts, the Army does not; the Air Force includes an aircraft attrition factor in its computations after 30 days of combat, the Navy does not.[26]
- The assumptions that go into the calculations—e.g., about orders of battle, platform attrition, or stock consumption, loss, and replenishment rates—are not conveyed along with the results, although estimates of these values are highly uncertain. The data used to estimate DOS figures are of the same type used to establish resource requirements and the services may be very reluctant to share them.[27] The same stocks would clearly last different lengths of time under different scenarios.
- Counting of resources is incomplete. For example, peacetime operating stocks and stocks in procurement or maintenance pipelines are not counted.
- The specific types of operations jeopardized by sustainability shortfalls are not specified. That is, the DOS measure is not output-oriented.

Because of Joint Staff and OSD dissatisfaction with DOS measures, the Materiel Sustainability planning guidance in the FY 1990–1994 DPG directed each service to

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[25]General Accounting Office, 1985, p. 29.

[26]Capability Evaluation Steering Group, 1986, p. 6.

[27]Reluctance is understandable, of course, since (a) no one can predict the underlying quantities with much confidence, (b) higher levels of management might dictate the use of different assumptions (e.g., in order to save money), and (c) there is a degree of negotiating power in being in sole possession of underlying data and computational mechanisms.

> develop operationally oriented measures of sustainability other than the current days-of-supply . for fuels, level-of-effort munitions, secondary items, and replacement end items . that will better describe the extent to which sustainability resources independently, and in combination can be expected to support wartime activity [28]

While this orientation may lose the apparent (but misleading) simplicity of the DOS measure, it should provide a more natural and potentially more powerful focus. The new assessments/measurements should clarify what portions of operational plans could or could not be supported with existing resources [29]

To facilitate the development of such measures, in June 1988 DoD established a Sustainability Assessment Task Force with membership from OSD, the Joint Staff, the Defense Logistics Agency, and operations and logistics leaders from the four services. The task force established criteria for sustainability measures, recommended solutions to definitional and procedural impediments to implementation of the Defense Planning Guidance, recommended ways to achieve consistency in establishing sustainability objectives and assessments in service POMs, and formulated tentative sustainability measures for each service. Its conclusions of greatest pertinence to our considerations are.

- Sustainability assessments should include all stocks of the items authorized for war reserve stockage located in all echelons of supply. in-unit peacetime operating stocks, retail stocks (service-owned stocks outside of their logistic commands—e g , afloat on resupply ships or undergoing organizational or intermediate maintenance), wholesale stocks (held by the service logistic commands, DLA, or the General Services Administration), and production base (materiel deliverable early enough to play in wartime) The distribution "pipelines" between these echelons should also be included.
- Readiness and sustainability are an overlapping continuum, and sustainability should be formally redefined.[30]
- Sustainability measures should (a) be "*easily understood* in terms of size of force, type of activity, and level of intensity

[28]See OASD(P&L), 1988b, p A-1

[29]Focusing only on munitions, a representative effort in this direction is Bell and Jandrositz, 1987

[30]The redefinition is restated here for convenience *Sustainability The ability to maintain the necessary level and duration of operational activity to achieve military objectives Sustainability is a function of providing for and maintaining those levels of ready forces, materiel, and consumables necessary to support military effort* (OASD(P&L), 1988b, p 12).

(operating tempo);" (b) consider "the time and activity dimension of the conflict;" (c) "*support the derivation* of programming and budgeting requirements;" (d) "be meaningful to the CINCs and Defense Resources Board" (in their PPBS roles), and (e) "allow for *common and consistent* application across . . . both manpower and materiel." This requires clear articulation of force size, type of activity, and level of intensity.

- To satisfy these criteria, sustainability measures should be distinguished by discrete time intervals, theaters, and mission areas Assessments should use a ten-day time interval through D+60 or until force size and postulated combat intensity stabilize in the theater (whichever is later) and a 30-day interval thereafter. (WARMAPS also uses ten-day intervals.)
- An assessment should be conducted of the "outyear sustainability which the POMs would provide."
- To characterize sustainability for secondary items, the services should apportion to each time interval in the scenario the dollar values of both the sustainability objective and the projected inventory
- Assessments should be based on one basic warfighting scenario, with apportionments (of both forces and resupply stocks) among theaters according to the Defense Planning Guidance's projected wartime force densities.[31]

These steps would substantially advance sustainability assessment. We endorse them (but see below regarding the last one), placing special emphasis on the first and fourth; include in sustainability assessments all stocks that could be brought to bear, and distinguish time intervals, theaters, and mission areas in sustainability assessments The former takes into account the full range of assets that constitute the sustainability stockpile, and the latter recognizes the flows of resources into the theater and through the users Estimating the flows may be somewhat difficult, especially since resource movement and (to a degree) production must be taken into account.[32] These recommendations would carry

[31]However, apportionments of about two-thirds of the secondary items approved for war reserve stockage that DLA manages are used by more than one service and "are not relatable to the differing force structures of the services," so "complete resolution of this situation may not be possible until the weapon system secondary item management concept is fully implemented" (Ibid., p xi)

[32]For PPBS purposes, the Sustainability Assessment Task Force identifies the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, OASD(PA&E), as providing movement capacity information to the services (ibid, p. 23) And it designates leadtime intervals within which orders for each supply class should be counted as available in the total stockpile. For example, orders for consumables and repair parts placed in 1993 should be counted as available at the end of 1994 (ibid, p 39)

stockpile reporting valuably beyond today's simplistic (and partial) counting schemes and translation into DOS figures.

We believe three additional steps would improve "stockpile reporting" still further:

- Treat multiple scenarios, not just one. While the PPBS currently operates on the basis of only one scenario, the unified and specified commands continually plan for many different scenarios. Top-level decisionmakers should be provided information indicating which types of contingencies our resources could support (or, probably more aptly, the degrees to which our resources could support operations in different contingencies)
- Specify mobilization and deployment lead times for each scenario considered. The time available for force mobilization and deployment affects the operating strengths that resource stockpiles must support. And the time available for industrial mobilization affects the quantities of materiel available for forward movement.
- Make explicit the assumptions that drive sustainability assessments, enabling sensitivity analyses and facilitating defense of the results. Figure 2 suggests one format for conveying this and other stockpile and stock flow information. Such formats suggest the straightforward use of electronic spreadsheets for assembling and transmitting this information, readily enabling "what if" exercises.[33]

Taken together, these improvements should provide much more comprehensive and credible assessments of the sustainabilities achievable with any set of resource stockpiles. Imbalances among resources would be as readily identifiable as with "standard" DOS representations, and the operational implications of shortfalls would be clarified. Measures at the operational level would be much more usefully comparable from one year to the next—for example, DoD could say, "Our missile stockpile [perhaps as augmented by a surge production capacity] now allows the Navy to fly __% more air-to-air sorties during days 20–30 of contingency X than it could have three years ago."

[33]For instance, "What if resource expenditures during period x were at rate y instead of at rate z? What if force closure were delayed so that x% fewer units of type y operated during period z? What if we pursued the strategy of "winning early" (e g, through substantially more intense operations and correspondingly high expenditures of resources) instead of "lasting longer"? (See, e g, Sullivan, 1987) Such questions must be answered to establish the robustness of resource adequacy

Theater: ______ Force Element: ______ Activity Area: ______

	Amount of Resource							Operational Objective		
Time Period	Produced in CONUS	Shipped to Theater	Lost Enroute	Received in Theater	Produced in Theater	Lost in Theater	Available for Use	Activity Level	% Supportable	Resource Amount Used
Resource		CONUS Stockpile			Theater Stockpile					
0-10										
11-20										
21-30										
31-40										
41-50										
51-60										
61-90										
...										
	(Pattern repeated for different types of resources)									
Resource		CONUS Stockpile			Theater Stockpile					
0-10										
11-20										
21-30										
31-40										
41-50										
51-60										
61-90										
...										
All Resources Combined										
0-10	Not applicable for Combined Resources									
11-20										
21-30										
31-40										
41-50										
51-60										
61-90										
...										

Fig. 2—A candidate format for reporting resource stockpiles and flows

These improvements have two major disadvantages, one technical and one political: First, it will be somewhat more difficult to account for the greater range of resources that could contribute to operational sustainability, especially (considering production, repair, movement, etc.) in estimating when and in what quantities they would be available to their users. WARMAPS already handles many of these considerations for human resources, so there is demonstrated capacity in DoD for such data collection and manipulation. Second, the assumptions (e.g., attrition, loss, and consumption rates) often implicit in sustainability estimates must be made explicit. In fact, of course, there is great uncertainty about many such rates—for example, because we cannot know where, when, or in what numbers the enemy will "present" targets. This seems no more a problem under the enhanced sustainability assessment structure than within DOS calculations

Mobilization Planning

Mobilization is the act of assembling and organizing national resources to support national objectives in time of war or other emergency.[34] Activating military reserves (both manpower and equipment), stepping up production of munitions and fuels, and invoking conscription are examples of mobilization activities. Early and effective mobilization can raise both readiness and sustainability before conflict begins, and it can be crucial in maintaining them once conflict begins.

Mobilization involves so many activities, organizations, and different planning concepts—only a few of which we can address here—that we divide this discussion into two parts: (1) force mobilization, the process by which the armed forces or part of them are brought to a state of readiness,[35] and (2) industrial mobilization, providing additional materiel and services for the military.

Force Mobilization. The "total force concept" reflects the dependencies of U.S. military capabilities on both active-duty and reserve components Table 5 shows that in 1987 more than 43 percent of U.S. military manpower was in the reserves.[36] While less than one-third of the other services' manpower is in the reserves, nearly 60 percent of the Army's manpower is reservists Table 6 illustrates the Army's great dependence on reserve units for its "combat service support" functions; more than two thirds of its supply, maintenance, and transportation units are in the selected reserves About half of the Army's "combat support" units (including separate artillery, combat engineer, signal battalions, and the like) and nearly one-third of its combat units are also in the selected reserve.

Ideally, the services try to place functional responsibilities in the reserves that suffer less from the severely limited time available to

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[34]Joint Chiefs of Staff, 1986a, p 223

[35]Ibid., p 180

[36]The selected reserve is organized in units in peacetime, the individual ready reserve is not The selected reserve also includes National Guard units that are controlled by state governors in peacetime Active-duty military personnel may be assigned to some reserve units, and some reservists may be employed as full-time civil servants to handle unit administrative, training, and logistic functions In 1987, about 154,000 full-time military and civil service personnel were assigned to selected reserve units For background information about the reserves, see Wilson, 1985

Table 5

ACTIVE AND RESERVE MILITARY MANPOWER, BY SERVICE AND ACTIVE AND RESERVE COMPONENTS, 1987
(Thousands)

	Army	Air Force	Navy	Marine Corps	Total
Active forces	781	607	587	200	2,175
Selected reserve	772	193	149	43	1,157
Individual ready reserve	355	50	80	52	537
Total	1,908	850	816	295	3,869

SOURCE Active and selected reserve data from U S. House of Representatives, 1988a, p 438, individual ready reserve data from U S House of Representatives, 1988b, p 511

Table 6

COMPANY-SIZED LOGISTICS UNITS IN ARMY FORCE STRUCTURE IN ACTIVE AND RESERVE COMPONENTS, 1982

Function	Active	Reserve	Total
Supply	50	179	229
Maintenance	59	159	218
Transportation	74	149	223
Total	183	487	670
(Percent)	(27 4)	(72 6)	(100)

SOURCE Sims et al, 1982, p A 3-2

them for training.[37] Nevertheless, many combat units are in the reserves, and they sometimes compare favorably with active-duty units in functional competitions.

The U.S. Code provides for five levels of force mobilization that permit activation of reserve units or individual reservists:

[37]The need for a great deal of *post-mobilization* training for reserve units is addressed, for example, in Skipper, 1984 See also Abramowitz, 1976, pp 58–65; and O'Meara, 1980, pp 17–23

- Selective mobilization: expanding the active force in response to a domestic emergency that does not result from external threat
- Presidential call-up: a maximum of 200,000 selected reservists for up to 90 days, which may be extended for another 90 days.[38]
- Partial mobilization: call-up of up to one million reservists (also including the members of the Individual Ready Reserve [IRR]), upon congressional or presidential directive, for up to 24 months.
- Full mobilization: call-up of *all* reserves, including selective recall of military retirees, to fill out the whole force structure.
- Total mobilization: expansion even beyond existing force structure, mobilizing national resources.

Short of these options, the status of active forces can also be upgraded through, for example, holding people in the military who are scheduled to separate; recalling people from leave; stopping permanent change of station moves from theaters of concern, expediting equipment repair; stepping up training activity, and cross-leveling (reallocating) available people, equipment, and supplies (Many such actions can be invoked by declaring different defense conditions ("DEFCONs"), and some can be undertaken by the services independently.) We consider these actions to be closely related to formal mobilization activities. They are extraordinary steps taken to raise unit condition in anticipation of force deployment or employment.

In view of this rich variety of mobilization and upgrading options, the number of possible paths toward enhanced levels and mixes of unit status is very large. Further, some mobilization steps can be approved only by high-level decisionmakers, and the timing and sequence of their decisions to undertake the various options can be anticipated only with considerable uncertainty. Consequently, there seems to be no overall view of the improvements that could be derived from various options and timing of force mobilization. Instead, fairly detailed systems have been developed to plan and manage different mobilization activities once they are authorized—e.g., the Selective Service System's "traffic cop" model addresses the assignment of geographic areas to military enlistment processing stations depending on whatever manpower requirements the services specify,[39] and each service has its own systems directed toward training scheduling, personnel assignment, and redistribution of equipment and supplies, for example.[40]

[38]These periods have recently been extended to 180 days apiece

[39]Bennett and Roll, 1981.

[40]As a sample, FORSCOM, with primary responsibility for Army mobilization, lists 24 systems of management or command procedures, each with a related data system, and specified communications channels (where appropriate) One is the Mobilization Equip-

In spite of the great variety of force mobilization possibilities, detailed plans exist for executing many individual activities, especially at lower organizational levels. In fact, most individual operating units have explicit "mobility plans," delineating the precise equipment to be prepared for deployment, which individuals will deploy, and the timing of the steps for preparing them The progenitors of these detailed plans, of course are the unified commanders' (CINCs') concepts of operations and corresponding OPLANs for different contingencies

From the perspective of readiness and sustainability assessment, the product of force upgrading and mobilization activities is fairly simple: increasing numbers of units over time that have achieved specified levels of resources and training. Identifying these time-varying patterns is not an explicit objective of present mobilization planning or evaluation activities, however, although related analyses are conducted. For example, the services project for the Total Force Capability Analysis (led by the Joint Staff) both when their units could be ready for deployment and the "levels of effectiveness" they would possess. (The latter are used in combat simulation models.)

