Analytic Architecture for Capabilities-Based Planning, Mission-System Analysis, and Transformation

Paul K. Davis

Prepared for the
Office of the Secretary of Defense

RAND
National Defense Research Institute

Preface

This monograph discusses how the Department of Defense could change its system of analysis to better support capabilities-based planning. It pulls together past work and adds new material on implementation, force transformation, and the economics of choice. The monograph is intended primarily for policymakers and analysts in the Department of Defense and other parts of the U.S. government concerned with defense planning. It may also be of interest to a much broader community because the concept of capabilities-based planning has only recently been emphasized and has not been discussed much in the public policy literature.

I completed the monograph with funds provided by the National Defense Research Institute, RAND's federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the unified commands, and the defense agencies. Comments are welcome and can be addressed to me at RAND's office in Santa Monica or, via email, to pdavis@rand.org.

Contents

Preface iii
Figures vii
Tables ix
Summary xi
Acknowledgments xxv
Acronyms and Abbreviations xxvii

1 INTRODUCTION 1
Objectives 1
Definitions 1
Context 2
Key Elements of Capabilities-Based Planning 4

2 CONCEPTUAL FRAMEWORK 5
The Role of the Secretary of Defense 5
The Old Paradigm of Setting Requirements with Point Scenarios 6
The Bounding-Threat Method 6
A Red Herring: The Comparison to Threat-Based Planning . . 8
Force Planning as an Exercise in Design 9
A Broad View of Design 9
Applying the Concept to Defense 11

3 UNDERSTANDING NEEDS AND DEFINING POTENTIAL "REQUIREMENTS" 15
Appreciating the Range of Possibilities 15
The New Challenges 15
Progress in Recognizing and Taking New Threats Seriously . . . 20
Defining a Design Space for Studying the Range of Plausible Scenarios 21

Moving Toward Requirement Setting 25

4 MISSION-SYSTEM ANALYSIS FOR ASSESSING CAPABILITIES: CONCEPTS AND ENABLERS 27
Motivation 27
Characterization of Mission-System Analysis 28
Depicting Results of Mission-System Analysis 30
Yes, But How Much Is Enough? 36
Highlighting the System Aspects 37
Enablers of Mission-System Analysis 38
Exploratory Analysis for Confronting Uncertainty 38
Using a Family of Models and Games 38
The Need to Address Probabilities 40
Summary 41

5 DEALING WITH VERTICAL AND HORIZONTAL COMPLEXITY OF CAPABILITY 43
Choosing Among Options in a Portfolio 45

6 THE CENTRAL AND MULTIFACETED ROLE OF BUILDING BLOCKS 51
General Comments 51
Types of Building Blocks 52
Capability for Rapid Assembly 53
Special Tailoring 54
Readiness for Rapid Assembly and Adaptation 55
Support Structure, Building Blocks, and Flexibility 56
The Problem of Hierarchies and Networks 56

7 IMPLICATIONS FOR FORCE TRANSFORMATION 59
Broad Observations 59
Transformation Goals as Described by the QDR 61

8 CONCLUSIONS AND RECOMMENDATIONS 65

Appendix—Some Historical Examples of Capabilities-Based Planning 67
Bibliography 71

Figures

S.1 Highlighting Critical Component Capabilities in Mission-System Analysis . . . xv
S.2 Mission-System Analysis . . . xix
S.3 Summary of Exploratory Analysis of Countermaneuver Capabilities . . . xx
S.4 Making Prompt Intervention More Feasible . . . xxii
1.1 An Illustrative Portfolio Representation of Defense Expenditures . . . 3
2.1 The Secretary of Defense's Role in Defense Planning . . . 6
2.2 A Schematic of Old-Fashioned Point-Scenario Threat-Based Planning . . . 7
2.3 Moving from Need to Capability . . . 9
2.4 A Process Model for Capabilities-Based Planning . . . 12
3.1 Changes in the Nature of the Threat . . . 17
3.2 Changes in the Nature of Key Operations . . . 19
3.3 Understanding the Design Space for Even One Name-Level Scenario . . . 22
4.1 The Process of Analyzing Mission-System Capabilities . . . 30
4.2 A Hypothetical Comparison of Force-Posture Options . . . 31
4.3 Summary of Exploratory Analysis of Countermaneuver Capabilities . . . 33
4.4 Scenario-Space Depiction of How a Joint Strike Force Could Enhance U.S. Military Capabilities . . . 35
4.5 Critical Components of the System for the Early-Halt Mission . . . 37
4.6 An Example of Exploratory Analysis . . . 39
4.7 Strengths and Weaknesses of a Family of Models and Games . . . 40
5.1 Integrating Horizontally and Vertically . . . 44

Tables

S.1 Possible Scenarios That Could Affect Projection Forces xii
S.2 Priority Operational Challenges for Projection Forces xiv
S.3 Relating the QDR's Goals for Transformation to the Operational Challenge of Countering Maneuver Forces . . . xvi
S.4 A Notional Scorecard for Assessing Alternatives in a Portfolio Framework xxiv
3.1 Possible Scenarios That Could Affect Projection Forces 16
3.2 Priority Operational Challenges for Projection Forces 20
5.1 A Notional Scorecard for Assessing Alternatives in a Portfolio Framework 46
7.1 Relating the QDR's Goals for Transformation to Operational Challenges 62

Summary

Force Planning in a Capabilities-Based Framework

Capabilities-based planning (CPB) is planning, under uncertainty, to provide capabilities suitable for a wide range of modern-day challenges and circumstances while working within an economic framework that necessitates choice. It contrasts with developing forces based on a specific threat and scenario. The Department of Defense (DoD) intends CPB to be a core concept in its future work and laid out related principles in the recent Quadrennial Defense Review (QDR) (Rumsfeld, 2001b). This monograph builds on that base and suggests ways to implement CPB in DoD's system of analysis.

CPB's implementation should emphasize flexibility, adaptiveness, and robustness of capability. That *implies* a modular, building-block approach to force design and operations. When "transformational changes" occur, it is because new modules have come into being (e.g., new force units, operational concepts, or systems). Although such matters are understood by those who actually develop new capabilities or task-organize for real-world operations, they are not readily discussed with the style of analysis that until recently characterized much of DoD's higher-level force planning. A new analytical architecture is needed with modernized constructs for

- identifying capability *needs*
- assessing capability *options* for effectiveness in stressful building-block *missions* (i.e., operations)
- making *choices* about requirements and ways to achieve them, and doing so in an integrative portfolio framework that addresses future war-fighting capabilities, force management, risk tradeoffs, and related matters in an economic framework.

What follows are suggestions on each of these, which also relate them to the QDR's list of transformation goals.

A New Analytical Architecture

Surveying Capability Needs

Appreciating the Range. As in many endeavors, a starting point is to appreciate the range of possibilities by itemizing plausible scenarios. The DoD has an elaborate process for identifying such a range of scenarios, but Table S.1 shows my own illustrative list. It ranges from old standbys, such as a North Korean invasion of the South, to more speculative possibilities such as an intervention against drug lords. The table considers only scenarios relevant to projection forces; different lists are needed when addressing homeland defense, space defense, control of the seas, and so on.

When elaborated, the scenarios in the table vary in the types of threat, terrain, and operations emphasized; timing considerations; the

Table S.1
Possible Scenarios That Could Affect Projection Forces

Iraq invades Kuwait and Saudi Arabia
North Korea invades South Korea
China attacks Taiwan
China emerges as regional peer competitor, perhaps threatening a unified Korea or otherwise coercing countries in the Asia-Pacific region
United States intervenes early in "next Bosnia," with the objective of deterring aggression by regular forces
United States intervenes in "next Kosovo" with objectives that include stopping the killing being accomplished by dispersed irregular forces
United States attacks rogue state or terrorist facilities with deep-underground mass-destruction weapons and missiles
United States attacks to root out terrorists (Afghanistan, Syria, Iran, and/or Libya)
United States strikes with missiles and aircraft against terrorist groups (Afghanistan, Syria, Iran, and/or Libya)
United States invades a rogue state to bring about a change of regime
United States invades to regain territory lost by a friendly nation
United States attacks drug czars in Latin America
Russia threatens or invades the Baltic states
India and Pakistan go to war with spillover effects (uncertain role for U.S. forces)
Arabs and Israelis go to war again (uncertain role for U.S. forces)

strength of allied forces; the logistical base for operations, and other factors. As illustrated by the table, some of the scenarios are generic, which avoids painting other countries as potential threats. Also, some items indicate what U.S. forces must do; others indicate only that some unspecified role may be necessary. Again, the point of this easy step of listing scenarios is merely to broaden the range of considerations.

Moving from Illustrative Scenarios to Capability Requirements. Although useful, such a list involves "name-level" scenarios: It provides no details about the all-important circumstances of conflict [e.g., the presence of anti-access tactics, including mass-destruction (or mass-casualty) weapons]. Indeed, the list is not very useful analytically except for broadening the imagination. The next step, then, is to abstract from Table S.1 an understanding of what generic capabilities might be needed. A full list would be enormous, but a great simplification is possible: There is simply no need to be comprehensive because most of the requisite capabilities will come along naturally. It would be silly, for example, for the Secretary of Defense to waste time exhorting the Air Force to assure the capability for air superiority. Instead, the Secretary should focus on a subset of especially important "operational challenges" that transcend individual detailed scenarios and require the attention of top leadership (i.e., particularly the Secretary of Defense, the Chairman of the Joint Chiefs of Staff, and the secretaries and chiefs of each service). With this in mind, Table S.2 gives my suggested set of priority "operational challenges" for projection forces. It is only illustrative, but it is more than a strawman.

In my view, such operational challenges should be expressed as missions that a future commander in chief (CINC) might be assigned (or, equivalently, as operations that the CINC would conduct to accomplish objectives). This is not just a matter of taste; it is a matter of focusing on military *outputs*: the capabilities to accomplish such missions. This is in contrast to planning for more platforms or communications bandwidth, which are merely inputs from a top-down DoD perspective. It is also in contrast to listing "activity areas," such as improving precision fires or improving collaborative planning. The operational challenges provide context and lead to valid metrics. Those

Table S.2
Priority Operational Challenges for Projection Forces

Immediate countering of enemy maneuver forces (e.g., halting an invasion quickly or tying down enemy forces while U.S. forces maneuver)
Immediate destruction of critical mobile targets such as vehicles carrying missiles armed with mass-casualty weapons
Effective stop-the-killing intervention in a small-scale contingency
Attack and destruction of mass-casualty weapons by inserting ground forces as well as conducting long-range strikes
Attack and destruction of terrorist strongholds
Early attacks or counteroffensives without massive buildup
Invasion after major loss of territory, into the teeth of an enemy able and willing to use mass-casualty weapons

listed in Table S.2 appear to be particularly important and challenging as we look forward in time, rather than back to the cold war.

Several of Table S.2's operational challenges emphasize "early" or "quick," for the same reason that U.S. Joint Forces Command has come to focus on rapid decisive operations (RDO). The same operations might not be particularly challenging if done on a more leisurely basis. Similarly, their difficulty depends sensitively on the circumstances assumed.

Taking a Mission-System View. The next step, for each operational challenge in Table S.2, is to develop alternative concepts of operations and to identify forces and programs to enable them. The concepts should be described in a variety of ways, many of them traditional, but one new form of description should be required routinely by service chiefs and secretaries, the Chairman of the Joint Chiefs of Staff, and the Secretary of Defense. That is a "mission-system description," such as suggested by Figure S.1, in which the potentially critical components of capability are identified so that planners can assure that *all* of those critical matters are addressed effectively.[1] As indicated by the block of text at the top right of the figure, the requirement is to be able to accomplish the mission in diverse and stressing circumstances, which may include anti-access strategies, short warning, and other complications. This is akin to the way in which design engineers work: requiring that each of their critical modules be robustly capable across a broad range of possible operating circumstances.

Relationship to QDR Goals. There is an important relationship between the methodology suggested here and the transformation goals recently enunciated in the QDR. Table S.3 illustrates this by arraying the QDR's goals (first column) against the critical components (second

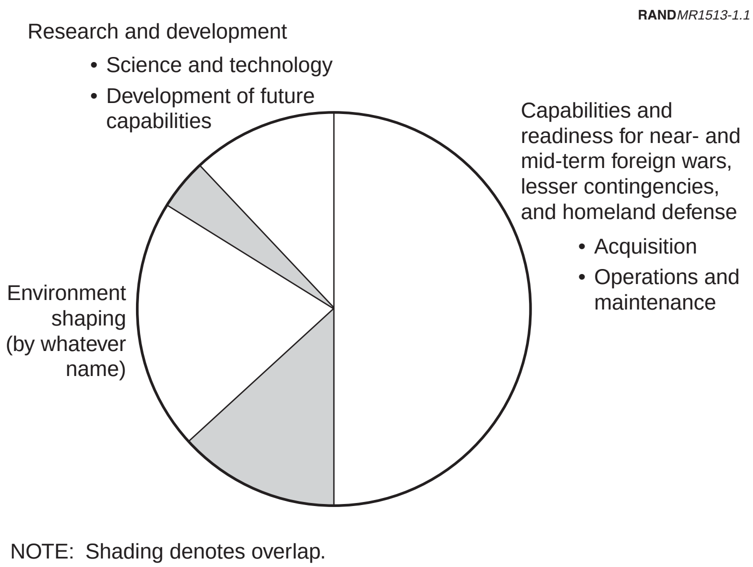


Figure S.1—Highlighting Critical Component Capabilities in Mission-System Analysis

Table S.3
Relating the QDR's Goals for Transformation to the Operational Challenge of Countering Maneuver Forces

	Critical Component				
QDR Goal	Deploy Forces and Logistics	Establish C^2 and C^4ISR	Suppress or Evade Air Defense	Attack Maneuver Forces	Illustrative Implications
Protect bases and defeat CBRNE		●	●		Counterforce attacks, passive defense, use of distant bases and naval systems
Assure information systems and conduct information operations		●	●	●	Immediate survivable ISR; fast spinup for C^2 competence; offensive IW attacks on IADS
Project forces in presence of anti-access and area-denial environments	●	●	●	●	Defend allies from missile attack and related coercion; sustain operations from long-range or secure naval platforms
Deny the enemy sanctuary		●	●	●	Preempt attacker as he stages for invasion; Conduct strategic bombing vs. C^2 and IADS
Enhance space capability		●	●	●	Maintain GPS precision and communications; enhance survivable ISR from space
Leverage information systems for interoperable joint C^4ISR	●	●	●	●	Networking, standards, standing joint command and control groups

NOTES: Bullets indicate where a QDR goal is particularly important to one of the critical components. IADS=integrated air defense system; GPS=global positioning system; ISR=intelligence, surveillance, and reconnaissance; C^2=command-control; C^4ISR=C^2, communications, computers, and ISR; CBRNE=chemical, biological, radiological, nuclear, and enhanced high-explosive weapons; IW=information warfare.

through fifth columns) of Table S.2's first operational challenge (countering maneuver forces). Accomplishing the critical components of the mission would be much facilitated by substantial improvements in the areas highlighted by the QDR's goals. Thus, this mission-system decomposition gives context to the QDR's goals, making evident the fact that they were not chosen arbitrarily.

Different operational challenges would relate to the QDR goals in different ways, but the example of Table S.3 shows that by addressing operational challenges systematically, the goals can be given concrete meaning. Metrics can then be identified and goals established. Actually doing this requires analysis, but we can use the example above to sketch the ideas (see Davis, McEver, and Wilson, 2002).

From Figure S.1, we can appreciate that success in quickly countering enemy maneuver would translate into something like stopping a maneuver within 100 km (relevant for, e.g., defense in Kuwait or protecting an allied faction in a rogue state). Since an invading army with relatively little ground opposition can maneuver at speeds of 40–100 km/day, it follows that the component capabilities must be achieved immediately—essentially on D-Day—*or* the attacker must be greatly slowed, while the other capabilities are building up. In some cases, such slowing might be possible (e.g., with preemptive strategic bombing), but in other cases it would not be possible. Thus, requirements should include the ability to achieve excellent command-control (C^2) and the other elements (communications, computers, intelligence, surveillance, and reconnaissance) of C^4ISR by D-Day—at least in circumstances in which doing so is physically possible (some degree of strategic warning, etc.). We could measure progress toward this goal by asking, for example, how long it would take after actionable strategic warning to achieve high-quality joint C^2 and various degrees of ISR. Metrics, then, fall out naturally from analysis in the mission-system framework. Prior work indicates, however, that many of the limiting factors affecting this metric relate to organizational issues and readiness for joint operations. This is why the QDR mandated the creation of standing joint task force headquarters (Rumsfeld, 2001b, p. 33). How quickly such a standing capability emerges and how well it performs can be monitored.

Figure S.1 also illustrates another aspect of metric setting. One critical component is to "suppress *or* avoid air defenses." This leaves open *how* the defenses can be dealt with [e.g., by suppression of enemy air defenses (SEAD), stealth, standoff weapons, or long-range missiles], thereby avoiding the overspecification that has been a classic problem in past efforts to manage through metrics.

Assessing Capability Options in a Mission-System Framework

Having established needs, the next step is to create and assess options and to suggest alternatives. The appropriate paradigm here is *mission-system analysis*, which is described schematically in Figure S.2. Given a mission and metrics of strategic and operational success (left), and given a set of capability options (top), good assessment requires *exploratory analysis* (center) over a broad range of circumstances (bottom). The result is not a simple score, but rather a depiction of *when* the capability option does well, marginally, or poorly (right). Most capability options, after all, will be adequate in some cases. The issue is how flexible, adaptive, and robust the capabilities will be. Recent advances in analytic methodology permit the "exploratory analysis" needed to assess such matters (see Davis, Bigelow, and McEver, 2001).

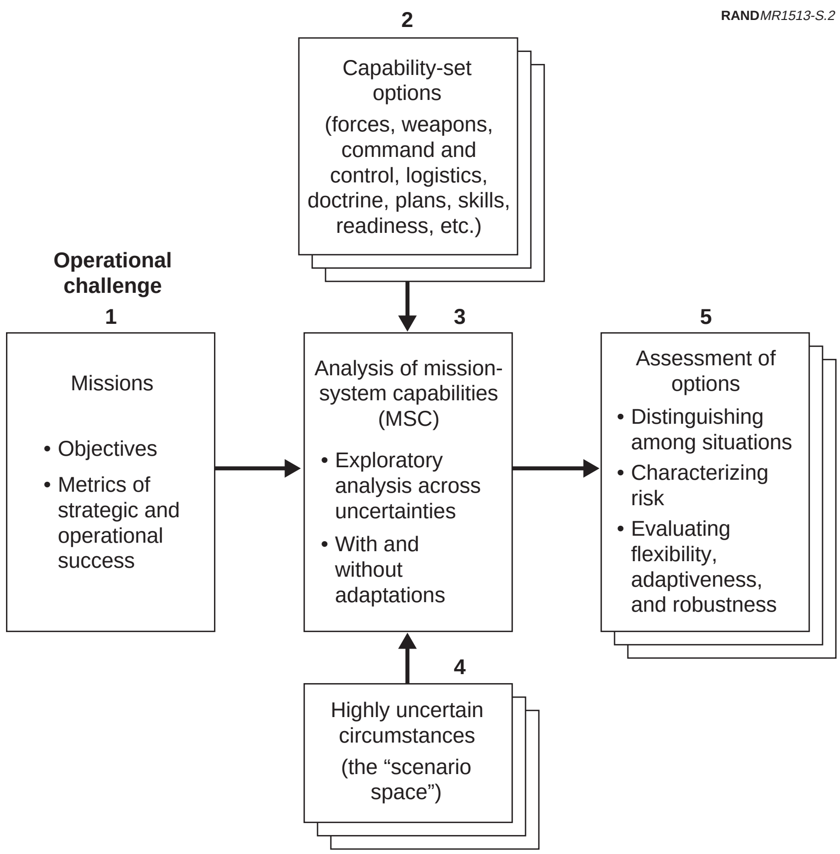
Implementing the concepts embodied in Figure S.2 will require a basic change in the character of DoD analysis, as department leadership already recognizes. First, the emphasis here is on operations or missions, rather than on total wars, because operations (or missions) are the critical building-block capabilities. Second, there is emphasis on evaluating capabilities under highly uncertain circumstances (warning time, quality of allies, qualitative capability of enemy forces, and so on). That is, the building blocks (modules) should be robustly capable.