We believe that force mobilization analysis and testing could contribute much more to the broad characterization of readiness (and sustainability, to a degree) than is the case today On the analysis side, the services currently use separate management information systems to consider different categories of resources (e.g., the Air Force examines manpower mobilization using COMPES/MANPER and the Army considers equipment redistribution using MOBERS). We recommend working toward bringing together the results of such analyses, casting the overall findings in terms of the estimated growing numbers of units of different types whose training, performance, and resource levels could be brought up to desired levels over time. It would clearly be preferable to have projections of the number of tank brigades,

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ment Redistribution System (MOBERS), intended to redistribute logistic assets—including equipment left in the United States by units deployed overseas and programmed to pick up POMCUS materiel—across mobilization stations Another is the Deployment, Employment, Mobilization Status System (DEMSTAT) (See U S Army Forces Command, 1987, pp 13–15) There are also several training management systems, one covering the evaluation and analysis of reserve units during annual training (See also U S Army, 1985) Especially important is the Mobilization Cross-Leveling System, a "real-time system that provides the installation commander and managers the capability to cross-level individuals in units and then fence the unit once mission-capable deployable strengths are met It also allows commanders above installation level the ability to redistribute assets among their units" The related management of personnel accession during mobilization is described by Pickett et al, 1986 For the Air Force's and Navy's analogs to many of these systems, see AF Regulation 28-5, *War Planning USAF Mobilization Planning*, Department of the Air Force, 29 May 1980, and OPNAVINST S3061 1, *Navy Capabilities and Mobilization Plan*, July 1982 engineering companies, or aircraft squadrons, for example, that could be marshalled with at least __ percent of their required assets and capable of performing at a specified performance level within __ days, rather than only statements of the quantities of different kinds of manpower or equipment that could be marshalled within __ days (even if—as is the case with WARMAPS, for example—these quantities were compared with total requirements).

It would also be important to establish the validity of such projections insofar as possible through rigorous testing programs. Our earlier discussion of functional testing noted the importance and variety of tests that could be adapted from current training and practice for individual units, these tests focusing on the time it takes units to achieve specified performance standards. We recognize that it may be more difficult to devise practical testing programs for reserve than active units. Reserve units typically have access to their members for only limited times, their members are less often fully qualified in their jobs, and they often lack the complete sets of equipment needed for training. Nevertheless, because they are such large and important portions of the total force and many of them come into play in the very early stages of deployment and employment, we believe they should not be exempted from tests Special arrangements would be needed to give some types of units "train-up" opportunities similar to those they would have upon actual mobilization. And, almost certainly, fewer of them could be tested per year.

Furthermore, broader scale tests/exercises are needed, to illuminate mobilization capabilities in the large. DoD is already devoting considerably more attention to this type of testing, however—motivated in some measure by the inadequacies discovered during the "Nifty Nugget" exercise of 1978.[41]

In summary, to reflect the great potential that force mobilization offers to readiness and sustainability, we recommend developing and applying unit-oriented performance tests and combining the analyses of different resources (manpower, equipment, and supplies) into profiles of the numbers of units of different types that could be placed in various categories of readiness over time under different combinations of mobilization options and timing. A capability for (at least rough) allocation of scarce force mobilization resources would be at the heart of

[41]See, for example, Fialka, 1980, pp 14-18, which indicated that in 1977 a large-scale mobilization would not have reinforced NATO in a timely way, that there were serious ammunition shortages, etc The primary lessons of Nifty Nugget were that mobilization authorities and procedures were not in place and well enough understood One of its consequences was the creation of the Joint Deployment Agency (JDA), now a part of USTRANSCOM For a summary of a recent partial mobilization exercise, see Martindale, 1988

this analysis. The allocation would consider the manpower, equipment, and initial supply resources held by units and in central, nonunit "inventories"; the units' requirements for these resources and for unit training; the capacities of induction, training, and redistribution systems; and the timing and priorities peculiar to specified contingencies.

In contrast to the incremental improvements we suggest for the other families of methods considered in this section, we are aware of no examples of systems, procedures, or studies that have considered force mobilization in the broad manner we outline. However, WARMAPS and MOBERS illustrate that mechanisms can be developed and used to address the dynamic demands and supplies of individual resources needed to pass from peacetime to wartime footing. We encourage linking systems that use such principles and translating any resulting resource shortfalls into reduced numbers of fully resourced units; reduced unit performance levels; or, if appropriate, reduced availability or performance of other units that depend for support/service on these resource-short units

Industrial Mobilization. As formally defined, industrial mobilization is "The transformation of industry from its peacetime activity to the industrial activity necessary to support military objectives. It includes the mobilization of materials, labor, capital, production facilities, and contributory items and services essential to the industrial program"[42] Undertaken early enough, industrial mobilization could contribute to both readiness and sustainability: Units' pre-deployment needs for resources could be filled, and longer-term materiel supplies could be augmented. But industrial mobilization can contribute more than just new materiel. Repair and distribution industry resources can also provide important services—e.g., through accelerated repair ("pipeline compression") and strategic movement resources (trains, trucks, ships, aircraft) and facilities (ports, storage, and materiel handling)

DoD defines industrial preparedness programs as "Plans, actions, or measures for the transformation of the industrial base, both government-owned and civilian-owned, from its peacetime activity to the emergency program necessary to support the national military objectives."[43] Consequently, our discussion considers both government-owned and civilian-owned industrial resources. Some "industrial" organizations are already parts of DoD (e.g., the Army's munitions plants and large portions of the services' logistic and transportation commands), and many others are already devoted to defense work (e.g., manufacturers and suppliers of military equipment and supplies). Mobilizing these organiza-

[42]Joint Chiefs of Staff, 1986a, p 180

[43]Ibid

tions mainly requires increasing their working hours; ensuring adequate supplies of raw materials, skilled labor, and long-lead-time components; and stepping up their production rates—essentially establishing a "surge" operation. If a long and large enough conflict were anticipated, of course, additional industrial capacity would be built or converted to meet DoD's needs.[44]

The roles and responsibilities for planning and managing industrial mobilization are widely distributed. The CINCs and the Joint Staff compile critical item lists and integrated priority lists that identify items especially crucial to their warfighting effectiveness. The Defense Logistics Agency and the services routinely conduct production base analyses (PBAs) to review industrial surge and expansion capacities for different materiels,[45] and they have procedures for expediting purchase, delivery, and overhaul/depot maintenance activities if necessary.[46] The Joint Staff occasionally leads cross-service PBAs,[47] and the OSD has published a Master Mobilization Plan.[48] The Office of the Secretary of Defense publishes other guidance[49] and conducts special studies.[50] Industries themselves participate in mobilization planning and analysis.[51] Special studies frequently address individual industrial sectors, especially ammunition production [52]

Because the range of activities and resources co dered in industrial mobilization is so broad, many agencies besides the DoD are involved The Planning Coordinating Committee· Emergency Preparedness/ Mobilization Planning tries to coordinate the many participating organizations—e.g., including the Federal Emergency Management

[44]See Polmar et al, 1988 Their alarming summary "American industry today is unable to expand its production to meet wartime mobilization needs in less than eighteen months It is not possible to surge the output of even the most important weapons and war materiel much faster than that The nation has been dependent for years on foreign sources of raw materials Now it is becoming dependent for critical manufactured goods as well, including some high-technology products that are essential to defense production" (p i) The document reports further that, "it would be difficult for the United States in the late 1980s to support a war on the same scale as Vietnam without a major mobilization effort" (p. 12)

[45]See, for example, U S Air Force, 1986

[46]The Defense Production Act permits priority contract performance and allocation of critical materials needed to produce military materiel.

[47]See, for example, Fowler, 1986, pp 30–33

[48]OASD, 1988a

[49]See, e g, OASD, 1985, 1987.

[50]For example, see Doherty et al, 1982.

[51]Beyond responses to surveys in PBAs, see, for example, Hercules Inc, 1980, SEMATECH Press Kit Paper (cited in Polmar et al, 1988, p 61) SEMATECH is a group of 14 computer and electronics manufacturers, Nicolas, 1983, Collins, 1983, or Cody et al, 1983

[52]As illustrations, see Schumacher, 1984 or McLaurin, 1981

Agency (FEMA), DoD, and the Departments of Energy, Transportation, Labor. Commerce. Health, Housing, and Treasury.[53] Industrial mobilization has received increasing attention in recent years, now making its importance felt in major exercises and war games.[54] DoD is considering developing a mobilization annex—an "outline mobilization plan"—for each service's biennial POM submission The annex would specify the steps, mobilization resources, and costs that would be required beyond peacetime programmed levels to achieve a C-3 SORTS condition for all forces and 180 days of supply within 18 months of a decision to mobilize.[55]

Two additional developments may prove especially important for making industrial mobilization planning and analysis more directly relevant to readiness and sustainability assessment: the "graduated mobilization response" (GMR) concept and the Joint Industrial Mobilization Planning Program (JIMPP) GMR would define a range of "mobilization packages," incremental mobilization steps that would be activated in response to warning.[56] Besides contributing to an improved, combat-ready posture of U S. forces and stockpiles, GMR offers options that U.S leaders could use to signal national resolve before force mobilization or deployment. The JIMPP is intended to

- Provide guidance to unify planning for industrial mobilization, including development of common planning assumptions and methods of assessing industrial capabilities and options
- Provide JCS the analytical tools to assess the feasibility of supplying the necessary hardware and supplies to support Operations Plans and Concepts of Operation.[57]

Three major analytical components being developed for the JIMPP are:

(1) a "requirements module" to calculate hardware requirements based on force deployments and planning factors,

(2) a "micro module" to incorporate detailed supply-side capabilities and options data at the level of the establishments producing specialized defense hardware, components, or parts, and

(3) a "macro module" to provide industry-level analyses of supply and demand to assess the economy-wide economic feasibility of the individual micro decisions

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[53]For a list of 40 "major emergency action papers" outside the DoD, see Polmar et al , 1988, p 55

[54]See, for example, NMIG Special Working Group, 1988

[55]Briefing by Muckerman, 1988

[56]See Taible, 1988, Polmar et al , 1988, p 12, or Weinberger, 1988, pp 139–140

[57]Institute for Defense Analyses, 1988

Although we have not had the opportunity to review the technical aspects of the JIMPP design, it seems oriented toward valuable objectives: forecasting the time-phased materiel requirements for different OPLANs and concepts of operations (CONOPs) along with the time-phased supplies of materiel available from industrial production We caution, however, that a great deal of uncertainty will inevitably remain about the actual demands and supplies that will develop in wartime. Demands, of course, will depend on the intensities of combat, the effectiveness of both sides' strategies, tactics, and weaponry; and the losses of stocks that occur en route or in storage. Furthermore, supplies will depend not only on manufacturing capacities, for example, but on the availability of raw materials, energy, labor, transport, and materiel handling, all of which can be subject to substantial uncertainty under some contingencies

The availability of transport resources for mobilization—e.g., the Civil Reserve Air Fleet (CRAF)—is fairly well understood. DoD and the Department of Transportation have coordinated plans and agreements with civilian transport firms to make available portions of their commercial rail, shipping, and airlift capacities for national emergencies.[58]

As a potential contributor to assessments of U.S. force readiness and sustainability, industrial mobilization suffers most from being substantially disjointed· Its planning and management are handled by a plethora of organizations, and the underlying demand and supply data are partial, dispersed, and uncertain.[59] Under the NSC, the Planning Coordinating Committee: Emergency Preparedness/Mobilization Planning (chaired by FEMA) spearheads the drive toward greater cohesion and consistency in industrial mobilization planning and analysis.[60] Beyond the organizational complexities, the vast and scattered data, and the unavoidable prediction uncertainties, industrial mobilization planning is confronted by several other special analytic difficulties. For example.

- Producers of different military materiel may depend on the same suppliers, raising the possibility of unrecognized constraints at the "lower tiers."[61]

[58]See, for example, Chenoweth, forthcoming

[59]See Bozek and Valletta, 1984

[60]The committee is new, superseding the National Mobilization Interagency Group (NMIG) This type of work has been assisted through numerous studies, performed in large part by the Institute for Defense Analyses (IDA) and the National Defense University's Mobilization Concepts Development Center (MCDC) See the bibliography for illustrative publications from IDA and MCDC.

[61]See, e g , Baumbusch and Harman, 1977, and Miller, 1978

- The civil and military sectors will inevitably compete for many of the same resources and production/service facilities.[62]
- Rigid peacetime specifications for materiel and service (e.g, requirements for long storage lives for munitions or for low damage levels in materiel handling) may be relaxed, enabling higher production and throughput rates.
- There are substitutes for many items—e.g.. "dumb bombs" can be used instead of some precision-guided munitions, and some medicines can substitute for others—although the substitutes are generally somewhat less effective. Thus, many requirements are not "absolute."
- Many raw materials and components for military equipment and supplies come from foreign countries. The United States maintains "strategic stockpiles" of many of these items [63]

Numerous options are available for raising the potential that could be realized from industrial mobilization—primarily through hastening the availability of supplies and services Examples include (1) stockpiling larger quantities of long-production-lead-time components (e.g, rocket motors) in peacetime, establishing a "rolling inventory" (first-in, first-out) that could permit high initial production rates upon mobilization; and (2) investing in standby production capacity. Quantitative industrial planning and evaluation must take such options into account

In spite of all the difficulties noted above, the evaluation information and, more important the additional military potential that can be derived from industrial mobilization planning obviously warrant the effort. Industrial mobilization would be vital to sustain U.S. capability in a long conventional war. And certain aspects of it (e g, repair pipeline compression and civilian transport mobilization) could even contribute to readiness and sustainability in the fairly near term. From an assessment perspective, it would be advantageous that changes in mobilization potential—provided they were determined carefully and consistently—would be fairly readily comparable over time

Without suggesting particulars about how such improvements should be achieved, we endorse three recommendations that seem to enjoy consensus support in the industrial mobilization planning community and that would raise the potential contribution of industrial mobilization planning and analysis to readiness and sustainability assessment:

[62]Interesting descriptions of this problem in history are in Novick, 1987, Vawter and Cassidy, 1983, and Fleming et al, 1983

[63]Polmar et al, 1988, pp 32-35, display the excesses and shortfalls in these stockpiles, emphasizing U S dependence on South Africa for several critical materials

- Improve the time-phased estimates of materiel/service requirements. The underlying assumptions need to be made explicit so that the integrity of the requirements can be considered. Furthermore, we believe it is important to routinely reflect differing requirements for differing contingencies and to account for a range of requirements even within a contingency, recognizing that the needs simply cannot be predicted accurately.[64]
- Develop and maintain databases about relevant production and service industrial sectors and provide linkages among them to enable cross-sector analyses.
- Develop quick-response analytic tools for estimating the time profiles of production and service industry outputs. These profiles would provide direct input into (1) compilations of unit holdings and equipment inventories to estimate the number of "whole, materiel-ready" units available for deployment or that could be constituted/reconstituted in combat theaters and (2) comparisons of original stockpiles and replenishment flows against projected consumption/losses of supplies.

Industrial mobilization has not received much play in defense fiscal planning in recent years, perhaps because most planning scenarios have assumed that large-scale conflict breaks out fairly quickly with no opportunity for industrial mobilization. In these circumstances, our forces must "fight with what they've got", and, for whatever reasons, few exercise and war game conflicts have been projected to last long enough for industrial mobilization to "kick in." An exception is the Naval War College's Global War Game.[65]

Deployment Planning

We use the term "deployment planning" to cover the range of activities on one hand from assessing the gross feasibility of moving forces and supplies from peacetime to wartime locations, to identifying the "packages" to be moved and planning detailed schedules for their movement on the other. As is typically the case for the other families

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[64]This is not to suggest that it is necessary (or even possible) to invest enough in either stockpiles or production/service capacity to eliminate (or to "buy out") the uncertainties that will characterize wartime requirements In fact, management adaptations inevitably will be needed to match available resources to the most pressing needs of the moment. Unpublished RAND research by Cohen, Abell, and Lippiatt discusses adaptation in the area of spare parts and maintenance.