Setting "requirements" is related to developing and assessing options. Analysis can illuminate the feasibility (and cost) of alternative requirement levels and can illuminate the attributes that good options require. To illustrate this, Figure S.3 is a compact summary for analysts of an extensive exploratory analysis of countermaneuver capabilities in which component capabilities and circumstances are both varied (Davis, McEver, and Wilson, 2002). The metric used is how quickly an invading army could be halted by interdiction alone. A possible goal for the metric is capability sufficient to achieve a halt in less than 100 km, as indicated by the horizontal lines. Figure S.3 shows how the countermaneuver of the interdiction force depends on five high-level variables:

- The attacker's average speed V (treated here as an input)
- A measure of the threat's effective size Z corresponding to the number of armored vehicles that must be killed to halt the attack

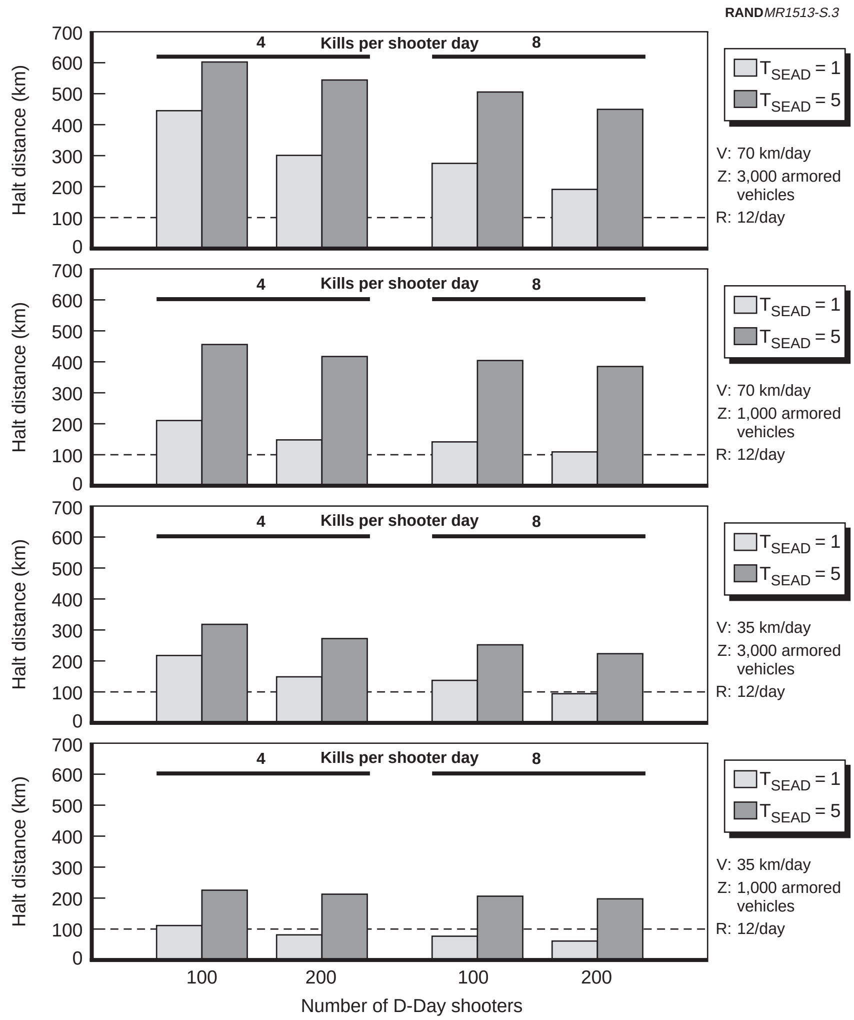
- The delay T_{SEAD} at the outset of war (D-Day) during which the interdictors are unable to attack because of air defenses
- The per-sortie or per-shot effectiveness of shooters once they are able to attack the invading army
- The number of shooters available to be used in the theater as of D-Day.

RANDMR1513-S.2



NOTE: For a given operational challenge (1), consider a set of options (2) for meeting the challenge; apply mission-system analysis methods (3) across a wide range of circumstances (4) to generate a comparative assessment of the options with appropriate metrics (5).

Figure S.2—Mission-System Analysis



NOTE: V=enemy speed; Z=effective enemy size (vehicles to kill for halt); R=deployment rate.

SOURCE: Davis, McEver, and Wilson, 2002.

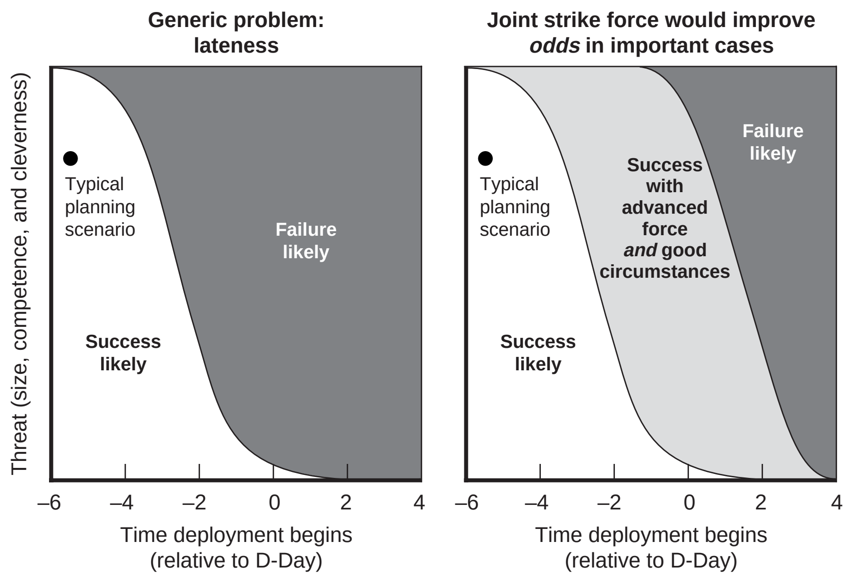
Figure S.3—Summary of Exploratory Analysis of Countermaneuver Capabilities

These variables are not arbitrary, but rather the result of deeper analysis showing them to be key aggregate variables that account indirectly for dozens of more-detailed variables. Thus, they are suitable for design work and for high-level summaries.

We see from Figure S.3 that the 100-km goal is achieved only when a *combination* of subordinate capabilities is achieved. Results for the light bars of the bottom row, for example, assume that air defenses are suppressed or evaded within a day; that the enemy's average speed can be kept small (35 km/day)—perhaps because of preemptive bombing of choke points; that the attacker can be stopped after only 1,000 armored vehicles are killed (e.g., 20 percent of those in a five-division attack, with 1,000 armored vehicles in each division, because of poorly motivated forces, or 50 percent of those in a two-division attack by determined forces); that each shooter is able to kill at least four armored vehicles per day after a delay time T_{SEAD}; and that shooters equivalent to at least 100 F-16s (a mix of long-range bombers, naval and Air Force aircraft, and naval missiles) are available by D-Day. Even better results are possible with more shooters or with more kills per sortie or shot. Conversely, outcomes are poor if the attacker's speed is high or the time required to suppress air defenses large. These results suggest that a goal of 100 km in this countermaneuver metric is feasible, but challenging. They also imply that good force-capability options will need to exploit the benefits of forward presence, standing joint task force command and control elements, standoff munitions, small smart bombs that increase per-sortie effectiveness, preemptive strikes on assembling forces or choke points, and so on.

If suitable force options have been developed and assessed, simple displays are needed to summarize the dominant reasoning that emerged from the assessment. Figure S.4 illustrates one such reductionist display designed for discussing the potential value of a rapidly employable joint strike force. The left and right panels both display the capability of the United States to intervene on the ground in a broad range of large and small scenarios differing in how quickly (relative to D-Day) U.S. forces can be ordered to deploy and engage, and in the size and competence of the threat. The left panel suggests that the baseline situation is that intervention would almost surely fail (dark area) unless U.S. forces were able to deploy well before D-Day—even for rather small threats. In contrast, the right panel suggests that a rapidly employable joint

RANDMR1513-S.4



NOTES: Figures assume use of strategic warning. Thus, if (full-scale) deployment begins on D-Day (0 on the x-axis), less dramatic and visible preparations may have been made for a week or more before then.

Left graphic: baseline capabilities; right graphic: capability with possible joint strike force.

Figure S.4—Making Prompt Intervention More Feasible

strike force of a sort that has been described in fair detail elsewhere[2] would markedly change that situation: Early intervention would be possible even with actions delayed until D-Day *if* the circumstances were right (e.g., if strategic warning had been used, if there were competent allies to provide reinforcement, or if the theater had considerable depth).

Because of the various *if*s, the improvement region is shown as light gray rather than white. Nonetheless, the contrast between the two panels suggests a transformational change of capability across a considerable range of conflicts. Many details have been omitted, but the story is a reasonable summary.

Integrations and Tradeoffs in an Economic Framework

Given such capabilities analysis, the next issue is integration and choice in the context of a budget. How does one trade off capabilities across operational challenges (missions) or across levels of detail? The cold reality here is that there exists no *rigorous* way to proceed without doing violence to the strategic issues. Instead, the approach needed is the familiar one of portfolio balancing. Such balancing should combine "hard" analysis with judgment and with qualitative, value-laded tradeoffs across goals—matters that are in the province of top decisionmakers. Such decisionmaking may be done simply—by skipping detailed methodology in search of low-hanging fruit—or it may be done with more structure. If formality is needed, then Table S.4 illustrates what a portfolio-management spreadsheet might look like. It contemplates tradeoffs in which we consider not just capabilities for war fighting in two classes of conflict, but also such considerations as force management, reassurance of allies, and dissuasion of would-be adversaries. Costs are explicit, and the methodology rank-orders options by their attractiveness when considering effectiveness achieved on the margin. The question addressed is where to spend the marginal billion dollars. The rank ordering generated will depend, of course, on the relative importance assigned to the different issues and to detailed assumptions. Recent methodological developments facilitate discovering which funding candidates rank highly across responsible variations in those judgments and assumptions. That is, they facilitate identifying robustly attractive investments (Hillestad and Davis, 1998). Experience demonstrates that such structuring of issues for decisionmaking can be quite valuable—so long as the willingness exists to make decisions requiring strategic judgments. For the examples of Table S.4, it is noteworthy that, even if many assumptions were changed, the small, smart bomb and standing Joint Task Force (JTF) headquarters would likely rank high. (The U.S. Joint Forces Command now has such a team, as of February 2002.)

Conclusion

To implement capabilities-based planning, the Department of Defense will need a new analytical architecture, arguably one along the lines of the one presented here. The architecture suggested focuses on modular capabilities and emphasizes mission-system analysis, exploratory analysis, and hierarchical portfolio methods for integration and tradeoffs in an economic framework. Although these methods can pose the issues for capabilities-based planning and add structure, their purpose is not to turn decisionmaking into something algorithmic, but rather to provide information about what is necessarily an exercise in investments dependent on strategic judgment.

Table S.4
A Notional Scorecard for Assessing Alternatives in a Portfolio Framework

Candidate Option for Funding	Capabilities in Conflict: Class-A Conflicts	Capabilities in Conflict: Class-B Conflicts	Force Manage-ment	Reassurance, Dissuasion, and Deterrence	Net Effec-tiveness	Marginal Cost ($B)	Ratio: Effectiveness over Cost
Weight	1/3	1/6	1/4	1/4	N.A.	N.A.	N.A.
Baseline	5.0	5.0	5.0	5.0	5.0	0.0	N.A.
Small bomb package 1	7.0	5.0	5.0	7.0	6.2	0.05	123
Standing JTF headquarters	7.0	7.0	5.0	8.0	6.8	0.25	27
Support for independent brigades	6.0	8.0	8.0	7.0	7.1	0.30	24
Extra F-22 squadron	7.0	5.0	5.0	7.0	6.2	0.60	10
C^4ISR package 1	7.0	5.0	5.0	8.0	6.4	1.00	6
C^4ISR package 2	8.0	8.0	5.0	7.0	7.0	2.00	4

NOTES: The options, values, and costs shown are purely notional. N.A. = not applicable. The meaning of the effectiveness scores is as follows: 0–2 very bad, 2–4 bad, 4–6 marginal, 6–8 good, and 8–10 very good. These are relative to the baseline force with scores of 5 in all categories. The baseline force is assumed to have no critical omissions. If it did, some of the table's scores might be quite different. Columns for Class-A and Class-B conflicts are intended to summarize much more extensive exploratory analyses. The table implicitly assumes a date for the assessments (e.g., five years from now). A variant table might contrast assessments for the near, mid, and long terms.

Endnotes

[1]Although Figure S.1 would apply in a wide range of scenarios, other decompositions would be needed if the concepts of operations were sufficiently different.

[2]See Gritton, Davis, Steeb, and Matsumura (2000), which grew out of work on the 1996 and 1998 Defense Science Boards.

Acknowledgments

Some of the material reflected in this monograph was originally developed in collaboration with David Gompert, Richard Kugler, and Richard Hillestad. Richard Kugler and David Kassing provided perceptive reviews of the draft manuscript, and Gene Gritton provided useful comments on a draft summary. I have benefited from numerous related discussions over the years with Glenn Kent. More generally, I would like to acknowledge the many defense analysts who have done capabilities-based planning for years without necessarily knowing that it had a name.

Acronyms and Abbreviations

ABL	Airborne Laser
ATACMS	Army Tactical Missile System
BUR	Bottom-Up Review
CBRNE	Chemical, biological, radiological, nuclear, and enhanced-high-explosive weapons
C^2	Command-control
C^4ISR	Command, control, communications, computers, intelligence, surveillance, and reconnaissance
CINC	Commander in Chief
CPB	Capabilities-based planning
DoD	Department of Defense
DPG	Defense planning guidance
EBO	Effects-based operations
GCCS	Global Command and Control System
GPS	Global Positioning System
IADS	Integrated air defense system
ISR	Intelligence, surveillance, and reconnaissance
IW	Information warfare
JFCOM	U.S. Joint Forces Command
JSF	Joint Strike Fighter
JSTARS	Joint Surveillance Target Attack Radar System
JTF	Joint task force
MEB	Marine Expeditionary Brigade
MRC	Major regional contingency

MSA	Mission-system analysis
MSC	Mission-system capabilities
MSP	Mission-system planning
MTW	Major theater war
QDR	Quadrennial Defense Review
R&D	Research and development
RDO	Rapid decisive operations
RV	Reentry vehicle
SAM	Surface-to-air missile
SEAD	Suppression of enemy air defenses
SecDef	Secretary of Defense
UAV	Unmanned aerial vehicle
UCAV	Unmanned combat aerial vehicle
WMD	Weapons of mass destruction

Chapter 1

Introduction

Objectives

Capabilities-based planning has become a central theme of defense planning. It is defined in broad terms in the new Quadrennial Defense Review (QDR) (Rumsfeld, 2001b), but opinions differ about its details and how to implement it. This monograph offers one cut at the problem by reviewing and extending ideas developed over the last decade.[1] Although the monograph is intended to be entirely consistent with the new QDR, its intention is to move one step deeper into details. It addresses the practical issue of how to approach capabilities-based planning analytically in a way that would serve the needs of the Secretary of Defense. The monograph provides a definition of capabilities-based planning, puts it in the larger context of defense activities generally, and then sketches an analytic architecture for carrying it out. Next, it relates capabilities-based planning to the objective of transforming U.S. forces to deal effectively with the changes taking place in military affairs. Finally, the monograph offers some conclusions and recommendations about how to proceed.

Definitions

Capabilities-based planning is planning, under uncertainty, to provide capabilities suitable for a wide range of modern-day challenges and circumstances, while working within an economic framework.

This seemingly innocuous definition has three important features. First, the notion of planning under uncertainty appears in the very first clause: uncertainty is fundamental, not a mere annoyance to be swept under the rug. Second, the idea is to develop capabilities—i.e., the general potential or wherewithal—to deal effectively not just with a well-defined single problem, but with a host of potential challenges and circumstances—including the "new challenges" that were discussed by President Bush and Secretary of Defense Rumsfeld even before they took office (see Bush, 1999; Rumsfeld, 2001a). Third, this is to be done not with the largesse of a blank-check policy (preparing for anything that might conceivably arise), but rather while working within an economic framework.

Which should come first when thinking about capabilities, strategy or budget? The answer is neither: Both are important and they are addressed iteratively. In a healthy defense-planning process, the full range of concerns are identified and estimates made of how they can be dealt with to various degrees of confidence—or, equivalently, with different types and degrees of risk. The issue of "How much is enough?" is then addressed and only then is a final budget established—one to which subsequent program building must adhere. This budget is always less than what defense planners would prefer, but greater than that preferred by competitors for the overall federal budget, as in the often heard complaint: More guns mean less money for education. The defense budget tends to go up or down on the basis of a broadly perceived sense of threat and a broadly perceived sense of what is needed to maintain the health of the armed services. Such matters are not deductive science.

In any case, capabilities-based planning has the virtue of encouraging prudent worrying about potential needs that go well beyond currently obvious threats. At the same time, it imposes the requirement for responsibility and choice.[2]

Context

Capabilities-based planning is only part of defense planning more generally, which can be seen as an exercise in portfolio management. The marginal dollar may be spent, for example, to increase or improve force structure, weapon platforms, homeland defense, overseas presence, leverage of allies, research and development (R&D), or transformation-related advanced prototyping. All are important, but tradeoffs must be made.

The portfolio of defense activities can be viewed in different ways. Figure 1.1 shows a particular depiction with purely illustrative allocations. It has major allocations for near- to mid-term capabilities and readiness; for environment shaping intended to increase the odds of favorable developments;[3] and for a broadly construed version of R&D that includes prototypes and provisional forces, which largely determine options for future capabilities. Figure 1.1 indicates with shading where categories overlap. In particular, standing U.S. capabilities in the forms of force structure, posture, and global reach help shape the environment and underwrite general deterrence, thereby reassuring allies and dissuading aggression among other things. Also, U.S. R&D activities contribute to general deterrence by conveying the impression that U.S. forces are not only the most powerful today, but are likely to stay that way: That is, the price of entry for competitors would be very high. And, of course, many activities that are seen as environment shaping—such as overseas basing and naval presence—also contribute to capa-

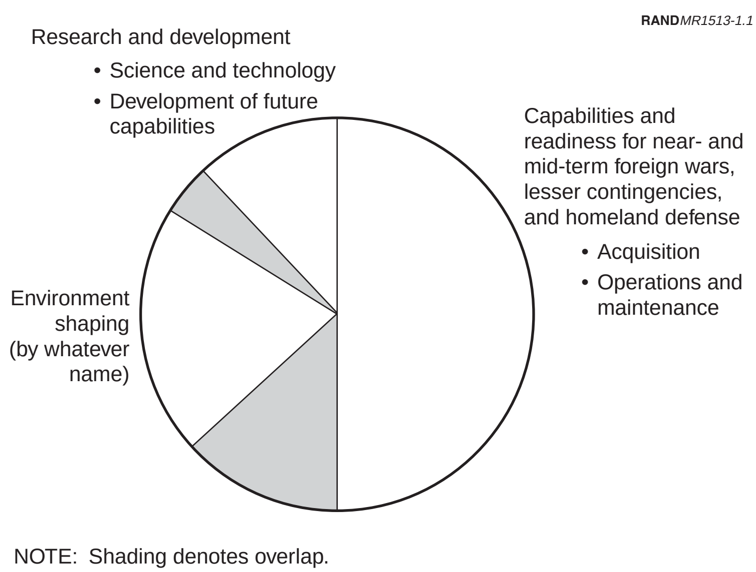


Figure 1.1—An Illustrative Portfolio Representation of Defense Expenditures

bilities and readiness for conflict. None of these are sufficient to prevent terrorist attacks. They are, however, important in pressuring the states who support terrorists and in mounting attacks on terrorist groupings when they can be located.

Despite the importance of the portfolio view and the value of all its components, the emphasis in this monograph is on capabilities analysis. Ultimately, assuring the existence of suitable capabilities for conflict remains the DoD's core responsibility. The exception to this focus is in Chapter 5, which discusses the difficult problem of integrating multiple considerations when it comes time to make choices and allocate resources.

Key Elements of Capabilities-Based Planning

The following are the key elements of capabilities-based planning:

- A conceptual framework for planning under uncertainty by emphasizing flexibility, robustness, and adaptiveness of capability.
- An analytical framework with three components:
  - understanding capability needs
  - assessing capability options at the level of mission or operation
  - choosing capability levels and choosing among capability options in an integrative portfolio framework that considers other factors (e.g., force management), different types of risk, and economic limitations.
- A solution framework that emphasizes "building blocks."

The next chapters deal with these issues in turn.

Endnotes

[1]See Davis (1994, Chs. 1–5); Davis, Gompert, and Kugler (1996); Davis, Gompert, Hillestad, and Johnson (1998), Hillestad and Davis (1998), and Davis, Bigelow, and McEver (2001).