[65]For a description of how industrial mobilization's role grew as that multiyear war game developed, see NMIG, 1988

of methods, deployment planning is accomplished by numerous organizations using a variety of data systems and analytic methods.[66] The ultimate output (the "measures") that come from deployment planning are essentially delivery dates for units, people, and materiel. The quantities delivered (to any specified location or echelon) can be accumulated into time-varying profiles (throughput) that carry important meaning for readiness and sustainability.

Deployment planning is an iterative part of the deliberate planning process Unified command staffs first use a module of the Joint Operational Planning System (JOPS) called the Transportation Feasibility Estimator (TFE),[67] simulating the ("strategic") movement by sea and air of the relevant forces and their support requirements from the point of embarkation (POE) in CONUS to the point of debarkation (POD) in the theater. They consider only the transportation resources apportioned for the OPLAN by the Joint Chiefs of Staff. The TFE identifies feasible arrival dates (FADs) for each unit and supply shipment, which are then compared with predefined latest (acceptable) arrival dates (LADs). Gross discrepancies must be resolved either through addition of movement capacity or alteration of movement requirements (e.g., by increased forward deployment or pre-positioning in peacetime, increased use of host-nation resources, revision of the combat concept of operations, or earlier initiation of the deployment). Once it is established that movement requirements and available movement assets are approximately commensurate, the services must "source" the units, people, and materiel to be moved—identify where those resources will come from. (This step is necessary for both mobilization and deployment planning.) Then the Military Airlift Command (MAC), the Military Sealift Command (MSC), and the Military Traffic Management Command (MTMC)[68] use their scheduling models—the Flow Generator System (FLOGEN), the Strategic Sealift Contingency Planning System (SEACOP), and the Mobility Analysis and Planning System (MAPS-II), respectively—to develop detailed movement "tables" (schedules) for transporting everything. Inevitably, many detailed discrepancies must be resolved in each step, a process facilitated by two major conferences for each OPLAN: the first addresses the identity, availability, and

[66]For a summary of the most prominent systems, including identification of the using organizations, see Transportation Systems Center, 1988

[67]See Armed Forces Staff College, 1988 pp 6-36, 6-37, pp 8-20 through 8-23

[68]These are the services' components of USTRANSCOM, they are commonly labeled "the transportation operating commands' (TOCs) Their participation with the unified commands in the deliberate planning process is coordinated by USTRANSCOM's Joint Deployment Division, formerly the Joint Staff's Joint Deployment Agency

location of the units, people, and materiel to be moved; the second addresses the movement of those resources.

The product of the deliberate planning process is the TPFDD or TPFDL.[69] Care is taken to emphasize that TPFDDs are "capability-based," not "requirements-based"—based on the resources available, not those the CINC believes are needed. The TPFDD is output from the JOPS to the Joint Deployment System (JDS), managed by USTRANSCOM. The JDS, which also interfaces with SORTS, is used to transform OPLAN data into operation orders during crisis execution.[70]

In the time-sensitive planning mode, essentially the same steps are completed, but in less time and in abbreviated form using the JDS straightaway.

Deployment planning and evaluation also occur in contexts besides contingency planning. For example, OSD and the Joint Staff conduct deployment studies in the PPBS and the Chairman's Net Assessment processes, respectively A battery of analysis tools also support such work. The most prominent is probably the Model for Intertheater Deployment by Air and Sea (MIDAS).[71] Others include, for example, RAPIDSIM and MINOTAUR, both intended to provide many of the results available with MIDAS but in less time and with fewer computer resources.

MIDAS appears to exemplify deployment models in terms of scope, advantages, and disadvantages. It is a scheduling model with the objective of minimizing the lateness of delivered "packages." On a daily basis, the model simulates the movement of equipment, supplies, and personnel by air and sea from CONUS to overseas locations In the model's input data, each unit to be transported is assigned an availability date and a required delivery date, and each transport aircraft and ship is also assigned an availability date. For each day in the planning period, the model allocates aircraft and ships to POEs as they become available. After loading, which may take up to several days, an aircraft or ship proceeds to the POD assigned for its cargo, and unloads. The model takes into account the cargo-handling capabilities of individual ports, convoy policies, the speed and capacity of various types of aircraft and ships, and attrition of aircraft, ships, and cargo.

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[69]Apparently because development of the TPFDD is so demanding and the resulting schedules so voluminous, some observers disparage the CINCs' OPLANs as "little more than travel plans"

[70]CINCs and services, linked through the World-Wide Military Command and Control System (WWMCCS), use the JDS to update TPFDDs Eventually, JOPS and the JDS will be merged in the new Joint Operational Planning and Execution System (JOPES) (For summaries of these systems, major modules, and relationships, see Armed Forces Staff College, 1986, Ch. 8)

[71]Keyfauver, 1987

In short, a MIDAS run assesses the ability of a given mix of aircraft and ships to meet specified delivery requirements.

The MIDAS model consists of about 15,000 statements in the PL/1 programming language. The Joint Staff typically needs about three months to set up the input data, much of this time is spent interacting with the services who must provide the data. It takes about another month to perform the various simulation runs required in a typical analysis. The actual central processing unit time per run is up to four hours[72] The output of the model tabulates "everything that happened," generally between 10,000 and 20,000 events. The user can extract information as desired from these events.

MIDAS has proved useful in numerous studies, but it suffers from two major disadvantages that limit its potential contribution to readiness and sustainability measurement: (1) Its scope excludes availability of units, people, and materiel and their movement and handling within the CONUS (although it accepts the results of these considerations as inputs), as well as their movement and handling within the combat theater; and (2) its data and computational requirements are large. Simpler, faster models such as RAPIDSIM and MINOTAUR may mitigate the second disadvantage Carried far enough, simplification might even permit incorporation of movement and handling within CONUS and/or the theaters.[73]

Not surprisingly, results from MIDAS-like models are generally sensitive to the input data that specify the availability of ships and aircraft, these availabilities, of course, can be difficult to predict Reserve and civilian ships and aircraft must be mobilized, and their availability can depend on, for example, declarations of alert and mobilization stages by U.S political leadership, commitment of transport assets by allies, and availability of manpower for operating transportation systems.[74] This further strengthens the argument for faster, less expensive models that could facilitate analyses of the feasibility of deployment and resupply under different assumptions about transport availability

It is especially important to find ways of hastening obtaining and setting up the data for processing by deployment models.

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[72]Other models are similar For example, a SUMMITS run (Scenario Unrestricted Mobility Model for Intratheater Simulation) takes 4-6 hours of mainframe computer time, but total "turnaround" time (including data setup) is at least three months

[73]A rudimentary spreadsheet model developed in ongoing work at RAND seems able to duplicate MIDAS results fairly closely in about 20 minutes' execution time on a desktop microcomputer

[74]Lacy, 1986b, for example, questions the availability of sailors for operating the transport fleet

An additional limitation of MIDAS-like models is that they do not model fuel consumption and refueling or other transport support activities. Instead, they assume that fuel is always available and that there are no delays due to secondary services—e.g., maintenance or fuel tanker shortfalls.

Deployment planning and modeling have obvious and important implications for both unit and force readiness and for force sustainability. They've been used, for example, to consider tradeoffs between unit readiness and strategic airlift capacity.[75] The delivery schedules they generate imply the time-varying force structure available for operations in the theater. Calculated properly (e.g., taking into account both the performance potential of the units emplaced and their dependencies on each other), these force profiles themselves could be valuable indicators of force readiness. These same profiles, together with information about the units previously in the theater and information about force employment expectations (including attrition, intensity, etc.), are needed to calculate the time-varying demand for sustainability supplies. Because augmentation and replenishment of any pre-positioned sustainability supplies occur mainly through the same movement and handling channels that deploy forces, the "nonunit cargo" flows through the deployment/distribution system must be included in evaluations of theater sustainability. Further, in-theater pre-positioning and agreements with allies or host nations to provide support (e.g., engineering, transport, or supply management) to U.S. forces reduce U.S. deployment and resupply requirements Using no more movement and handling resources, these options permit faster emplacement of force structure and additional sustainability resources (provided the individual units and materiels are available for movement.)

These close relationships between movement and handling systems and actual readiness and sustainability argue strongly for pursuing the conflicting objectives of speed/simplicity and broader scope in movement and handling modeling.

Combat Modeling and War Gaming

Combat models and war games are typically used to consider the effects of alternative strategies and force structures in opposition to known or hypothesized enemy strategies and force structures. They generally pay limited attention to matters of readiness and sustainability. Combat models are generally implemented as computer programs

[75]Smartt, 1988, shows that earlier availability of units enables their deployment by sealift (regarded as much less expensive than airlift), still achieving the CINC's schedule requirements

that string together series of simulated force-against-force engagements, keeping track of "output" measures such as·

- Territorial changes over time: movement of the FLOT, square miles lost or gained, etc.,
- Cumulative casualties incurred by each side,
- Forces remaining on each side at different times.

Mathematical relationships whose principal inputs typically include both sides' force sizes and estimates of their relative effectiveness are used to predict the outcomes of individual battles. War games typically employ combat models to adjudicate the battles that are generated by the opponents' selected strategies and tactics. War games can be either man-in-the-loop (people choose plans, strategies, and tactics on the basis of enemy actions, negotiations with allies and third parties, intelligence information, etc.), analytic (computers are programmed to select strategies and tactics, generally on the basis of optimization or artificial intelligence logic), or a combination of the two.

The data and computer requirements for detailed combat models can be extremely large The Army's developing Force Evaluation Model (FORCEM), for example. typically needs tens of thousands of elements of input data and requires 8–10 hours of mainframe computer time to simulate 60 days of large-scale conflict.[76] Some other prominent, large-scale combat/war gaming simulation models include the Joint Theater-Level Simulation (JTLS) model[77] implemented for use by the unified commands in developing concepts of operations and OPLANs, the Joint Analytic Warfare System (JAWS)[78] being developed for the Joint Staff, the RAND Strategy Assessment System (RSAS),[79] and the Tactical Sequential Analytic Game Evaluator (TACSAGE)[80] FORCEM and JTLS represent single-theater operations and relationships in substantial detail JAWS and RSAS can represent global conflicts, and both can use computerized "expert systems" to play the roles of opposing, allied, and even neutral decisionmakers This option permits much more rapid completion of games, repetition to examine the

[76]The Army uses FORCEM (or its predecessor, CEM, the Concepts Evaluation Model) in its PPBS process largely to estimate requirements for combat resources

[77]See Jet Propulsion Laboratory, 1986a, along with Booz, Allen, and Hamilton, 1986

[78]See, for example, Logicon, Inc., 1986 JAWS is expected to have the flexibility to represent a widely varying scope of conflict—from country-vs-country to global war—and different levels of resolution—e g, from weapon-vs-weapon to corps-vs-corps

[79]See, for example, Davis and Winnefeld, 1983 The RSAS is currently implemented at OSD's Office of Net Assessment, the Joint Staff, the National Defense University, the Naval Postgraduate School, and the Naval War College

[80]Unpublished RAND research by R J. Hillestad.

variability in outcomes, and exploration of many more alternatives. It vastly reduces the manpower required to conduct war games. TACSAGE admits no human intervention in the course of its analysis, using optimization methods to allocate air sorties to maximize the achievement of opposing sides' objectives in a two-sided game.

Combat models and war games vary in their perspective (e.g., from corps commander to theater commander to the Joint Chiefs of Staff), their interactiveness with users, their transparency, their emphasis on command/control and combat processes, the theaters to which they apply, the degree to which they integrate across theaters, the types of arms considered, and so on. Because the computational requirements of such models are so large, numerous efforts have been made to develop smaller, more manageable models. Examples include the State-of-the-art Contingency Analysis (SOTACA) model[81] and RAND's Army Logistics Analysis-Extended (ALA-X) methodology.[82] The SOTACA model is for the unified commands to quickly explore a range of broad operational options, a few of which would then be examined using the more detailed JTLS. The ALA-X is actually a "tool-kit" of microcomputer-sized models intended for use by Army headquarters staffs during PPBS deliberations, it is designed to produce results consistent with those from FORCEM.

War games typically involve scores of human players, controllers, and technical support staff. Some examples include the Joint Staff's Total Force Capability Analysis (TFCA) (which has been adapted for the new biennial net assessment by the Chairman of the Joint Chiefs of Staff) and games conducted at the Naval War College Personnel come from all services, some playing roles for the opposing side, and they are supported by several different models.[83]

As the technology and practice of war gaming develop, more attention is turning toward providing timely information about logistic and manpower resources, forcing participating strategy and operations planners and decisionmakers to consider limitations in support resources Historically, it has been very difficult to generate such information. It must be influenced by cumulative and immediately recent combat and logistic activity; it tends to become extremely detailed (because of the myriad logistic resources that can become constraining); and it requires substantial data bases, rapid analysis

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[81]Cushman and Carraway, 1986

[82]Bigelow, 1988

[83]The TFCA, for instance, uses air-land combat models called INBATIM (Integrated Battlefield Interactive Model) and TACWAR (Tactical Warfare Model), a naval warfare model called NAVMOD (Naval Model), and MIDAS This requires "extensive off-line integration of the models" (See, e g, Logicon, Inc, 1986, pp 2-4)

capabilities; and several people to collect and manage the data, conduct the analyses, and organize the results for the strategy and operations planners and decisionmakers.[84] One prominent effort aimed at reducing the cost of war gaming and increasing the realism with which support resources are considered is the Joint Exercise Support System (JESS),[85] which lets participating battle staffs stay at their command posts, linking them through their own communications channels to a network of computer workstations that manage combat-affecting data (including logistics and manpower) and tap a combat model (Tactical Simulation, TACSIM) to judge engagement outcomes. JESS addresses corps-level conflicts. It tracks quantities in categories within all classes of supply (except Class II, individual equipment, and Class VI, personal items); convoy content, movement, and attrition; battle and nonbattle equipment and personnel damage/casualties; maintenance and medical facilities; equipment items under repair; and personnel distinguished by their career management field or military occupational specialty.

Generally, the broader a combat model's or war game's scope, the lower its fidelity in representing readiness and sustainability considerations. JESS is exceptional, for example, in that it keeps track of so many different categories of supply and personnel.[86] Naturally, the more detail maintained, the greater the data and computational burdens.

Combat modeling and war gaming offer important advantages as potential contributors to readiness and sustainability assessment. Conceptually, they come much closer to estimating "ultimate outcomes"—i.e. they predict the results of war. They distinguish the constituent mission areas and locations, and they explicitly represent operational scale and the time dimension, all features deemed highly desirable in readiness and sustainability assessments. Furthermore, in spite of the complexity of the data, assumptions, activity, and analyses that generate them, the results are fairly simple to interpret: What territory was gained or lost? What were the personnel and equipment casualties?

But their disadvantages, dictated by their current limitations, are also very important. Their attention to representing combat interactions, a highly complex task by itself, overwhelms attention to

[84]At the Naval War College's annual "Global War Game," for instance, the "logistics control group" numbers about two dozen, and scores of players participate in the mobilization planning and management activities.

[85]Jet Propulsion Laboratory, 1986a. JESS is intended to greatly increase the "realism, versatility, repeatability, and accessibility" (the latter for post-exercise analysis) of command-post exercises (CPXs) without requiring substantial additional costs.