[2]Some historical examples of capabilities-based planning are summarized in the appendix.

[3]The environment-shaping concept was first used in the Department of Defense (DoD) by Cheney (1993), following earlier work on post–cold war strategic planning in the late 1980s (see Davis, 1994, Ch. 6). The concept reemerged in the first Quadrennial Defense Review (Cohen, 1997). The DoD's new strategy emphasizes assuring allies and dissuading, deterring, and defeating adversaries (Rumsfeld, 2001a, p. iv). The functions of shaping are spread among all four of these new components.

Chapter 2

Conceptual Framework

The Role of the Secretary of Defense

A good starting point for the conceptual framework is reviewing the role of the Secretary of Defense (SecDef). Figure 2.1 sketches a view in which the SecDef's role is one of establishing objectives, directions, and requirements. It also includes developing appropriate management-forcing functions and measures by which to monitor progress and recognize the need for adjustments or special intervention. In this framework, the SecDef ordinarily looks to his "operating divisions" (the military services) for solution options and then chooses among the options as necessary.

To be sure, the process is less clear-cut in practice. For example, the Chairman of the Joint Chiefs of Staff has a crucial role in advising the SecDef and the president. Further, he runs the Joint Staff, which influences the solutions pursued by the services. He also often acts on behalf of the commanders in chief (CINCs) of the many joint commands worldwide. The Office of the Secretary of Defense may do much to promote fresh thinking and even promote particular ideas. Working in the other direction, the service chiefs and secretaries influence what the SecDef concludes should be the objectives, requirements, and general direction. And, of course, on rare instances, the options chosen are not creations of the services, but rather top-down "national" decisions. Nonetheless, the idealization painted by Figure 2.1 is at the core of our defense system.

How, then, can the SecDef fulfill his role? What constructs and process would best serve his needs? Let us first review the old planning paradigm and then discuss how capabilities-based planning differs from it.

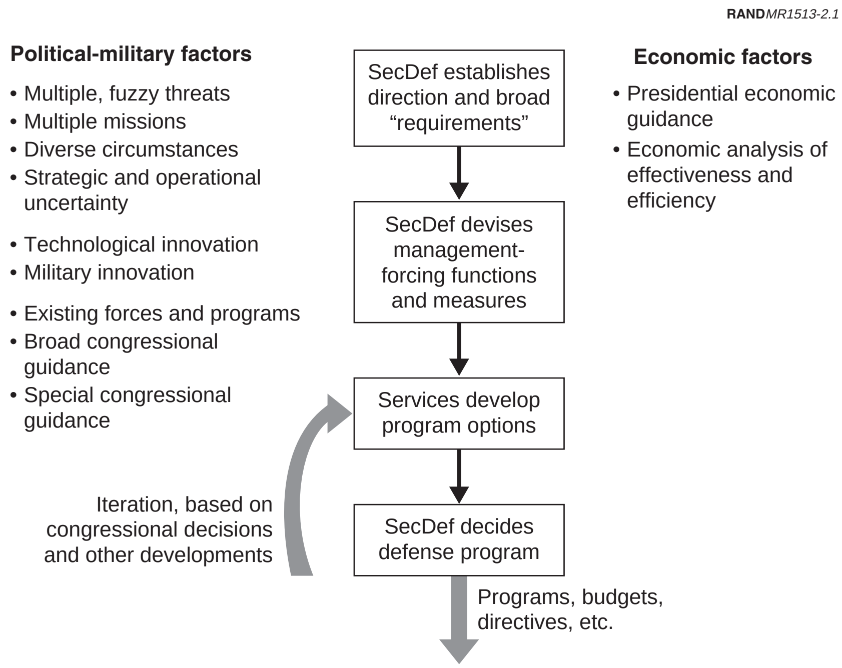


Figure 2.1—The Secretary of Defense's Role in Defense Planning

The Old Paradigm of Setting Requirements with Point Scenarios

The Bounding-Threat Method

Capabilities-based planning is nothing new. Indeed, the defense-planning system has always been intended to serve the function of assuring future capabilities that would prove versatile in circumstances not originally foreseen. However, for nearly four decades, starting with Robert McNamara's period as SecDef, the method for accomplishing defense planning was one of bounding threats. The idea was that using those bounding threats as requirements, as represented by one or two point scenarios, would lead to the appropriate capabilities. There were always other considerations, but the bounding threat was a core concept taught to and used by generations of planners.

The bounding-scenario method was ultimately a trick, a shortcut that served reasonably well for many years. There were few illusions in the minds of the secretaries, who understood full well that the forces developed would be used in a myriad of ways unlike those of the bounding scenarios. The trick worked because the Soviet Union was an immense and multifaceted threat—challenging us worldwide, and in the air, land, sea, and space. The trick no longer works. Indeed, it has not worked for more than a decade, but Secretary Aspin prolonged its life by substituting the bounding scenario with the concept of planning for two major regional contingencies (MRCs), later renamed major theater wars (MTWs). These were quickly interpreted—despite cautionary words in the Bottom-Up Review (BUR)—as merely substituting a new bounding-threat scenario such as that sketched in Figure 2.2.[1] In the 1990s, the scenarios were beefed up for force-planning purposes by assuming larger versions of the Iraqi and North Korean threats than seemed likely to exist. Today it is apparent that the United States needs a large force structure, but not particularly because of the Iraqi and North Korean threats, and not necessarily built around the current units or those units as currently configured. Planning around such threat scenarios now seems antiquated.[2]

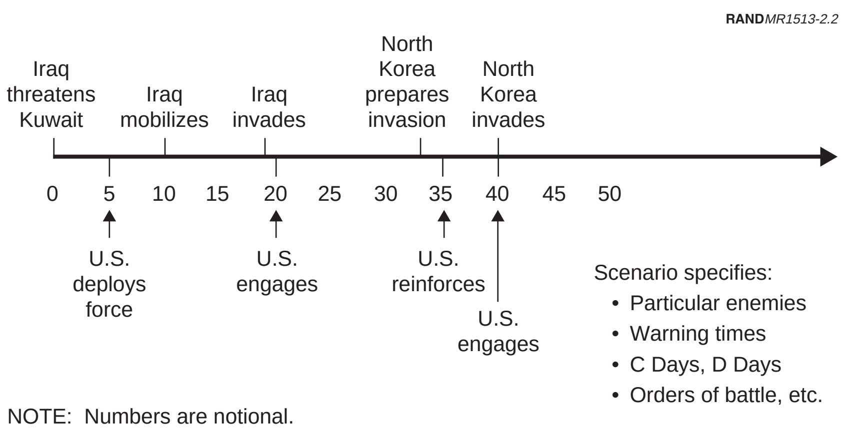


Figure 2.2—A Schematic of Old-Fashioned Point-Scenario Threat-Based Planning

A Red Herring: The Comparison to Threat-Based Planning

Before moving on, it is useful to comment explicitly on a common misconception related to the bounding-scenario approach. Capabilities-based planning is often contrasted in discussion and articles with "threat-based planning," which is confusing because capabilities-based planning is also very much concerned about threats. No one seriously proposes that the Department of Defense should spend nearly $400 billion per year for general insurance against the abstract possibility that some threat might conceivably arise somewhere, sometime—especially when threats currently exist and other potential challenges can be seen on the horizon. It follows that

> The correct contrast is not with "threat-based planning" as that phrase is interpreted literally, but rather with dependence on a specific bounding threat as represented by one or a very few point scenarios.

Point-scenario planning is characterized by a fixation on particular enemies, particular wars, and particular assumptions about those wars—a fixation that comes at the expense of more flexible and adaptive planning. A symptom of the problem can be seen in the extraordinary attention paid, until recently, to the notorious two-MTW scenario involving Iraq and North Korea.

A problem in moving away from such fixations is that serious capabilities planning and operations planning require the concreteness that comes with considering specific scenarios—either real or credibly constructed. Further, the enthusiasm and focus needed to generate good ideas or to worry about problems creatively are enhanced when the scenario being considered is either real or obviously a relevant surrogate. Using approximations of "real" scenarios has sometimes proven convenient. The price paid in suppressing uncertainty, however, has been great: The planning system was behaving as though the illustrative scenarios were "the" scenarios.

If point scenarios are inappropriate, then what should replace them? Is replacing them so hard and complex? To answer these questions, it is useful to step aside from the defense problem temporarily and consider more general matters that will perhaps change the baseline for thinking about what is "reasonable."

Force Planning as an Exercise in Design

A Broad View of Design

To establish a broad view before returning to defense planning, consider the process, familiar in many domains of everyday life, sketched in Figure 2.3. It shows the process of conceiving, designing, and building something—as that process might be seen by an engineer, architect, or systems designer. It begins (top left) with someone having a problem and an objective, as well as broad knowledge. This stimulates a broad

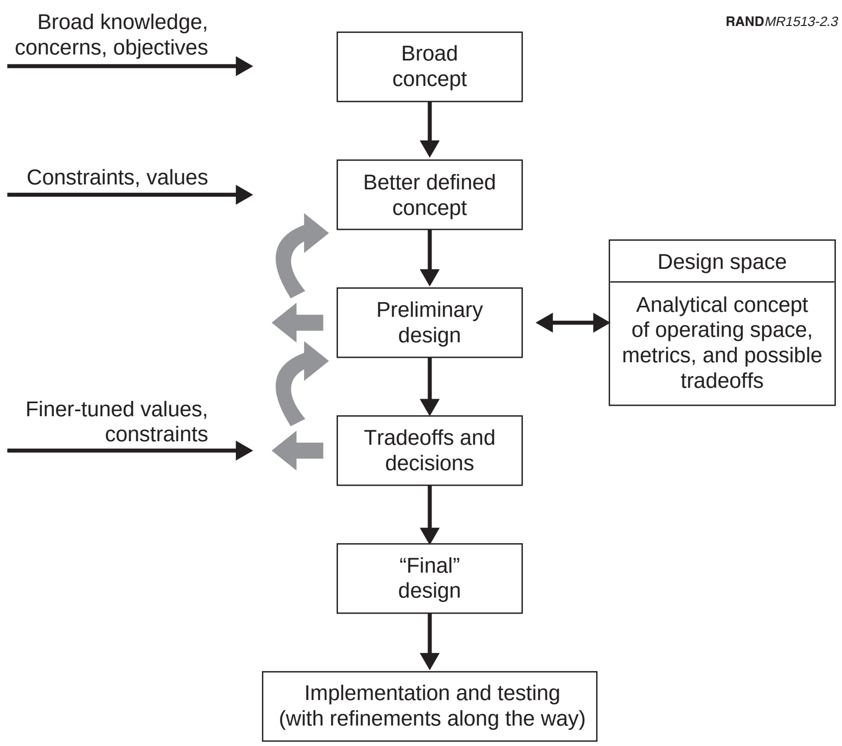


Figure 2.3—Moving from Need to Capability

concept for how to achieve the objective (i.e., what kind of house or airplane to build or what kind of organization to create). Broad concepts, however, only go so far. The next step is to start sharpening the concept by identifying values, concerns, and constraints in more detail. Once this preliminary design is done, then final design can proceed in earnest.

Different skills are required for preliminary design than for broad conceptualizing. The designer must understand and define (1) the "operating space," (2) metrics for assessing the goodness of a design along multiple dimensions, and (3) the tradeoffs that might be made. Once these matters are well understood, it is time to work with the client again—to ask the client to think about the tradeoffs identified and make more decisions about what is desired.

These desires often include flexibility. The house being built, for example, may need to be flexible enough to change character as children are born, grow up, and leave their parents in an empty nest. Perhaps the parents have vague hopes of someday adding a work studio, or of running a business from their home. And, of course, they want to have plenty of electrical sockets, phone lines, and possibly cable connections. Who knows where they will want to have equipment, or even what that equipment will be? They cannot evaluate the design solely in terms of their current needs. Other examples would require building in even greater flexibility. The designer of a new commercial aircraft would need to recognize that the aircraft might eventually be used anywhere in the world and for different types of load. Such a designer cannot usefully work with specifics, as can a homebuilder who knows where a house will be located. Instead, he must move to broader, more generic constructs. Indeed, aircraft designers frequently talk about matters such as the envelope of performance, rather than a detailed "scenario" for the aircraft's use. Note, however, that they may be very interested in knowing many plausible scenarios of use in order to help sharpen their sense of what the capability envelopes should be. For example, having been sensitized to a range of scenarios, a helicopter designer would be more likely than otherwise to build in requirements for operating in mountains and in deserts with blade-eroding dust storms.

Returning to Figure 2.3, after enough crucial decisions are made based on preliminary design and identification of tradeoffs, the process moves to "final" design, with quotes reminding us that changes will still be made along the way. When that final design is ready, a transition occurs and yet another set of skills come into play. Actually implementing the final design requires a builder, not just an architect. Indeed, it probably requires a general contractor and quite a number of subcontractors.

The most important single element of Figure 2.3 for the purposes of this monograph is the concept of design space indicated on the right. This is essential to good design. It is what allows the designer to move from broad notions to something concrete and to identify the myriad of issues that must be addressed. Figure 2.3 shows only a single design space. The real problem is more complex: There are very different design issues for the house as a whole, the kitchen, the master bedroom, and so on (or for the fuselage, the wings, the navigation system, etc.). These are only partly modular, since decisions about one component will likely have implications for the others. It follows that Figure 2.3 is shorthand for a process involving multiple subprocesses of the sort indicated and a high-level integration.

Applying the Concept to Defense

With this background, Figure 2.4 describes schematically a process for capabilities-based planning motivated by seeing defense planning as involving a design process as discussed above. Although it looks much like any other process–flow chart, it actually has a number of important features consistent with the general process of Figure 2.3, but quite different from the way in which defense planning has been generally conceived. The concept of "understanding the potential requirements space" is significant, as is the emphasis on "requirements" being the result of decisions, rather than something deduced from intelligence projections. Farther along in the flow (item 4), this depiction emphasizes assessing capability options under uncertainty. Finally, Figure 2.4 reminds us—through the icons indicating hierarchy—that the "understanding of potential requirements," development of proposed capabilities, and evaluation of capability options must be accomplished at multiple levels and in numerous components of effort. Choices must be made both within and across components, both vertically and horizontally.

One might reasonably ask at this point who (what organization) is or should be responsible for each of the steps in Figure 2.4. Is the concept one of classic top-down planning, with the Secretary of Defense responsible for much of the process? The answer is complex because the reality is complex. It is true that capabilities-based planning requires a good deal of top-down process, but this occurs not in a single line (SecDef downward), but in multiple lines. In particular, each of the military departments goes through the entire process shown within its own domain of responsibilities. To be sure, the Secretary of Defense is the key figure for establishing national requirements, but those are informed by the services' individual analyses. Further, in the style preferred by recent secretaries, and certainly by Secretary Rumsfeld, many of the planning responsibilities are delegated horizontally to the service departments, which are seen as akin to operating divisions. I say "hor-

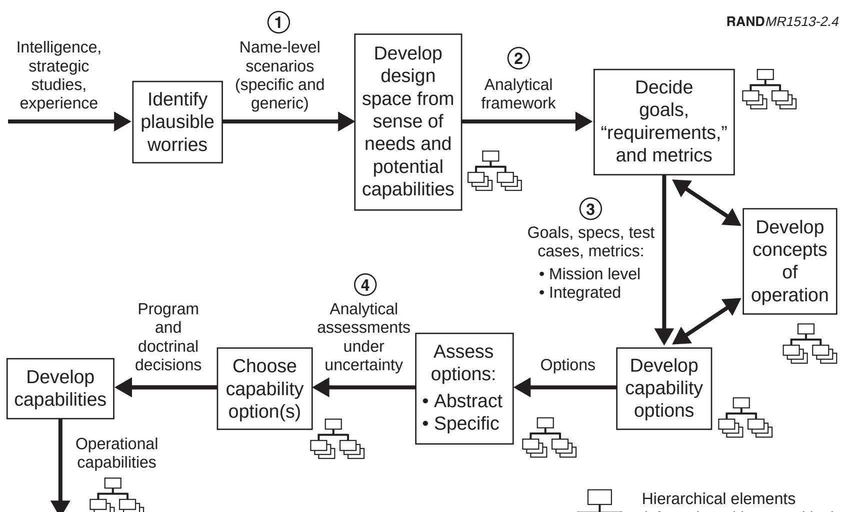


Figure 2.4—A Process Model for Capabilities-Based Planning

izontally" because that which is delegated is still very high level planning. The Secretary of Defense should personally establish objectives, metrics, and requirements only when there is a need to do so—as on issues such as total force size or jointness, or when, for whatever reason, developments needed will not occur naturally.[3]

With this background, Chapters 3–5 expand upon issues raised in Figure 2.4. Taken together, these chapters sketch the essence of a new analytical architecture for the Department of Defense. The purpose is not to discuss organizational structure and details of process, but rather to describe guiding paradigms.

Endnotes

[1]See Aspin (1993). Alternatives were considered. In particular, generic constructs, such as the MTW-East and MTW-West scenarios suggested by General Powell in 1990, were rejected by Secretary Aspin as too abstract. It was apparently not yet time for capabilities-based planning. Although the inappropriately named Bottom-Up Review defined what it called building blocks with the intention of emphasizing broad capability, the building blocks were highly aggregated and utterly traditional in terms of how capabilities were conceived (essentially divisions, tactical fighter wings, carrier battle groups, and amphibious ready groups).

[2]It is not that the Iraqi and North Korean threats have gone away. However, the problems they pose relate more to in-place or rapidly deployable forces than to total force structure (Davis, Hillestad, and Crawford, 1997). The demands of total force structure are dictated largely by the diversity of worldwide obligations and challenges that have been so prevalent in recent years (Davis and Kugler, 1997). Both points are recognized implicitly in the DoD's recent QDR (Rumsfeld, 2001b).

[3]This concern arises, for example, when dealing with force transformation, rather than with more normal force modernization. Even here, the SecDef's intention should typically be to stimulate and incentivize service-based transformation, rather than to impose it. The most notable exceptions relate to jointness and are illustrated by the recent QDR's mandate regarding standing joint task force capabilities (which I believe relate primarily to command and control issues—i.e., to headquarters issues—rather than to combat forces).

Chapter 3

Understanding Needs and Defining Potential "Requirements"

Appreciating the Range of Possibilities

The first step of Figure 2.4 is to identify the range of plausible worries. That is, it begins by recognizing the wide range of potential future threats, rather than focusing on one or two as was common during the cold war. It urges developing a lengthy list of "name-level scenarios" (scenarios defined only to the extent of giving them names that indicate broadly the nature of conflict being considered), both specific and generic—i.e., identifying broadly what the United States needs to be worried about—not just some "bounding threat," but a richer and more realistic list. The list should deal with the here and now, the mid term, and the longer term. It should include specific threats and more-generic threats.

Before September 11, such a list—if concerned with U.S. projection forces rather than homeland defense—might have been something like that in Table 3.1, with a mixture of specific and generic scenarios.

The list is longer, of course, when we include missions for homeland defense or other functions beyond those of force projection.

The New Challenges

In the wake of September 11, priorities for concern obviously have shifted. Not only is it necessary to put far greater effort in homeland defense in all of its dimensions, but it is also necessary to rethink projection-force capabilities. Even before September 11, it was apparent that the nature of the threat had changed. Figure 3.1 illustrates how one might think about such matters conceptually with the objective of informing analytic architecture.

This depiction of capabilities uses a "spider chart" to compare cold-war challenges to those we now see. A given threat is depicted by marking the appropriate point along each axis (warning, enemy war incentives, etc.), and then connecting those points to form an envelope. The farther out the envelope reaches along a given dimension, the worse the challenge. The thick shaded line shows the envelope of capability that characterizes challenges of the cold war with the Soviet Union. These challenges may also pertain in the future, if a regional- or global-peer competitor emerges. The dashed-line envelope pertains to rogue states, and the solid-line envelope applies to the current class of terrorist threat.