[86]There are still many more categories than JESS can represent. For example, JESS distinguishes up to only 36 types of personnel.

readiness and sustainability aspects. Constituent deployment and resupply modeling is extremely crude, for instance, and performance levels (in terms of effectiveness "parameters") typically are not represented as depending explicitly on preparation time (which would allow resource cross-leveling and additional training, for example). The computer and data requirements are already large, and developers expect that high-fidelity representation of readiness and sustainability aspects would stretch these requirements beyond practical limits. Moreover, combat outcome prediction depends on many other factors that seem outside the scope of U.S. readiness and sustainability measurement—e.g., choices of strategies and tactics by both sides; estimates of the effectiveness of U.S., allied, and enemy weapon systems; and estimates of the readiness and sustainability of allied and enemy forces. Finally, combat models and war games typically represent only a single course of a war, and that often affected by the interactive decisions of human players, which severely limits the validity of comparisons made from one year to the next.

Nevertheless, it may be possible to exploit these methods' principles (and perhaps even some of their underlying computer tools), shifting the emphasis from combat modeling to mobilization, deployment, and support modeling. Consider the RSAS, for example. Probably the most highly integrated system designed from a top-down perspective, the RSAS is an analytic war gaming system that can be used for human gaming, interrupted simulation, or closed simulation. It has the perspective of theater commanders or national authorities. It integrates ground, air, and maritime forces. Its resolution is appropriate to strategic- and operational level analysis. It includes models of airlift and sealift and monitors days of supply by nationality and for a few resource categories. Its combat models reflect parameterized estimates of force effectiveness that depend on training time and mission. Military strategies are explicit in RSAS work and are readily changed.[87] The treatment of theater logistics is primitive, however, and it currently has no algorithms relating the availability of support forces to combat effectiveness. We believe it would be possible to extend these aspects of the RSAS, making it represent readiness and sustainability more directly and accurately. For purposes of readiness and sustainability assessment, in fact, it may even be possible to

[87]RAND has used the RSAS in numerous DoD studies dealing with the Central Region balance, conventional arms control, strategic nuclear balance, the potential value of standoff conventional munitions in secondary theaters, and assessing alternative global military strategies It is being used within the government for war gaming (e g, at the National Defense University and the Naval War College), education in operational art and strategic assessment (e g, at the Naval Postgraduate School and at the services' war college), and special studies

bypass the (relatively large and assumption-laden) segments of the RSAS that adjudicate combat. The same underlying tools—involving flexible decision tables and principles of artificial intelligence, for example—promise to represent the situation dependencies that would affect readiness and sustainability resource management in different contingencies. And the capability of employing the RSAS repeatedly and quickly—even without human intervention, if that option is desired—might enable investigations of the robustness of readiness and sustainability resources/postures across a range of contingencies and considering uncertainties within contingencies.

Explorations and improvements in incorporating these considerations in combat models, war games, and exercises are under way on several fronts. JESS, JAWS, and ALA-X are examples. We endorse such incorporation; RAND undoubtedly will participate vigorously in advancing the necessary concepts and developments. We believe, however, that many more years will pass before the extensions needed to represent readiness and sustainability in sufficient detail and scope and for a variety of contingencies and assumptions can be made comprehensive and practical enough for combat models and war games to support regular readiness-and-sustainability-related decisionmaking at the OSD, Joint Staff, and congressional levels

For purposes of improving such measurement in the meantime, we recommend concentrating on the development of an integrated framework for representing how units and forces are readied and deployed for war and how their resource and service needs are met (how they are sustained) once they are there. (See Sec. IV.) This may involve the synthesis and/or development of mobilization, deployment, and sustainment models whose concepts might eventually merge with those of combat models and war games to enable more "bottom-line" evaluations of the effects of readiness and sustainability resources on combat outcomes In fact, as we have suggested for the RSAS, it may be possible to use many of the data management, decision representation, and computational structures that currently support combat models and war games in establishing such a framework.

SUMMARY

Myriad individual models, data systems, and procedures exist within the seven families of approaches discussed in this section. Although the judgments listed in Table 7 may be somewhat inaccurate for any one of the methods within a family, we believe they summarize the degrees to which each family *currently and generally* possesses each of the eight characteristics posited in Sec. II as "ideal" for readiness and sustainability measurement methods.

Table 7 indicates that combat models and war games offer a range of advantages over other methods. Especially attractive is their characterization of "ultimate outputs"—i.e., war outcomes. Incorporation

Table 7

SUMMARY OF IDEAL MEASUREMENT CHARACTERISTICS

Readiness/Sustainability "Ideal" Measurement Characteristic	Approaches Oriented Toward: Units			Forces			
	A	U	F	S	M	D	C
Measure outputs, not merely inputs							
Mission dimension	1[a]	3	4	2[a]	2	2	5
Location dimension (theater)	1	3	2	3	2	4	5
Scale dimension	0[a]	1	2	2[a]	3	4	4
Time dimension	1[a]	4	1[a]	3[a]	3	3	4
Practical							
Undisruptive	2	4	1[a]	2	4	4	4
Inexpensive	3	3	1	3	3	3	2[a]
Understandable	2[a]	4	4	2	1	3	4
Objective, verifiable	3	4	3	3	2	[illegible]	4
Reflect robustness	1[a]	4	2	2[a]	2[a]	3	3
Useful to data providers	3	4	5	3	1	2	3
Values comparable over time	2[a]	4	4	2[a]	2	4	1[a]
Comprehensive (transition from peacetime)							
Peacetime manning	5	1	3[a]	0	5	3	2
Peacetime stocks	2[a]	2[a]	1[a]	4[a]	4	2[a]	2[a]
Peacetime OPTEMPOs	2[a]	2	3[a]	0	2[a]	2	1
Mobilization	0[a]	1[a]	1[a]	1[a]	4	3	2[a]
Deployment	0[a]	1[a]	2[a]	2[a]	2[a]	4	3[a]
Permit evaluation of tradeoffs	0	4	4	0	0	2[a]	1[a]

NOTES A - Asset reporting; U - Unit modeling; F - Functional testing, S - Stockpile reporting; M - Mobilization planning; D - Deployment planning; C - Combat modeling/war gaming

0 - Lacks characteristic completely
1 - Small degree of characteristic
2 - Degree less than average of characteristic
3 - Average degree of characteristic
4 - Degree greater than average of characteristic
5 - High degree of characteristic

[a]Shows promise for substantial improvement

of automated decision rules overcomes two of the approach's major shortcomings by reducing the dependence on human players· It makes the methods more practical and their results more comparable from one evaluation to the next. Unfortunately, however, these tools are already generally complex, and it will be difficult to keep them practical and simultaneously incorporate the scope and detail needed to reflect readiness and sustainability.

Asset and stockpile reporting, essentially representing today's methods of characterizing readiness and sustainability, display important weaknesses But several improvements are possible that could avoid many of these problems. For example, asset reporting could emphasize "training readiness" much more strongly, focusing on the length of time required to bring units up to specified performance standards and comparing these times with deployment schedule requirements. And stockpile reporting could take into account a wider range of resources, recognize distinct mission areas, and make explicit the assumptions (e.g, concerning consumption, attrition, and resupply rates) that dictate how long supplies of materiel and manpower would last.

IV. AN INTEGRATED FRAMEWORK FOR READINESS AND SUSTAINABILITY ASSESSMENT

Each family of methods described in Sec. III has its own strengths and weaknesses, and we have nominated ways of improving their potential contributions to readiness and sustainability measurement. Many of the improvements we recommend would involve linking one method to one or more others. For example:

- For (unit) asset reporting we suggest emphasizing the training time needed to achieve specified performance standards, the time needed to restore equipment to full operating condition, and the time to prepare for deployment; linking these times with information about unit equipment and supplies and about nonunit stockpiles to estimate the increasing numbers of units of each type available over time, and comparing those numbers against deployment requirements
- For mobilization planning we recommend accounting for the capacities of induction and individual training centers, the capacities of training and practice ranges, the distribution of materiel stockpiles, the production of additional materiel, the cross-leveling of materiel and manpower among units, etc., enabling comparisons of the forces and materiel ready for movement with the deployment capacities that can be marshalled.
- For combat modeling and war gaming we recommend higher fidelity representation of logistic, manpower, and deployment/resupply limitations, permitting the course of the simulated war to be influenced interactively by readiness and sustainability considerations

Many such extensions (and even mergers) of present methodological approaches seem both desirable and feasible.

If such incremental changes seem advantageous, what about going all the way, merging all seven approaches into a single, comprehensive, integrated approach? Recall from Table 7 that for each ideal measurement characteristic, at least one approach rates high. Is it possible to combine these strengths by integrating the approaches? We believe that, unfortunately, complete integration will not be possible within the next several years. Each approach is already complex in its own right, involving numerous organizations, extensive data and assumptions, and, often, substantial computerized data processing. Even if it could be done technically, harnessing them all together would probably yield a mechanism far too large, cumbersome, and data-hungry to support and operate routinely Furthermore, although such a mechanism's "ultimate output" (presumably, projections of the likely course(s) of war, derived through analytic war games) would be an excellent sort to inform top-level decisionmakers, it would be based on so many estimates and assumptions about highly uncertain matters that decisionmakers could fairly question its believability.[1] It would also be too large to permit much sensitivity analysis, making it extremely difficult to address such questions as· "What if U S. leaders authorized greater or earlier mobilization; what if peacetime operating tempos were increased so that units could achieve wartime performance levels quicker; what if stockpiles were larger in specified locations; or what if deployment and/or resupply transport capacity were changed?"

Because of their already large, complex, and assumption-laden nature, combat modeling and analytic war gaming raise the greatest barrier to the practicality and understandability of such a "totally integrated" assessment mechanism. Consequently, we recommend considering a framework that would integrate the other six approaches, which treat readiness and sustainability much more directly; they collectively require fewer assumptions about allies' and enemies' capabilities, and they represent a formidable integration challenge in themselves. Furthermore, the experience and capabilities that would come from integrating them could prove instrumental in any eventual integration with combat models and analytic war games.[2]

In this section we first outline the forms and types of readiness and sustainability measurements that could come from such an integrated assessment framework and then sketch a coarse conceptual design for the framework itself.

READINESS AND SUSTAINABILITY MEASURES FROM INTEGRATED ASSESSMENTS

We believe that assessments of U.S. readiness and sustainability should examine the *amounts of different kinds of missions U S. forces could conduct over time*—e.g., as depicted in Fig. 3 This type of

[1]See, for example, Davis, 1988

[2]In fact, as suggested in Sec. III, one possibility is to represent readiness and sustainability considerations using the same types of data structures, decision tables, etc, that analytic war games employ. These methods are very powerful and flexible, and their use would facilitate any potential later integration with combat modeling and war gaming

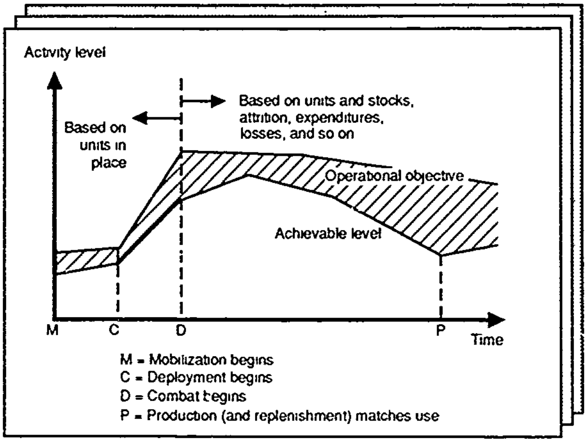

Fig. 3—Integrated measurement: Mission activity levels over time

assessment, especially when evaluated in the context of CINCs' views about the adequacy of the quantities and timeliness of mission availability, would come much closer to answering questions about the risks and imbalances implicit in U S defense programs. We believe such assessments should be developed routinely for different types of contingencies (i.e., different scenarios) and that dependencies should be clarified about how the assessed values depend on uncertain parameters—e.g., the degree and timing of mobilization and deployment relative to the beginning of fighting, the intensity of combat, combatant and resupply attrition rates, and resource consumption and loss rates.

In essence, such assessments would translate information about the peacetime status of unit and nonunit resources (the information about *inputs* collected through today's stockpile and unit asset reporting systems) into estimates of force *outputs*: how much of several key types of activities our forces could conduct over time. It would be important in such assessments to identify the factors that limit the availability of mission activities—e g., specific shortfalls in the pre-mobilization readiness of units (if certain types of units require too long to assemble or train up to an acceptable performance standard), in pre-positioned (or other) stockpiles of unit equipment or supplies, or in transportation or materiel handling capacities Current conceptions of both readiness and sustainability would be combined in such assessments: Both units (whose resources SORTS' "readiness measurement" captures today) and nonunit resources (represented to a large degree in DOS "sustainability" figures) are needed to generate mission activity. Furthermore, these assessments would be influenced by data characterizing mobilization, deployment, and the interdependencies among units and operations of different types.

Three questions arise immediately about this idea of integrated measurement: (1) What are the appropriate mission areas? (2) How could high-level decisionmakers interpret the combined meaning of a collection of profiles like those depicted in Fig. 3 (especially since each one might vary depending on assumptions about, for instance, mobilization, deployment, or consumption)? (3) Could such assessments be developed practically?

First, the CINCs and services should select mission areas. Several breakdowns are already specified that may suffice For example, the Navy distinguishes anti-air warfare, strike warfare, mine warfare, and construction among 15 mission areas used in SORTS reporting, and the Air Force distinguishes offensive counter air, close air support, aerial refueling, and surveillance and reconnaissance among 20 missions and specialized tasks.[3] The Army's Battlefield Operating System (BOS)[4] breaks down Army field activities into seven major functional areas. The number of distinct mission areas should be kept small to permit overall review and understanding by OSD and Congress, but it must be large enough to account for substantially different rates of resource consumption and for dependencies among different types of operations. For example, offensive operations generally consume more fuel and ammunition than do defensive operations, construction units and transportation management units sometimes must lead to prepare the way and manage the forward movement of combat units and support resources, airlift and sealift units must be available to haul other

[3]U S Navy, 1987, p 5 7, and Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force*, March 1984. Of course, major "support mission areas" also need to be distinguished, for they often constrain the usability of combat mission areas This, too, should be relatively straightforward. For instance, USAF's *Combat Support Doctrine* (AFM 2-15, December 1985) outlines several familiar "logistics" functions including, as examples, storage, maintenance, training, graves registration, and construction

[4]U S Army, 1989

deploying units; close air support and certain ground combat units should be in place at the same time; and maintenance, supply, and medical units must be in place to sustain the operational capabilities of combat units.

Second, interpretation of the variety of curves depicting mission activity levels over time could be facilitated in several ways:

- By finding the area under each curve out to some specified time. This would promote year-to-year comparisons in such terms as: "We can now emplace and support forces and resources enabling 15 percent more of Mission X within the first 10 days after mobilization than we could three years ago."
- By summarizing the curves in a manner paralleling C-levels and S-ratings. For example, a mission area projected to be available in at least 90 percent of a specified objective ("required") quantity might be classified "M-1," but one available in only 85 percent of the objective quantity might be classified "M-2."
- By simply having them reviewed, evaluated, and summarized by the unified and specified commanders responsible for operations in contingencies similar to those on which the curves are based. These commanders have vested interests in making sure that OSD and congressional decisionmakers understand and recognize readiness and sustainability shortfalls.