Table 3.1
Possible Scenarios That Could Affect Projection Forces

Iraq invades Kuwait and Saudi Arabia
North Korea invades South Korea
China attacks Taiwan
China emerges as regional peer competitor, perhaps threatening a unified Korea or otherwise coercing countries in the Asia-Pacific region
United States intervenes early in "next Bosnia," with the objective of deterring aggression by regular forces
United States intervenes in "next Kosovo" with objectives that include stopping the killing being accomplished by dispersed irregular forces
United States attacks rogue state or terrorist facilities with deep-underground mass-destruction weapons and missiles
United States attacks to "root out" terrorists (Afghanistan, Syria, Iran, and/or Libya)
United States strikes with missiles and aircraft against terrorist groups (Afghanistan, Syria, Iran, and/or Libya)
United States invades a rogue state to bring about a change of regime
United States invades to regain territory lost by a friendly nation
United States attacks drug czars in Latin America
Russia threatens or invades the Baltic states
India and Pakistan go to war with spillover effects (uncertain role for U.S. forces)
Arabs and Israelis go to war again (uncertain role for U.S. forces)

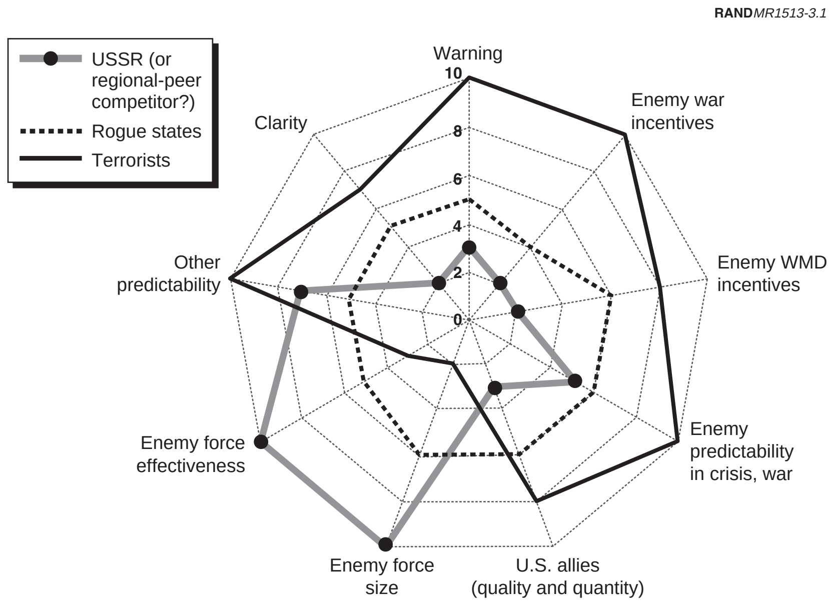


Figure 3.1—Changes in the Nature of the Threat

What is most striking about the display is that the dangers are of a different kind now than previously. Whereas the old Soviet Union (and a possible future peer competitor) is characterized by very large and capable forces, the newer threats stress our capabilities quite differently and are arguably more dangerous in most respects. The Soviet Union was highly risk-averse, had no interest in nuclear war (despite having studied and prepared for it conscientiously), and had plans for war that we probably understood reasonably well. Our NATO allies were both reliable and capable. If war came, there was likely to be adequate strategic and even tactical warning, although many of us conducted studies noting how difficult reacting well to warning could be. In contrast, the rogue states that we think about now have more incentives to cause war in the first place, and to threaten or actually use weapons of mass destruction (WMD). They are not status-quo powers, and they know that they can be destroyed if they engage the United States "symmetrically," to use that overdone expression, or if they allow a U.S. counteroffensive that could force regime change and quite possibly lead to their leaders' deaths or imprisonment.

Even worse is the terrorist threat. Although the forces involved are small, they are in nearly all other respects more troublesome: They have positive incentives (even if bizarre by our reasoning) to use WMD, their tactics are unpredictable, and so on. And, although international support for U.S. actions in the wake of September 11 have been largely encouraging, the staying power of both allies and the general citizenry would be in doubt if terrorism attacks persisted long enough and if eradication of terrorism were proving impossible.

From the above perceptions comes heightened sensitivity for the need to have capabilities that have never been highlighted in core force-planning scenarios. Only the requirements for flexibility and adaptiveness have been highlighted. In addition, however, one might think of capabilities such as

- deep and sustainable reach
- instruments for coercing the nations that support or harbor terrorists
- ground-force units with some of the characteristics of special operations forces, but with greater size, greater sustainability, and greater capability to attack and destroy deep-underground facilities, and to find and destroy terrorist groups
- ground-force units with improved and sustainable capability for anti-terrorist operations in cities
- homeland defense components such as continental air defense, missile defense, border defense, and consequence management.

This is not the place to assess any of these or to propose particular solutions. Rather, let it suffice to say that the modern world poses challenges that go beyond those that have traditionally been the focus of attention in force planning. Also, it is apparent that the capabilities in question do not lend themselves to being specified by detailed point scenarios. "Envelopes of capability" are more useful metrics (e.g., the number of cities that could be simultaneously supported with rescue and decontamination teams, or the length of time that anti-terrorist deep interventions abroad could be sustained militarily, with and without the support of something like the Northern Alliance in the Afghanistan campaign).

In any case, Figure 3.2 uses the earlier spider-plot format to dramatize how different the relevant operations appear to be in the new era of conflict. If rapid reinforcement to support forward defense behind prepared lines with stalwart and capable allies was the core operation during the cold war (solid-line envelope), the key operations in the future (and even today) appear to be quite different.[1] None of the requisite capabilities are coming along "naturally," but rather seem to need high-level DoD attention. This means that they can be expressed as special "operational challenges" as shown in Table 3.2. The table, however, focuses on a subset of projection-force issues that appear to me to need particular attention. Other analysts might construct a somewhat different list.[2]

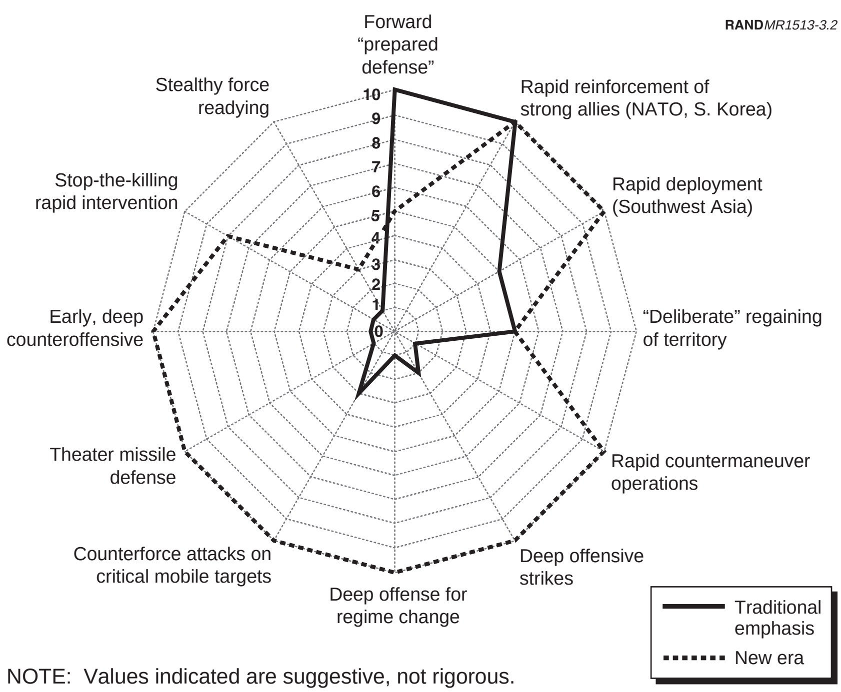


Figure 3.2—Changes in the Nature of Key Operations

Table 3.2
Priority Operational Challenges for Projection Forces

Immediate countering of enemy maneuver forces (e.g., halting an invasion quickly or tying down enemy forces while U.S. forces maneuver)
Immediate destruction of critical mobile targets such as vehicles carrying missiles armed with mass-casualty weapons
Effective stop-the-killing intervention in a small-scale contingency
Attack and destruction of mass-casualty weapons by inserting ground forces as well as conducting long-range strikes
Attack and destruction of terrorist strongholds
Early attacks or counteroffensives without massive buildup
Invasion after major loss of territory, into the teeth of an enemy able and willing to use mass-casualty weapons

Significantly, meeting the operational challenges suggested in Table 3.2 will not come about without changes that can reasonably be characterized as transformational. By this I mean that the changes will be substantial and will involve changes in the very nature of operations, not merely their efficiency. They will typically require new building-block operations, as well as the technology and organizational structures to support them.[3]

Progress in Recognizing and Taking New Threats Seriously

Although until recently public and congressional attention continued to focus on the two-MTW problem translated to mean something like that shown in Figure 2.2, much progress has in fact been made by the DoD in broadening its conception of threat. Starting in roughly 1996—well before September 11, 2001—the DoD and other parts of the U.S. government were deeply involved in conceiving, worrying about, and even gaming scenarios for a wide range of threats. These have been reflected in richly posed scenarios used to stimulate thinking and worry. The groundwork for such efforts has been laid over a period of years and through several administrations by the Office of Net Assessment, the Defense Science Board, the war colleges, and study organizations.

Even before September 11, then, no one needed to sensitize the DoD to the range of plausible worries. Nonetheless, prior to 2001, very little had changed in the nuts and bolts of defense planning's analysis system to reflect these worries (Larson and Peters, 2001). Instead, the concerns most often expressed related to operational tempo and the need to plan for a next generation of military forces (see, e.g., Flournoy, 2001). As Secretary Rumsfeld has noted, however, the new types of danger have been strongly emphasized for some time by President Bush (Rumsfeld, 2001a; Bush, 1999). To them, transforming U.S. forces must include preparing for the new dangers.

Defining a Design Space for Studying the Range of Plausible Scenarios

Although the DoD has been vigorous in conceiving and worrying about a broad range of future threats, it has done more poorly in translating broad concepts of threat into something approximating an analytically sharp design space.

The de facto conception of "analytical framework" has continued to revolve around the big point scenarios. Policy documents have exhorted military organizations to worry about flexibility and adaptiveness, but when it has come time to do in-depth studies of the sort that affects programs, the terms of reference often read very much as though nothing had changed. The focus has been on point scenarios defined in extraordinary detail, with uncertainty not seriously represented.[4]

Figure 3.3 (adapted from Davis, Gompert, and Kugler, 1996) suggests that the enrichment of scenario analysis should occur in two steps: broadening the range of name-level scenarios, as discussed in the previous section, and—for each significant name-level scenario—developing a design space that recognizes the full dimensionality of uncertainty. Although the DoD has taken the first step, and although the September 11 attack guarantees that there will be no recidivism to the traditional point scenarios, not much progress has been made on Step Two.