We caution that assessments of the type we recommend need not be based on actual OPLANs. In fact, because OPLANs reflect real intentions, are based only on current resource availabilities, and can change substantially when a new CINC takes over, they should probably not provide the context for high-level readiness and sustainability assessments. It would be preferable to consider illustrative scenarios that might need to be changed less often and would facilitate freer discussions and assessments of alternative resource mixes that could become available through altered funding levels.

Finally, the practicality of developing the kinds of assessments we propose remains to be established. DoD should not spend as much time and effort assessing readiness and sustainability as it spends developing OPLANs. We believe that adequate assessments can be developed with much less effort; we will shortly describe our initial ideas about how that could be done. At this point we merely emphasize that DoD already conducts important steps that could contribute to the integrated framework we propose. Some of them may need to be simplified to make the proposed framework practical, and the development of such assessments will probably always be difficult, but we believe the potential benefits justify the attempt. The framework would illuminate the coherence/consistency of U.S. force structure, units, and resources that dictate (and depend on) force readiness and sustainability.

Before we outline an analytic framework that would lead to the broad, integrated assessments we envision, we describe some of its constituent assessments that seem conceptually closer to today's notions of readiness and sustainability.

Readiness In Integrated Assessments

The approach we suggest distinguishes clearly between unit and force readiness: *A unit's readiness would be characterized primarily in terms of how long it would take to bring it from its premobilization status to a specified wartime performance standard, primarily through training.*[5] See Fig. 4.[6] The time required to make the unit's equipment fully mission capable and to prepare for deployment would also be considered.[7]

Force readiness is more comprehensive, depending on unit readiness and the location and type of contingency, of course, but also on the ability to provide the training expected in unit readiness assessments, to configure units with full manning and sets of equipment, and to

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[5]As noted previously, the Army already includes in SORTS reports coarse categorical estimates of the time required to achieve complete training, and Follmann et al., 1986, have derived empirical estimates of the steaming days required for Navy combatant ships to transit between adjacent C-levels in training readiness. And all services, when participating in deliberate planning or providing inputs for Joint Staff studies such as TFCA, already estimate when units can be available for deployment. SORTS' other options for reporting unit training status (the percentage of crews fully trained or the percentage of unit training completed) are regarded as more objective and verifiable than estimates of how long it would take to complete training. (See, for example, GAO, 1986a, p. 16.) Nevertheless, through approaches like the Army's Battalion-Level Training Model (BLTM) and carefully designed functional tests, we believe the objectivity and verifiability of such time estimates could be increased substantially.

[6]Naturally, the lower the wartime performance standard, the sooner it can be achieved. In practice, units could be deployed before they achieve the desired standards. Later we will consider the profiles of the number of units that could be emplaced having achieved different levels of performance.

[7]The times required to "equip-up" and "man-up" are also important in projecting the timely availability of units' capabilities, of course, but they are frequently not subject to much influence by the units themselves. Such "missing resources" must be provided from outside. In many cases it may be possible, and even planned, to prepare units using only their existing resources and to augment them just before deployment or even after. (For example, many Army units will draw and use POMCUS equipment.) Thus, we emphasize obtaining data routinely from units to identify what they have, what they would need to train up, and how long that would take. Ascertaining whether the resources are available to permit the train-up and to augment units' manning and equipage are matters for higher organizational echelons.

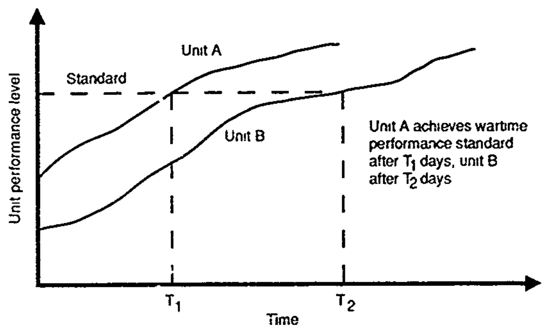

Fig. 4—Training readiness. Time required to achieve wartime performance standard

deploy units and materiel in the proper sequences and quantities. *Force readiness would be characterized in profiles showing, over time, the increasing numbers of different types of force elements that could achieve required performance levels and be emplaced in the area of operations.*

Figure 5 portrays the conceptual relationship between unit and force readiness. The critical linkage is *time.* The longer it takes units to reach wartime performance standards and the more restricted the training capacity or the movement/handling capacity, for instance, the fewer the units that can be put in place over time. Such "force readiness" time profiles would project what kinds of forces the United States could put in place, how many, and how quickly—important information for judging the likelihood of deterring conflict or prevailing if deterrence fails

Sustainability in Integrated Assessments

Sustainability assessments should also reflect the location, types, and timing of military activity. First, sustainability assessments should project the growing stockpiles of nonunit resources—materiel and manpower—that would become available in the CONUS after different periods of mobilization Similar to units whose performance levels have been raised to specified wartime standards, the growing stockpiles

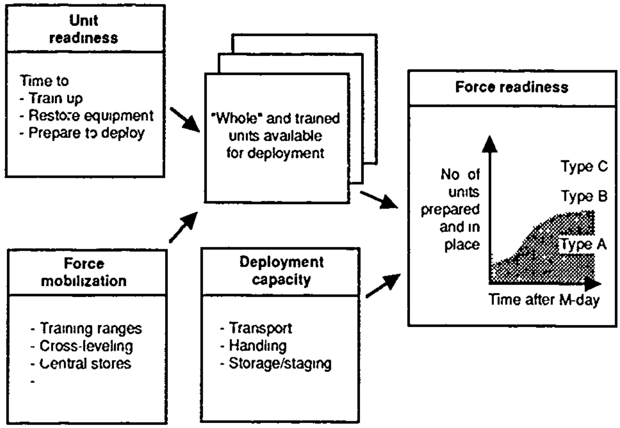

Fig. 5—Force readiness depends on unit readiness, mobilization, and deployment

of nonunit resources would be available for movement into theaters of operation Perhaps through host-nation agreements or prewar contracts, additional resources (e.g, transport personnel and petroleum products) may become available in the theaters without resupply from the CONUS. Movement and handling capacity would be used to move CONUS nonunit resources into the theaters, augmenting theater stockpiles. Of course the movement and handling capacity must be shared with deploying units. Nominally, the proportion of movement and handling capacities devoted to resupply grows and the proportion devoted to unit deployment shrinks as conflicts proceed. In any case, the cumulative quantities of nonunit resources brought into a theater increase over time, as Fig. 6 illustrates Naturally, the growth of these supplies is influenced by the length of mobilization lead time, the allocation of movement and handling capacity, and any losses incurred en route, items about which there is considerable a priori uncertainty.

Second, sustainability assessments should project the demands for nonunit materiel and manpower that contingency operations would

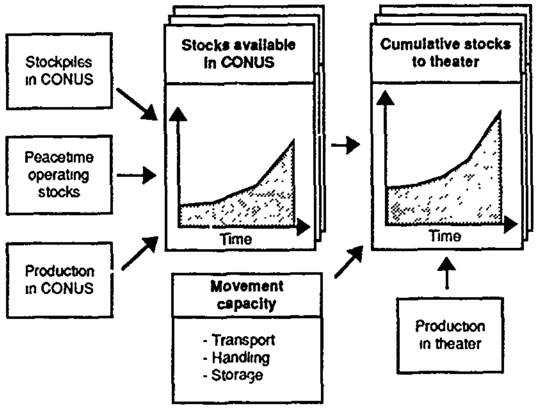

Fig. 6—Growing cumulative supplies of stocks within the theater

require. Information needed to make these projections, of course, includes the types and numbers of units available in the theater (from force readiness assessments), their consumption of resources, and their generation of needs for services and resupply. Again, these are items about which there is substantial uncertainty.[8]

Figure 7 illustrates a notional example of this kind of evaluation, a comparison between an objective (or targeted) level of operations for a mission area and the level actually supportable with available units, supplies, and services. (Services include, for example, maintenance, supply, and medical functions.) As noted in Sec. III, large-scale simulation models have been used in the past (see, e.g., Shishko and Paulson, 1981,

[8]Nevertheless, this type of information must be estimated (or assumed) even under current assessment methods to determine DOS figures To cope with the variety and magnitudes of uncertainties concerning several parameters that affect estimates of sustainability, we recommend conducting sensitivity analyses to investigate how much the estimates change with changes in these parameters and to evaluate the adequacy (and robustness) of given quantities and distributions of materiel and manpower under different assumptions about these unpredictable quantities.

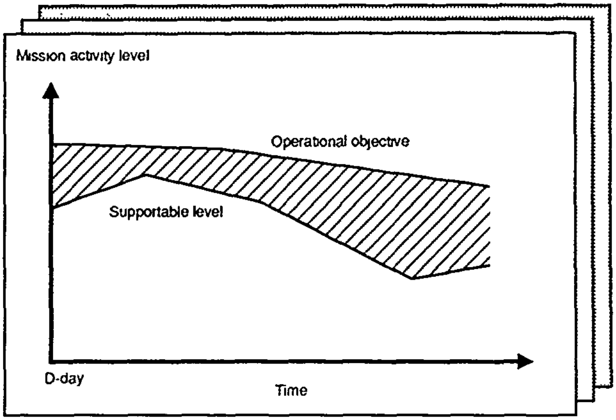

Fig 7—Activity levels supportable in different mission areas

or Emerson, 1982) to derive such curves. We suggest below the possibility of projecting such curves using simpler, faster evaluation methods

Two convenient ways of consolidating the time-varying profiles of sustainable missions—like those depicted in Fig. 7—include.

- Finding the area under each "supportable profile" (permitting such statements as "we can now sustain __ percent more of mission X during the first 60 days of conflict than we could three years ago") or the area above each curve and below the objective curve (permitting such statements as "we can now sustain __ percent more of the first 60 days' objective for mission X than we could three years ago").
- Use a categorical scheme like that C-levels and S-ratings currently use—"M-levels," as suggested above.

Sustainability summaries would constitute the integrated framework's final overall assessments, reflecting the amounts of different types of missions U.S. forces could conduct over time. These assessments would combine the relevant data about unit and force readiness, about stockpiles inside and outside the theaters, and about mobilization and deployment/resupply capacities

A FRAMEWORK FOR INTEGRATED ASSESSMENTS

This discussion emphasizes the logical structure required to make readiness and sustainability assessments of the types outlined above The practicality of the structure is of major importance and interest, but it is not established unequivocally here, it remains an objective of research and development

Figure 8 depicts major dependencies in the transition from peacetime to wartime, beginning with a specified peacetime posture (reflected in force structure, asset levels and distributions, operating tempos, etc) and proceeding through the generation of mission activities in operational locations. For instance, the force size and mix (the force profile) available in the theater (upper left portion of Fig. 8) depend on the times required to train up any units forward-deployed in peacetime, on reinforcements brought from the CONUS (through lift and handling capacity), and on any pre-positioned unit materiel (e g , POMCUS) The availability of units and materiel in the CONUS for movement to the theater is influenced heavily by the timing and degree of mobilization. The availability of units and materiel in the theater, in turn, is affected heavily by the timing and degree of deployment and resupply. Finally, the "ultimate" quantities of mission activities executed in the theater are affected heavily by (assumed) employment, attrition, and consumption patterns, the aspects of operations that are most relevant to sustainability assessment The scenario aspects about which there is considerable a priori uncertainty are enclosed in boxes in Fig 8. For any major contingency being considered, we believe it is important to examine the sensitivity of the integrated performance measures (mission activity levels over time) to variations in these assumptions

Figure 9 depicts the relationships among the six approaches discussed in Sec III that would constitute the integrated readiness and sustainability assessment framework. The (unit) asset-reporting and (nonunit) stockpile-reporting approaches are combined in Fig 9; they would simply count and categorize the manpower and materiel available in peacetime, emphasizing training readiness for units (the time required to achieve a wartime performance standard). Next, analysis of mobilization potential would project the additional quantities of manpower, materiel, and units that could become available over time. Then, deployment and distribution analysis would estimate the

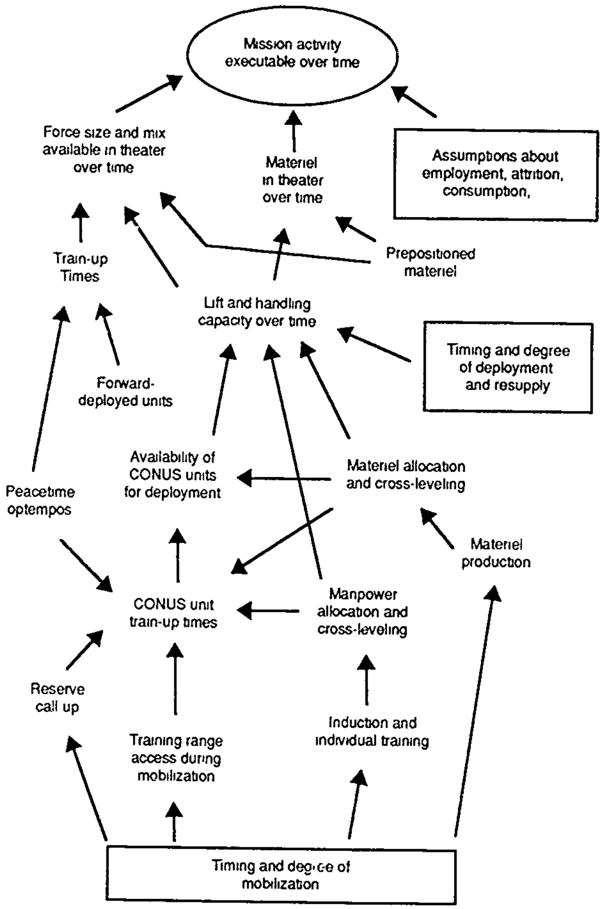

Fig. 8—Dependencies in the transition from a specified peacetime posture

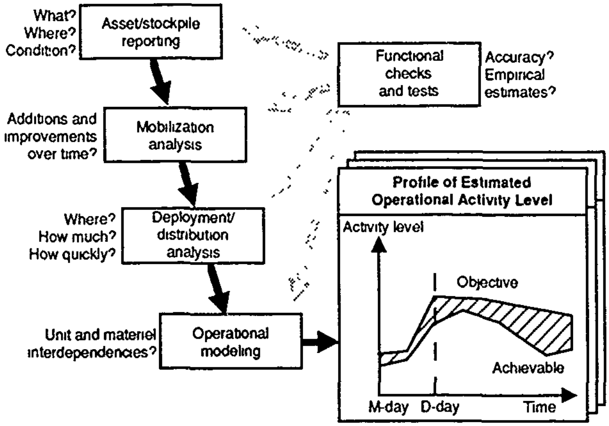

Fig 9—Relationships among existing assessment approaches in an integrated framework

quantities of units and materiels of different types that could be emplaced in the area(s) of interest over time. Finally, operational modeling (perhaps full-fledged unit modeling, but probably something simpler and faster) would convert information about available units and support resources and information about operations (e.g., employment patterns and corresponding expenditure and attrition rates) into profiles of the mission activity levels that could be achieved.

Notice that all the steps mentioned so far are analytic, presumably limiting the resources required in the assessment process and increasing the likelihood that sensitivity analyses would be possible. But Fig. 9 also shows functional testing as prominent in the integrated framework. Functional testing would be crucial, we believe, to verify several important operational assumptions imbedded in the analytic framework—e.g., the times required to achieve performance standards or to prepare for deployment, the quantities of units and materiel that transport and handling could accommodate, and the mission activity levels that units could generate with specified assets. In fact, if enough functional tests could be performed, the results might even permit statistical estimation of some of these quantitative relationships.

Now let us examine in somewhat more detail the problems that would be considered at each major step in this framework.

Step 1: Asset/Stockpile Reporting

In principle, this first step would be nearly the same as today's readiness and sustainability "measurement": It would simply describe "what resources are out there." (Unlike today's reporting methods, however, this stage requires no comparison with "required resources.") The principal questions about the integrated measurement system's design for this step are (1) in what detail should resources be counted, and (2) how should one estimate the time until a unit could achieve a wartime standard of performance?

Detail in Resource Counting. This question seems no different for the integrated approach than for today's SORTS and DOS reporting. DoD has hundreds of types of equipment and ammunition, thousands of types of specialized personnel, and hundreds of thousands of types of secondary items (spare parts, rations, personal items, etc.). Although there are numerous systems for tracking these resources, neither the integrated assessment framework nor any current assessment approach allows distinguishing *all* of them and reflecting the constraints they place on readiness or sustainability. Aggregations are necessary to limit both the amounts of data that readiness and sustainability measurement systems must handle and the detail that must be assimilated by decisionmakers who review the assessments.

The need will persist for individual units and for theater commanders to identify and report shortages of individual resources. The services themselves can correct many such shortages through redistribution of resources; higher-level decisionmakers' reviews should not be "cluttered" with such detail. Detailed shortages that reflect needs for additional resources can always be highlighted individually.

Broad-scale readiness and sustainability assessments, of the types deemed appropriate for high-level decisionmakers, need to be developed fairly rapidly, simply, and economically. The services will inevitably perform more detailed analyses in their calculations of requirements during the PPBS process as will the unified commands, their components, and the services in their development of OPLANs. Detailed resource management decisionmaking needs such analyses, but readiness and sustainability assessments for high-level decisionmaking do not.

Time to Achieve Wartime Performance Standards. DoD-wide, units already estimate how much of their equipment can be fully mission-capable within 72 hours, and the services estimate the lengths of time required to prepare for deployment. (In fact, deployment preparation is frequently practiced in peacetime.) But only the Army routinely estimates how long it would take its units to attain a specified performance standard (The standard is stated in terms of the mission-essential task list required for each unit's wartime missions.) Such estimates can be either entirely subjective or based on systematic analysis of training activities and times (e.g, similar to the Army's BLTM), or a combination of the two We recommend development of methods that depend less on commanders' judgments and more on reviewable, repeatable, and consistent analyses In either case, occasional exercises should be conducted to test the validity of the estimates.

Several other important questions arise with respect to this "train-up time". How should performance standards be selected? How should performance be measured? How should readiness and sustainability assessments handle the fact that units may deploy before achieving the wartime performance standard?

The first question would be little different under the integrated framework than under today's SORTS framework. Military judgment must determine the tasks that units should be able to perform and the levels (reflected in success rates and completion times, for example) at which they should be performed. The services already make and use such judgments. To preserve the comparability of readiness and sustainability from one year to the next, the performance objectives must remain stable.

Military judgment must also be the foundation for determining the performance measurement scales and acceptable scores for different kinds of units For example, it may be adequate to rate maintenance units' performance levels on the basis of individuals' knowledge and skills; but many units (e.g, maneuver units, ship combat crews, air defense units, and construction units) must be rated on team performance—e.g, reflecting timely and accurate detection of targets or rapid and effective preparation of operating sites The services already use rating scales to judge competitions among similar units and to provide feedback from training exercises.

Since some contingencies may require some units to deploy before they can achieve a specified wartime performance standard, it would be useful to partition unit performance rating scales into bands—in a manner similar to today's partitions in C-levels and S-ratings. Thus, different performance levels ("P-ratings") might be projected for units if they receive different amounts of mobilization/preparation time (i.e, "train-up time"), as illustrated in Fig 10. The longer the preparation time, the higher the unit's subsequent performance level and P-rating

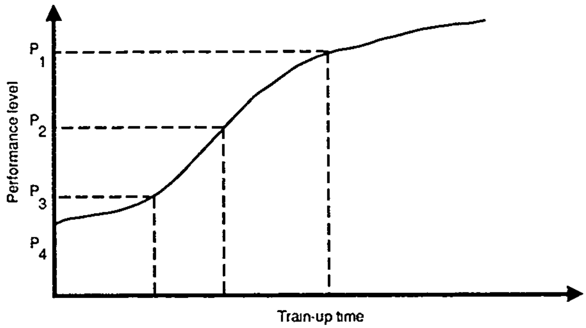

Fig. 10—Unit performance improves with train-up time

and the greater the number of units that could achieve higher P-ratings before deploying.

In summary, unit assets and nonunit stockpiles would be reported under the integrated assessment framework in ways quite similar to today's reporting under SORTS and DOS measures While C-levels and S-ratings might continue to be useful to guide resource allocations within the services, the integrated framework would need only the raw counts of specified resources in different locations and conditions. Much greater emphasis would fall on estimating the times required for units to achieve designated performance standards. This rich mix of information would be input for the next step in the integrated framework mobilization analysis

Step 2: Mobilization Analysis

The objective of this step is to project the quantities of units, people, and materiel that could be marshalled for deployment to combat theaters or prepared for employment (for those already in their theaters of operation, which can include the CONUS for strategic, strategic lift, and port management/operation units, for example). As in our earlier discussion of mobilization planning, it is useful to consider force mobilization and industrial mobilization separately.

Force Mobilization. As outlined in Sec. III, force mobilization involves several steps, and it must distribute many resources among competing requirements. It considers the equipment, manning, and training needs of individual units, coordinating the provision of forces tailored for different contingencies. The degree and type of mobilization dictate the depth of selective reserve unit activation, individual ready reserve call-up, and, possibly, conscription; and the contingency dictates the priorities accorded different types of units.

To project the numbers of different kinds of units that could be prepared over time, we envision a time-phased resource allocation model whose principal inputs would be (1) the scope of additional resources available for the mobilization (e.g., reserve units and new manpower), (2) the relevant unit and nonunit asset counts and unit train-up times developed in Step 1, (3) the capacities of mobilization activities (e.g., induction centers, specialist training schools, staging areas, and unit training ranges), and (4) the timing and priorities pertinent to the contingency being analyzed. The latter would guide the allocation of limited resources—e.g., favoring transport, materiel handling, construction, and long-range bombing units for a short-warning, large-scale contingency in Southwest Asia or favoring reconnaissance, strike warfare, and amphibious and airborne assault units for a longer lead-time, small-scale contingency in the Caribbean. The concept is illustrated in Fig. 11. Although there are data systems and analysis capabilities akin to this idea (e.g., the Army's MOBERS, OSD's WARMAPS, and the Selective Service System's "Traffic Cop" model), we are not aware of any automated, network-oriented, resource allocation models of the type we believe is needed for force mobilization analysis within an integrated readiness and sustainability assessment framework. The functional design, conceptual demonstration, and subsequent development of this capability would be a major undertaking in moving toward the integrated assessment framework. A paramount objective, of course, would be to limit the tool's size, complexity, and data requirements.[9]

Industrial Mobilization. Where force mobilization allocates existing manpower, equipment, and training resources (thus preparing units and forces), industrial mobilization taps potential military-industrial capacity and converts commercial industrial capacity to military support (thus providing additional materiel, especially munitions, and

[9]A closely related model that treats both force mobilization and deployment is being formulated at RAND to support research identifying potential future force structures for the Army. While the model is oriented toward force structure design, it may be possible to use many of its principles for evaluating force mobilization potential within a broad readiness and sustainability assessment framework.

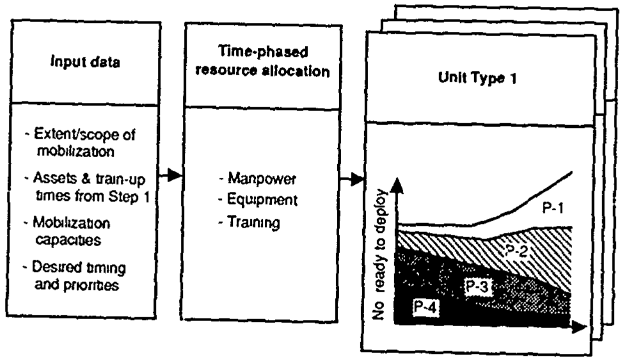

Fig. 11—Concept for force mobilization analysis

services, especially transport and maintenance). The services and DLA assess industrial capacity fairly regularly—e g., in PBAs and in maintaining CRAF and maritime shipping arrangements

Both industrial production and service capacities would figure in an integrated readiness and sustainability assessment framework. The output of these capacities would grow over time and, depending on the degree of mobilization, the capacities themselves could grow. If industrial mobilization were early and large enough, it could produce materiel and services for use even in initial force mobilization and deployment, not only later for repair and resupply

Information about industrial mobilization potential seems substantial, but it is disjointed and difficult to interpret in its current disparate forms Some industrial mobilization information is fairly straightforward—e.g., time-varying quantities of airlift and sealift capacities that could be added, or additional materiel production or repair obtainable from existing facilities through more work shifts. Other information is more complex and difficult to derive—e.g., the production available from plants that could be converted to military production, also considering any dependencies on the same second- or third-tier suppliers.[10]

[10]As noted earlier, the Institute for Defense Analyses is developing convenient automated methods (microcomputer-sized) for projecting the amounts of different materiels producible over time under different degrees of industrial mobilization (see Institute for Defense Analyses, 1988) This kind of analytic capability would be an

We believe an integrated readiness and sustainability assessment framework would provide a valuable, coherent structure for organizing information about industrial mobilization. Most important, it would link such information to the related aspects of force mobilization, deployment, and resupply that together enable mission activity levels in operational theaters. In a manner paralleling force mobilization analysis, industrial mobilization analysis would be guided by objectives and priorities pertinent to the contingencies being considered and to the resources already available to DoD, both in CONUS and pre-positioned.

Step 3: Deployment/Distribution Analysis

Deployment and distribution analysis addresses the movement, handling, and storage of unit and nonunit equipment, manpower, and materiel from premobilization locations to points of use. We noted in Sec. III that the analytic methods in greatest use for such analyses have extensive data requirements, are large and complex, and generally focus only on strategic (intercontinental) movement. Smaller, simpler, faster models are needed to facilitate integrated readiness and sustainability assessments (1) to incorporate movements and intermodal transfers in CONUS and operational theaters, (2) because the calculations for other parts of the integrated assessment also may be substantial, and (3) to permit examination of different scenarios and of sensitivities to assumptions within scenarios. The current existence of smaller, faster models for strategic movement analysis suggests the possibility of developing a practical deployment and distribution model or adapting one or more current models for use in integrated readiness and sustainability assessment.

Movement, handling, and storage capacities are inevitably limited and must be allocated over time to different purposes. Consequently, to translate the profiles of units and resources available in the CONUS into profiles of deliveries to destinations in operating theaters, deployment and distribution analysis must be guided by requirements and priorities that would differ among contingencies and over time within contingencies. The inputs to deployment and distribution analysis within the integrated assessment framework would include (1) these requirements and priorities; (2) the availability and characteristics of movement, handling, and storage capacities; and (3) the availability of units, manpower, and materiel for movement. Most of the data for (2) and (3) would come from Step 1 (asset/stockpile reporting) and Step 2 (mobilization analysis). Part of the data in (2) that characterizes

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important component of an integrated readiness and sustainability assessment framework capacities would reflect assumptions about fractional losses during shipment, handling, or storage. (Depending on the contingency, substantial resource losses may be due to enemy actions.)

The output from deployment and distribution analysis would be the profiles of units and materiels available in operating locations over time, as depicted in Fig 12.

At first it might seem that little new conceptual thinking would be required to merge deployment and distribution analysis into an integrated readiness and sustainability assessment framework. The challenge seems primarily in keeping this analysis simple enough—e.g., by merely aligning throughput with capacity rather than generating movement schedules—so that its calculations do not overwhelm the remainder of the integrated analysis. But a complicating factor may not be treated adequately in current analyses: the availability of manpower, equipment, supplies, and services for the movement, handling, and management units that conduct and oversee deployment and distribution. Just as for deploying units and materiels, the availability of resources for deployment units should be estimated on the basis of data from asset/stockpile reporting and mobilization analysis. Means should be developed to diminish the estimated throughput of deployment/distribution networks commensurate with shortages of resources needed to operate the networks.

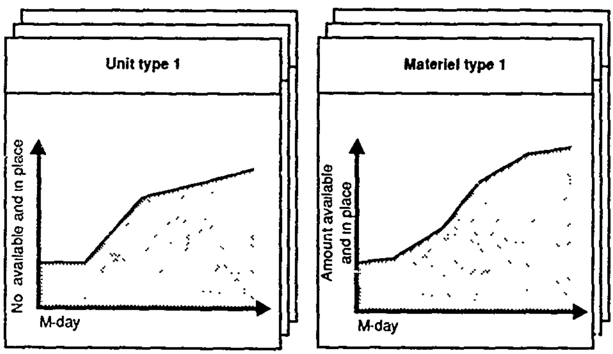

Fig. 12—Deployment/distribution analysis projects availability of units and materiel in operating locations

Step 4: Operational Analysis

The final analytic step is to convert the profiles of units and materiels available in operating locations to estimates of the mission activity levels achievable over time, the integrated assessment's ultimate indicators of readiness and sustainability. Two fundamentally different considerations must guide this conversion. (1) functional relationships among units and materiel, and (2) assumptions about resource utilization, attrition, and consumption.

Functional Relationships Among Units and Materiel. We have just noted how unit deployment and materiel distribution depend on the availability of units (and the operating and support resources required by those units) to operate and manage transport and handling networks. Other dependencies should also be considered—some units need to fight together, as close air support and ground combat units do, and some only support other units, as maintenance, supply, and medical units do. In case the companion or supporting units are unavailable or lack resources critical to their operations, then the employment/mission-generation patterns of the affected units should be altered. For example, aircraft may fly fewer close air support missions if fewer ground combat units are available, and they will fly fewer missions, regardless of type, if their own supporting maintenance units are unavailable.

We are hopeful that such dependencies can be recognized and represented in an integrated readiness and sustainability assessment framework without resorting to arcane simulation methods. Instead, we believe a conceptually simpler "input-output" analysis may suffice.[11] The activity level for each type of mission would depend on the availability of the units and resources that generate that mission, and the availability of those units and resources would depend sequentially on the availability of other units and resources, tracing back to the profiles of units and resources available in the theater—the profiles derived in Step 3's deployment and distribution analysis.

Resource Utilization, Attrition, and Consumption. Assumptions about these rates must be made today to estimate the numbers of days of supply represented in materiel stockpiles. The services have "planning factors" that tell, for example, how much ammunition and fuel would be consumed by an Army armored division in a day's offensive vs. defensive operations (also depending on the location), by a squadron of Air Force F-16s flying a specified variety of sorties, or by Navy destroyers escorting convoys. Each service also makes

[11]Input-output models, often in the form of "linear Leontief models," have been used to represent the complex interactions of industrial sectors in analyses of entire national economies See Leontief, 1966, for example.

assumptions about attrition of combat equipment, casualties among personnel, losses of resources en route and in storage, restoration of equipment and personnel casualties through repair and medical care, etc. Such assumptions exert the final influence in assessments of mission activity levels achievable over time, combined with the dependencies just noted among units and materiels, they regulate the draw-down of the profiles of units and materiel available in the theater.

We envision unit analysis within the integrated readiness and sustainability assessment framework being simpler than the "unit modeling" described in Sec. III. Monte Carlo simulation techniques should not be necessary. Instead, straightforward "electronic spreadsheets" may suffice. Spreadsheets' matrix structure seems well-suited to handle the dependencies of mission activity levels on the availability of relevant units and materiels and on assumptions about utilization, consumption, etc. Spreadsheets' simplicity and rapid computations should permit ready analysis of sensitivities to these availabilities and assumptions, also facilitating the identification of the bottlenecks and resource shortfalls that most limit the achievement of operational objectives.[12]

Step 5: Functional Testing

As noted at the outset, the integrated assessment framework relies on a series of analyses to project the profiles of mission activity levels that could be achieved in different contingencies These analyses would draw several conclusions and use several estimates/hypotheses that could and should be tested—specifically concerning:

- The amounts of train-up time needed to achieve specified unit performance levels,
- The times required to prepare for deployment,
- The amounts of materiel that can be handled and moved within specified amounts of time,
- The numbers of missions that can be generated with a specified mix of resources and support.

The services already conduct many exercises and tests that could be emulated or adapted to serve measurement purposes as well as training. Unfortunately, there is considerable institutional resistance to

[12]Unpublished RAND research by Hodges and Pyles discusses the need to account for operational and support uncertainties and for responsive resource allocation in projecting operational performance

sharing information about the results of exercises and tests.[13] The challenge is to design and conduct functional tests and to compile and summarize the results in ways useful for high-level decisionmakers while preserving a program of exercises and tests that will provide crucial information for training feedback, problem identification, and performance improvement.

SUMMARY AND SOME ORGANIZATIONAL CONSIDERATIONS

Emphasizing different aspects of it Figs. 13 and 14 depict the integrated readiness and sustainability assessment framework as we have outlined it Figure 13 emphasizes the major evaluations performed, showing (1) the buildup of units and materiel in the CONUS, (2) the changing availability of movement and handling capacities, (3) the buildup of units and materiel in the theaters of operation, and, finally, (4) the levels of mission activity those units and materiel could support. Naturally, these quantities would vary across contingencies/scenarios (distinguished by, for example, location, scale, and mobilization and deployment timing) and with assumptions about the contingencies (e.g., concerning force employment patterns, combat intensities, and attrition and consumption rates). Figure 14 emphasizes the elements of information that would be passed from one stage of the integrated assessment to the next and the additional information that would be needed at each step.

Obviously, because the scope of information the integrated assessment would incorporate is so wide and there is so much uncertainty about some of that information (e.g., mobilization depth and timing, attrition rates, consumption rates), it would be crucial to design the system to minimize data and computational requirements. This must be done to make even single integrated assessments practical but, even more so, to permit repeated evaluations under different scenarios and assumptions.

Much of the information needed to make such integrated readiness and sustainability assessments is already available somewhere within DoD. Our preliminary ideas about the sources of each major type of information needed are summarized in Table 8. That information

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[13]Some reasons cited for this resistance include reduced career prospects for commanders if their units perform below expectations, the "unfairness" of testing units without full sets of resources or without warning long enough to prepare for the test, and reduced credibility of requirements statements if units somehow managed to perform well even without full resources

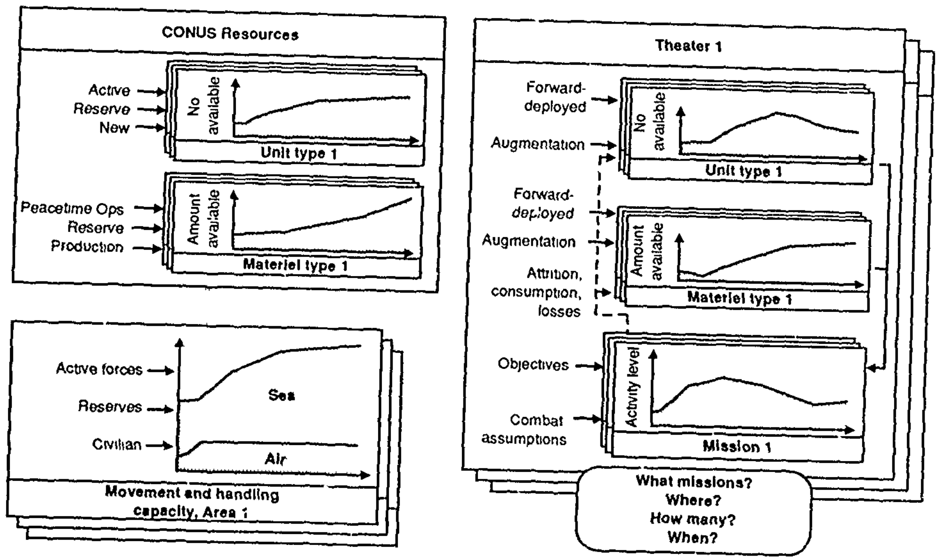

Fig. 13—Major quantitative evaluations in an integrated readiness and sustainability assessment

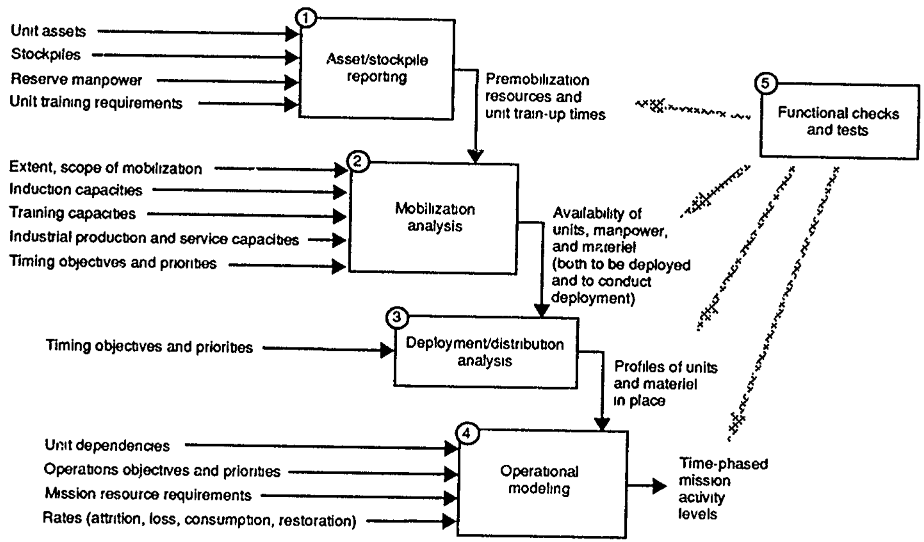

Fig. 14—Information used in each step of integrated readiness and sustainability assessment

Table 8

SOURCES OF INFORMATION FOR INTEGRATED READINESS AND SUSTAINABILITY ASSESSMENT

Information	Source
Step 1: Asset/Stockpile Reporting	
Unit assets and conditions	Individual units
CONUS stockpiles	Item/system managers
OCONUS stockpiles	Theater components
Nonunit reserve manpower	Services/OSD(RA)
Unit task training times	Services
Step 2 Mobilization Analysis	
Extent/scope of mobilization[a]	OUSD(P)
Premobilization materiel resources	Services (in Step 1)
Induction capacities	Services & SSS[b]
Training capacities	Services
Unit train-up times and resources	Units (in Step 1)
Industrial production/service capacities	Acquisition community
Desired timing and priorities	CINCs
Step 3 Deployment/Distribution Analysis	
Units, manpower, materiel available in CONUS	Step 2
Movement, handling, storage availability profiles	Step 2
Timing requirements and priorities	CINCs
Step 4: Unit Analysis	
Unit and materiel availability profiles	Step 3
Mission activity level objectives and priorities	CINCs
Operational and support unit dependencies	Services
Mission resource requirements[a]	Services/CINCs
Attrition rates[a]	Services/CINCs
Consumption rates[a]	Services/CINCs
Loss rates[a]	Services/CINCs
Restoration rates[a]	Services/CINCs

[a]These values vary with scenario and assumptions within scenario
[b]Selective Service System

would vary over time, of course. It would be primarily the services' responsibility to project changes in this information for outyear assessments—e.g., changes in unit assets, nonunit stockpiles, and attrition rates.

Context for Integrated Assessments

The nearest thing to integrated assessment of readiness and sustainability occurs today within DoD's deliberate planning process: The CINCs establish operational requirements, the services align units and resources against those requirements, and corresponding, fairly detailed deployment and resupply schedules are developed. Development or revision of an OPLAN takes many months, however, and there is no final assessment of the mission activity level profiles (and no corresponding analysis of sensitivities to uncertainties about assumptions). Presumably, any inconsistencies between units' readiness (as indicated in SORTS reports) and their deployment schedules in OPLANs will be (1) resolved by predeployment mobilization (e g., providing needed personnel, equipment, or training), (2) accommodated in the event by adjusting deployment schedules to allow units time to upgrade their resources and training, or (3) ignored (units that are not fully manned, equipped, or trained will be deployed anyway). Further, recognized shortfalls in support services or supplies reportedly do not "interfere" much with combat unit movement planning. Moreover, the CINCs' operational strategies may change fairly frequently And finally, deliberate planning (naturally) considers only current resources, not those that would be provided by a proposed funding program In any case, the resulting OPLANs are not available for ext rnal review. Consequently, integrated readiness and sustainability assessment probably should not try to "ride on the shoulders" of deliberate planning

High-level defense resource allocation and fiscal decisionmaking need less detailed information than is required for individual OPLANs But to understand the coherence and risks implicit in alternative programs, force structures, and funding levels, we believe they need the broader, albeit coarser, scope that integrated readiness and sustainability assessment would provide They should have well-worked-out answers to such questions as.

- How much (of different types of missions) could our forces and resources do under different scenarios? (Tacitly, this includes how soon and how long.)
- What are the potential influences of uncertainties (e g., platform attrition, personnel casualties, materiel consumption, and loss rates) on those amounts?
- What are the influences of different degrees and timing of mobilization on those amounts?
- What are the principal bottlenecks or resource shortfalls that limit those amounts? How could those problems be resolved? How long would that take? What would it cost?

- How much more or less could our forces and resources do in the future if funding levels followed a specified pattern?

The integrated assessment framework could only help answer the portions of such questions that concern mission activity levels and identification of limiting factors, of course. Fiscal decisionmakers and service resource managers would have to answer the questions about technical alternatives, costs, and funding levels.

To consider the robustness of the U.S. readiness and sustainability posture, we believe that integrated assessments should be performed regularly for three to six scenarios, say ranging from small-scale insertion in a single, remote country to worldwide conflict envisioned in the Defense Planning Guidance's illustrative planning scenario or the "base-case family of plans" Given the need to consider alternatives within some scenarios, the range and extent of data required, and the need to limit the resources devoted to making such assessments, integrated assessments probably should be conducted for each scenario only every two or three years. This should be sufficient for high-level decisionmakers to review comprehensively:

- Where things stand now.
- How that compares with the last assessment
- How things would change under different future funding patterns.

Such information would help decisionmakers prioritize readiness and sustainability programs in the defense budget, identifying payoffs and risks in meaningful terms and providing information on the costliness of national security commitments and objectives. Decisionmakers would select broad directions for change In the years between integrated assessment reports for one scenario, detailed constituent status information could be provided, much as it is today, showing, for example, the status of unit equipage, the times required to bring units up to wartime performance standards, cargo handling and transport capacities, and materiel supplies

Organizational Considerations

As indicated in Table 8, the services would be the sources of most of the information required for making integrated readiness and sustainability assessments. In fact, in developing their new "operationally oriented measures of sustainability"[14] (OOMS), they will be compiling most of the data needed, although only for the illustrative planning

[14]See OASD, 1988b

scenario. Their OOMS analysis itself will concentrate on sustainability much more than readiness, and it will not consider manpower resources. Plans call for OSD(PA&E) to provide the services with allocations of cargo capacity for the illustrative planning scenario so they can project the flows of materiels from CONUS to the theaters.

Cargo capacity is only one resource that needs to be coordinated among the services, however. Military operations frequently require combat units from different services simultaneously. And one service may receive support from another (e.g., the Army handles considerable port operations and materiel ground movement for the Air Force). Thus, the development of integrated assessments would require additional support from OSD or the Joint Staff. Some office or group overseeing or cutting across the services would have to take overall responsibility for coordinating integrated readiness and sustainability assessments. This office (or these offices) would also be the focal point for communications among the services, OSD, the Joint Staff, the CINCs, and Congress about integrated readiness and sustainability assessments.

The range of information and scope of analysis for integrated readiness and sustainability assessments are extremely wide. No single office in DoD attempts even to collect, let alone coordinate, such information or analyses today; efforts remain dispersed and disconnected. The nearest analog to integrated readiness and sustainability assessment is probably the Chairman's (biennial) Net Assessment coordinated by the Joint Staff's Force Structure, Resources, and Assessment Directorate (JS/J-8). This ambitious assessment has been undertaken only fairly recently. It incorporates all four "pillars" of military capability, and, admittedly, it incorporates readiness and sustainability considerations only very coarsely.[15] Other DoD offices whose concerns span the range of integrated readiness and sustainability assessment are OSD's (1) Director of Net Assessment and (2) Assistant Secretary of Defense (Program Analysis and Evaluation). It may be possible to add integrated readiness and sustainability assessment to one or more of these three offices' responsibilities, but we believe it would be very difficult and awkward for any of the three to marshal the necessary resources and data. Readiness and sustainability are simply not the primary objects of their attention.

Under current organizational structure, primary interest in and responsibility for readiness and sustainability in DoD—outside the services' headquarters and CONUS elements, of course—are found in:

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[15]As outlined in Sec. III and the beginning of this section, we believe it will be a long time before such combat modeling and war gaming can represent resources, mobilization, deployment, and resource utilization/consumption/losses with enough fidelity and efficiency to permit very useful integrated assessments of readiness and sustainability.

- The unified and specified commands,
- Three Joint Staff Directorates: Operational Plans and Interoperability (J-7), Logistics (J-4), and Force Structure, Resources, and Assessment (J-8);
- Four OSD offices: Assistant Secretary of Defense (Force Management and Personnel), Assistant Secretary of Defense (Reserve Affairs), Assistant Secretary of Defense (Production and Logistics), and Under Secretary of Defense (Policy).[16]

A previous DoD organization structure included an Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics, an office whose scope probably would have provided a more natural context for coordinating/consolidating/performing integrated readiness and sustainability assessments than any current office.

Currently, DoD has several somewhat ad hoc mechanisms for dealing with readiness and sustainability. One is a new Conventional Forces Readiness Committee, intended to

> coordinate and integrate . policies and issues affecting readiness, defined as the ability of our forces (e.g, personnel, weapons and equipment) to perform their missions, from the exercise of Presidential call-up authority, mobilization, or the beginning of conflict until warfighting objectives are achieved . [including] the ability to deploy and employ without unacceptable delays [considering] manpower requirements, training, peacetime OPTEMPO, logistics, installations, force composition and balance, and other aspects of readiness.[17]

Another is the DoD Sustainability Assessment Task Force mentioned earlier. Chaired by the Assistant Secretary of Defense for Production and Logistics and with members from the Joint Staff, OASD(FM&P), OASD(PA&E), DLA, and the services, the SATF has formulated guidance for establishing operationally oriented measures of sustainability.[18] The SATF continues as a forum for exchanging information about progress in developing operationally oriented sustainability measures The Joint Staff and the unified and specified commands have a

[16]The latter's responsibility includes mobilization and deployment policy

[17]For additional information, see OASD, 1989 The CFRC is chaired by the Assistant Secretary of Defense (ASD) for Force Management and Personnel, the vice chair is the ASD for Reserve Affairs Members include the ASD for Production and Logistics, the ASD for Program Analysis and Evaluation, the ASD for Health Affairs, the DoD Comptroller, a representative of the Under Secretary of Defense for Policy, a representative designated by the Chairman of the Joint Chiefs of Staff, and the ASDs for Manpower from each service.

[18]See OASD, 1988b

Joint Sustainability Assessment Working Group that serves a similar purpose but emphasizes their special concerns

No current DoD office has the appropriate scope or current capabilities to make it a clear-cut choice for developing or coordinating integrated readiness and sustainability assessments We raise this not because we see it as an insurmountable problem or because we recommend a particular resolution for it The coordination of information, assumptions, and procedures for developing integrated assessments is probably beyond the capability of a committee or task force DoD may need to develop a different or special organizational arrangement if it hopes eventually to conduct routine integrated readiness and sustainability assessments akin to those outlined here This should probably remain a secondary concern for the time being, pending technical determination of the practicality of such assessments.

V. CONCLUSIONS AND RECOMMENDATIONS

Today's indicators of readiness and sustainability—mainly SORTS reports and DOS figures—do not provide high-level defense decisionmakers with information appropriate to their needs. The indicators help the CINCs and services plan how they would meet different contingencies with current forces and resources, and they help the services identify problem areas where extra management attention or reallocation of existing resources could improve near-term capabilities for meeting contingencies. But they are much less helpful for choosing future funding levels for readiness and sustainability accounts in the DoD budget. High-level decisionmakers need to understand (1) how severely readiness or sustainability limitations constrain U.S. military capabilities for different contingencies and (2) how the constraints would be affected by altered levels of funding for readiness and sustainability accounts.

We believe that estimates of the levels of activity that U.S. forces could achieve over time in different contingencies would provide much more useful information to high-level decisionmakers. Using continuous numerical scales and showing changes during a contingency, such integrated assessments should prove more sensitive to resource level changes and allow easier comparisons from one year to another.

In contrast, today's SORTS data report only the (categorical) "fill" of the manpower, equipment/supplies, and training required by each unit for its most demanding mission or operational capability. (SORTS summaries are typically based on a mixture of possible contingencies.) This information is about "inputs, not outputs," and its implications for distinct contingencies cannot be inferred directly Further, SORTS data generally ignore improvements in unit condition achievable through mobilization, cross-leveling, and pre-deployment training,[1] problems in moving units into wartime/contingency operating locations, and the operational dependencies among units of different types. In sum, SORTS provides little insight into overall force readiness for any specified contingency.

Also in contrast, today's DOS figures for different commodities and classes of supply also emphasize resource inputs, not operational outputs. On the positive side, DOS figures do reflect the time dimension,

[1]There are exceptions, of course For example, Marine Corps units also count certain materiel "in stores," and many Army and Marine Corps units report categorical estimates of the numbers of days required to complete training

and, in the form of CINCs' S-ratings, they distinguish theaters and scenarios (although reflecting only the most demanding scenario for each theater). They do not reflect the full range of stocks available for operational support, however—e.g., including those available from the CONUS upon mobilization and deployment or those from industrial production. And the dependence of DOS figures on the timing of placement of forces in theaters and on assumptions about (uncertain) operating, consumption, attrition, and loss rates, for example, is left unclear.[2]

Integrated assessments of the type we recommend would reflect both readiness and sustainability in terms of mission activity levels achievable over time. The scope of resources considered would be broader for both, the contextual scenarios for their assessment would be specified and consistent, the assessment values would be more sensitive to resource changes, and readiness and sustainability status should be more readily comparable from one year to another.

It is important that readiness and sustainability be assessed for multiple contingencies/scenarios, treating each contingency distinctly. Different contingencies obviously call for different types and degrees of readiness and sustainability, and at any moment U.S. forces will be more nearly ready or sustainable for some contingencies than others. Further, the chances vary that different contingencies will occur Decisionmakers need to understand how our readiness and sustainability posture varies with respect to different contingencies and how it could be changed with altered programs and funding levels. We recommend developing from three to seven or eight scenarios for which readiness and sustainability assessments would be made. These should range from large-scale, extended conventional warfare to small-scale, short-term amphibious and airborne assaults/occupations of island or coastal areas. Such scenarios need not cover the entire range of CINCs' OPLANs, but they should represent a wide enough range to stress different aspects of readiness and sustainability and to reflect different chances that they will actually occur. Decisionmakers should aim for robustness of posture across contingencies, recognizing explicitly that some contingencies are more likely and others are more taxing.

It may take quite some time to develop practical methods for making integrated assessments of the type we propose. Consequently, we recommend several incremental steps that would simultaneously build

[2]Making WARMAPS' time-dependent comparisons of demands and supplies requires making such data and assumptions explicit for the manpower resource Even so, WARMAPS-predicted manpower shortages are not translated into operational implications; indeed, this translation is impossible given WARMAPS' current degree of aggregation of occupational specialties

the components of an integrated framework and, in the interim, improve today's methods of reporting/measuring readiness and sustainability. These recommendations are in three categories, pertaining to: (1) unit readiness, (2) force readiness, and (3) sustainability. We conclude with recommendations pointed toward developing and evaluating the overall integrated assessment framework itself.

Unit Readiness

The DoD should continue internally reporting the "fill" of unit manpower, equipment, supplies, and training, compared with specified wartime requirements, to support contingency planning, identification of needs for management improvement, reallocation of existing resources, and identification of detailed requirements for additional resources But to provide more useful information for high-level decisionmakers, DoD should:

- Specify performance measurement scales and standards for different types of units. (Note. the scope and level of unit proficiency required may vary among contingencies.) The services already have measurement schemes that could be used, perhaps nearly as is, for many types of units, e.g., the Army Training and Evaluation Program (ARTEP)
- Develop systematic means for estimating how long it would take units to achieve different levels or standards on those measurement scales. This, too, is already possible for some types of units.[3] Summaries of these estimated times would constitute well-behaved indicators of unit readiness For example: "The average time required for units of type X to train up to standard is now 12 days" Or "15 units (5 percent, say) of units of type X could now achieve their wartime performance standard within 3 days"[4] Such indicators should respond promptly to changes in peacetime operating tempos.
- Identify the resources each unit needs to maintain its peacetime proficiency and to accomplish its performance upgrade through

[3]For instance, the Navy has empirical estimates of the steaming days required for Navy combatant ships to transit between adjacent SORTS C-levels in training readiness (Follmann et al, 1986), and the Army's Battalion-Level Training Model (see CACI, 1987) holds promise for extension along these lines

[4]Different performance thresholds might be established for each unit type since units may have to deploy before they have achieved their full wartime performance standard This would permit such statements as "25 percent of the units of type X could achieve performance standard P-1 in 8 days, say, and another 30 percent could achieve performance standard P-2"

predeployment train-up. Emphasis should be given to the subset of those resources that must be in the unit's possession during peacetime. For example, tank battalions need fewer tanks and pieces of test equipment for training than they would need for combat operations The resources that units would need for wartime operations must exist somewhere—e.g., in other units, in central storage in the CONUS, pre-positioned on ships, or in POMCUS. Not all of those resources need to be in the hands of units in peacetime This, too, is already handled for some types of units and resources.[5] Units should also report any additional equipment, manpower, or facilities needed to accomplish their train-up. Those needs would be addressed by processes we recommend below for assessing *force* readiness.

- Develop and conduct functional tests and (statistical) experimental designs to confirm or refute the train-up time estimates for units Such tests should be given with limited notice and resources, they should be abbreviated to conserve testing resources (consequently, tested units would perform only portions of their full range of tasks), and they should be scored objectively (e g., by instrumented means and by outside raters).

The emphasis in unit readiness reporting and management would shift away from minimizing shortfalls below a specified inventory of resources and toward minimizing the length of time it takes to achieve specified performance standards (Emphasize unit outputs, not unit inputs.)

FORCE READINESS

Force readiness is a broader and more complex concept than unit readiness; it is scarcely addressed today[6] No account is taken of the improvements in C-levels that cross-leveling of resources or mobilization may allow. And it is not clear whether the targeted deployment schedules could be supported by available transportation and materiel handling units and resources.

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[5]For example for Marine Corps units with some unit equipment in storage or for Navy ships whose crews would be augmented by reservists upon mobilization

[6]Nevertheless, comparisons are occasionally drawn between units' C-levels and their deployment schedules—e g, showing the percentage of infantry, communication, intelligence, or medical units scheduled to deploy within the first days of a scenario that report C-3 or C-4, sometimes delineating the broad shortfalls (e g, equipment or training) that cause them to report C-3 or C-4.

DoD could obtain a better representation and understanding of force readiness by building on the time-oriented representation of unit readiness just outlined as follows:

- Coordinate databases of induction, individual training, individual and unit processing, and unit training capacities that would be used to provide people, equipment, and training to units in a contingency
- Coordinate databases of manpower, equipment, and supplies available to fill out units' resources and training before deployment or employment
- Establish a desired schedule for using units within the combat theater(s). This schedule must recognize the functional dependencies among units—e g , some units must precede others, move others, fight in partnership with others, or maintain others.
- Using data about units' holdings and their estimated train-up times, about additional resources available from outside the units, and about processing and training capacities, project profiles of the numbers of units of different types that could be filled out, trained up, and prepared for either deployment (if in CONUS) or employment (if already in theater).
- Using these profiles plus corresponding information about transport and handling capacities, identify shortfalls from the desired schedule identified above This is the same concept followed in DoD's RIMS project (see Smartt, 1988).
- Obtain reviews and interpretations of the resulting information from the relevant unified commanders.

The timeliness and performance levels of units that provide transport, handling, and management services for force deployments would be summarized in information about unit readiness. And the ability of such units to meet these times and performance levels should also be checked with functional tests. Their capabilities and availabilities are especially important in projecting force readiness in terms of the force mixes delivered to operating theaters over time.

All these efforts would be oriented toward answering the fundamental question: "How quickly could the United States put a specified (and viable) force in place for a given contingency?" Not incidentally, "viable" would require that the specified force be big enough, that its units be trained up to acceptable performance levels, and that its internal structure be sound—i e., units needed by other in-place units must also be in place. Alternatively, the question could be stated. "How much (viable) force could we put in place within X days?"

The answers to this question, too, would be on continuous numerical scales, and they should vary with such determinants as forward deployment, peacetime operating tempos, stockpiled equipment, and force mobilization degree and timing

SUSTAINABILITY

Our recommendations for making incremental improvements in sustainability indicators are consistent with those advanced by DoD's Sustainability Assessment Task Force (OASD, 1988b), except we recommend assessments be developed for multiple scenarios:

- Coordinate databases of supplies of people and materiel available from stockpiles, reserves, residuals from active forces, industrial production, and induction and training in the CONUS. The time-varying profiles of resources available from these sources establish the maximum amounts potentially movable to the operational theaters.
- Using those profiles, allocations of movement and handling capacity, and information about pre-positioned stockpiles, project profiles of the cumulative quantities of materiel and replacement personnel available in operational theaters.
- Distinguish operational mission areas and identify activity level goals for each mission area and each geographic area over time for each scenario. (The combination of forward-deployed forces and those deployed after C-day[7] dictate the maximum possible mission activity levels, ignoring any limitations due to supply or replacement shortfalls.)
- Delineate assumptions (and ranges of uncertainty) for such rates as attrition, losses, and consumption associated with different types of mission activity.
- For resources that are "consumed" in use (e.g., munitions and fuel), sequentially decrement the cumulative quantities available in the theater by the amounts dictated by these assumptions and by the mission area activity level goals. For resources that may be "restored" (e.g, through maintenance or medical services), take into account the "returns" when decrementing the cumulative quantities available in the theater. Considering both kinds of resources, estimate over time the shortfalls from mission area activity level goals.[8]

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[7]The first day of deployment is called C-day

[8]Simulation models and spreadsheet techniques have been noted as methods for making these estimates However, maldistribution of resources presents an especially diffi-

- Obtain reviews by the relevant CINCs of the estimated achievable activity levels in the different mission areas, also providing the relevant assumptions about mobilization lead time, attrition and consumption rates, etc.
- The timeliness of availability and the performance levels of those units oriented toward sustainment—e g., maintenance, medical, and supply units—would be summarized in information about unit readiness. The ability of such units to meet those times and performance levels should also be checked using functional tests

Except for the last recommendation, these improvements in sustainability assessment emphasize assessing the consistency and adequacy of support resources—"people and things," not the integrity of the whole Such overall integration is the subject of our last set of recommendations.

OVERALL INTEGRATION

The wide range of resources that would be considered under our previous recommendations, together with the variety of organizations and analysis methods that would come into play, argue strongly for special efforts to bring it all together. The feasibility of at least two paths toward integration should be examined: (1) assimilating integrated assessments from piecemeal analyses and methods that are currently available or that would become available through the improvements already proposed and (2) synthesizing new and simpler but more comprehensive and faster analytic methods Both could be pursued in the following rough steps:

- Survey in greater detail the analysis tools currently used for (1) mobilization planning and evaluation, (2) deployment and distribution planning and evaluation, and (3) sustainability resource requirements determination and sustainability evaluation Such a survey would involve a search for practical analytic methods for each step and data/information interfaces that could link the steps constituting an integrated assessment.

cult problem in making such evaluations Other RAND research shows that given a fixed set of spare parts and repair capabilities, weapon system availability (hence maximum mission activity levels) can be altered substantially depending on where these resources are located and how their distribution and utilization are prioritized in response to changing conditions (See Berman et al, 1988) The same principles apply to ammunition, fuels, and manpower

- Delineate the most practical combinations and linkages of existing and emerging data and analysis methods that might make up the integrated framework. Describe the corresponding advantages and disadvantages of such a conglomeration, also addressing the major costs and risks expected in doing the integration this way
- Delineate the inputs, outputs, and functionalities of modules that would make up an "ideal" version of the integrated framework. Describe the corresponding advantages and disadvantages and anticipate the costs and risks in its development
- If one approach emerges as clearly preferable at this point, abandon the other A combination of the two might appear even more attractive If a particular approach is deemed sufficiently promising, undertake (1) development/synthesis of constituent analytic tools and/or data linkages and (2) definition of at least two scenarios and collection of corresponding data to permit methodological testing and demonstration
- Experiment with the methods and data, examining the influences of, for example, peacetime OPTEMPOS, stockpiles, timing and degree of mobilization and deployment, attrition and consumption assumptions Expose decisionmakers to the outputs and relationships that the integrated framework provides Revise the prototype implementation and analysis as appropriate.
- If the results of prototype development and demonstration warrant, prepare detailed functional specifications for a "production" version of the integrated assessment system (or for components of such a system) and proceed with development.

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