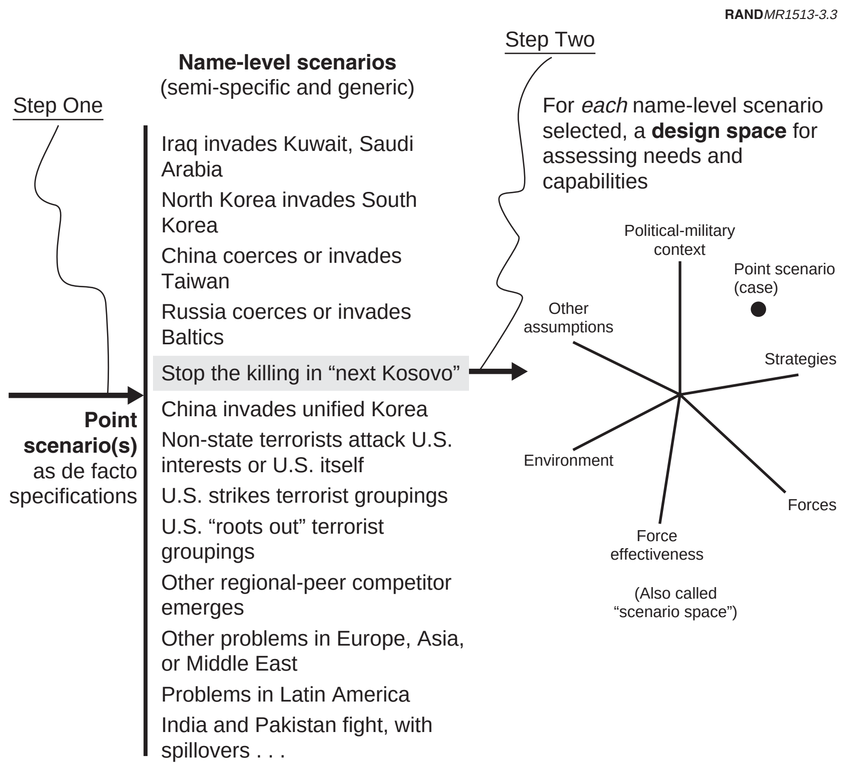


Figure 3.3—Understanding the Design Space for Even One Name-Level Scenario

This failure is best understood in terms of organizational inertia. There was no shortage of forward thinking or innovation, nor of interest in hedging, flexibility, and adaptiveness. However, the department's routine processes went on as before. Non-routine processes, such as forward-looking war games to look at the new challenges and concepts of force transformation went on in parallel, but many of the "big studies" went on as before because there was no demand for change (and because of the disconnect among DoD's parts).

Another factor here is that the DoD has not sufficiently appreciated the importance of design and system thinking.[5] As an example that may be meaningful to many readers, consider how one goes about identifying capabilities needed for a wide range of challenges. Developing a long list of name-level scenarios is a good thing to do. However, a common error has been to assume that thinking about a scenario in Korea and a scenario in the Persian Gulf is enough to generate the needed force requirements. The attitude seems to have been: "How different could anyone want the scenarios to be? After all, they involve different continents and different styles of warfare. Further, we have assumed enemy force levels and capabilities well beyond what we see today, so the scenarios are bounding." That seems to have been the extent of understanding regarding the space of requirements.

The picture changes quickly if one takes a more analytical view, thinking in terms of defining the design space. As Figure 3.3 suggests, for each "name-level scenario" (e.g., Iraq tries again or China threatens a future unified Korea) conflict could occur in a myriad of ways. This is indicated by the notion of a "scenario space" (perhaps better called a "case space" or "assumptions space") for each name-level scenario. This can be systematized by imagining that one is setting up a war game or simulation to assess capabilities for a given name-level scenario. The outcome will depend on all of the inputs, which can be placed into six categories:

1. Political-military context (e.g., how the war came about, who is allied with whom, the degree of strategic warning, forward stationing of forces).
2. Objectives and strategies (e.g., the other sides' political and military objectives; their military strategies, such as anti-access strategies that threaten regional states with WMD if they grant the United States basing rights, strategic deception minimizing usable warning, and distractions, such as apparently unrelated terrorist events in the United States itself).[6]
3. Forces (size, character, and nominal capabilities).
4. Force effectiveness (accounting for training, morale, cohesion, etc.).
5. Environment (terrain, weather, etc.).
6. Other model assumptions (movement speed of maneuver forces, real-world weapon effectiveness given fog of war and unanticipated low-level tactics).

The interpretation of the outcome will also depend strongly on the criteria for success. For example, requiring an early halt is different from requiring an eventual halt; requiring the ability to accomplish a decisive counteroffensive deep into the enemy's homeland is different from just defeating his army; minimizing losses changes the character of outcome. Indeed, such issues of criteria may be regarded as a seventh category.

A payoff for going through this type of systematic thinking is that one comes to have a very different conception of capability requirements. One learns, for example, that the "name" of the scenario is often much less important than the details buried in databases. What matters is not preparing to fight Iraq again, but, for example, being able to countermaneuver units quickly through both interdiction and the interposition of capable ground forces. The biggest issue is often not total force capability, but the capabilities that can be employed very early—even with minimal warning.[7] Command and control is crucial, whether it be in one theater or another. Further, in defining capability needs, we should not count upon the advantages provided to us by particular point scenarios.

This raises one of the great ironies. Although it is often claimed that DoD does worst-case planning, the reality is that DoD's old point scenarios stressed only some of the capabilities needed, while making very optimistic assumptions about others. No single point scenario can avoid this problem. Designers in other domains have come to realize this, which is one reason why these designers work more with abstracted expression of capabilities (e.g., the performance envelope of a fighter aircraft).

As a final comment before moving on, the categories of operations referred to in Figure 3.2 and the categories above are not merely grist for an essay. Rather, they together represent a tangible and practical element of analytical architecture. For some years now, my colleagues and I have routinely used versions of this structure in developing analytic plans for studies. A key element of initial study design is literally going through the categories to understand what variables should be addressed in the particular study. The results are plans for "exploratory analysis" across the design space of cases (Davis, 2001b). We shall return to this in Chapter 4.

Moving Toward Requirement Setting

If we now look back at Figure 2.4, we can see that the third highlighted step (choose goals, requirements, and metrics) is quite different in a capabilities-based framework than what has been normal practice. Normal practice in the DoD was to use high-level point scenarios (such as that shown in Figure 2.2) as requirement setters. This is why so many individuals within the defense establishment and certainly outside it have continued to believe that the two-MTW requirement was "the" requirement established by the Secretary of Defense. In the capabilities-based framework of Figure 2.4, however, the goals, requirements, and metrics established should be more disaggregated and should be conceived much more in terms of capability "envelopes" than particular scenarios. As indicated in the figure, much of this conception should deal with mission-level issues rather than full-theater or multi-theater scenarios. The reasons are several:

1. One or a very few point scenarios cannot stress all the capabilities that need to be stressed in requirement setting. A scenario that is tough in some respects (e.g., large enemy force) will be easier in others (e.g., preparing large forces imply strategic warning).
2. Scenarios carry with them special circumstances that simplify the military problems and serve as a crutch (e.g., prestocked bases with developed infrastructures).
3. Many capabilities need to be specified in "continuous spaces," in terms of capability envelopes.

The problem is ultimately hierarchical; requirements for component capabilities need to be established within their own domains, without being constrained by the particular examples represented in higher-level scenarios.

Therefore the next chapter addresses mission-system capability.

Endnotes

[1]As with most such schematics, the details of the graphing are subjective. Precision is not intended.

[2]Similar contrasts are discussed in Binnendijk and Kugler (2001).

[3]My definition of transformation is a functional one, and the baseline is considered to be the early 1990s in recognition of the fact that considerable transformation has already come about and is continuing apace. Merely because some initiative was begun earlier and was not called "transformation" should not determine whether it is deemed transformational. A prime example here is the recent experience in Afghanistan, which called for new quintessentially joint operations that made superb use of modern technology. Can anyone deny that the use of unmanned aerial vehicles, special-forces spotter teams, close coordination with Northern Alliance forces, and highly precise effects-based targeting represented a glimpse of something profoundly different from warfare of decades past?

[4]Strong words to this effect can be found in Defense Science Board (1996, Vol. 2, Section IV), which reported conclusions of a study team led by Major General Jasper Welch (USAF, retired).

[5]A similar theme was emphasized in National Research Council (2000), a study conducted for the U.S. Navy.

[6]Such problems have been anticipated for years, although such anticipation could not head off September 11. See Bennett, Gardiner, and Fox (1994). Although discussion of attacks on the U.S. homeland was severely muted in print (p. 496), it was very much a part of the future-of-warfare games described.

[7]See, for example, Davis, Hillestad, and Crawford (1997), which summarizes insights from large studies done for the Office of the Secretary of Defense, the Joint Staff, and the Air Force. One of the observations made in those studies was that the standard point scenarios obscured the fact that the marginal division or wing in force structure was less important to outcome than leading-edge capabilities. Large force structure is very desirable for other reasons related to worldwide commitments, rotation bases, general deterrence, and general prudence such as having forces available for use in the western hemisphere, but that is another matter.

Chapter 4

Mission-System Analysis for Assessing Capabilities: Concepts and Enablers

Motivation

As mentioned earlier, full-scale theater-level scenarios are an inappropriate basis for capabilities-based planning. This is especially so if—as discussed in Chapter 5—we focus on building-block capabilities. In a building-block approach, we want to define, develop, and test the building blocks primarily within their own domain. An analogy exists to software modules. These are defined, written, and tested more or less independently from the full context in which they will be used. A software module's purpose may be, for example, to compute the boiling point of water. The module must be proven valid for a wide range of conditions (notably involving pressure), but once that has been done, it need not be tested in a large-scale experiment involving a great deal of equipment, people, and processes because the calculation module is independent.

Arguably, the same type of test should hold for military operations and, particularly, subordinate operations. The capability to conduct joint interdiction operations with long-range fires, for example, should be *largely* independent of the capability to control the littoral waters. As with most complex adaptive systems, "everything affects everything," but the interactions are relatively narrow and circumscribed. This is the phenomenon of "nearly decomposable hierarchies" celebrated in the theoretical literature. The "nearly" carries a lot of weight, however: The interactions between modules may be a small fraction of all interactions, but they may be subtle and crucial in some instances.

Large-scale system engineering efforts have sometimes failed because of such interactions (Miller and Lessard, 2001; Doyle, 1997, pp. 155ff). Thus, the analogy to a simple software module calculating boiling point is only approximate.

Since missions are building blocks or modules of campaigns, they are appropriate modules on which to focus capabilities-based planning.

Characterization of Mission-System Analysis

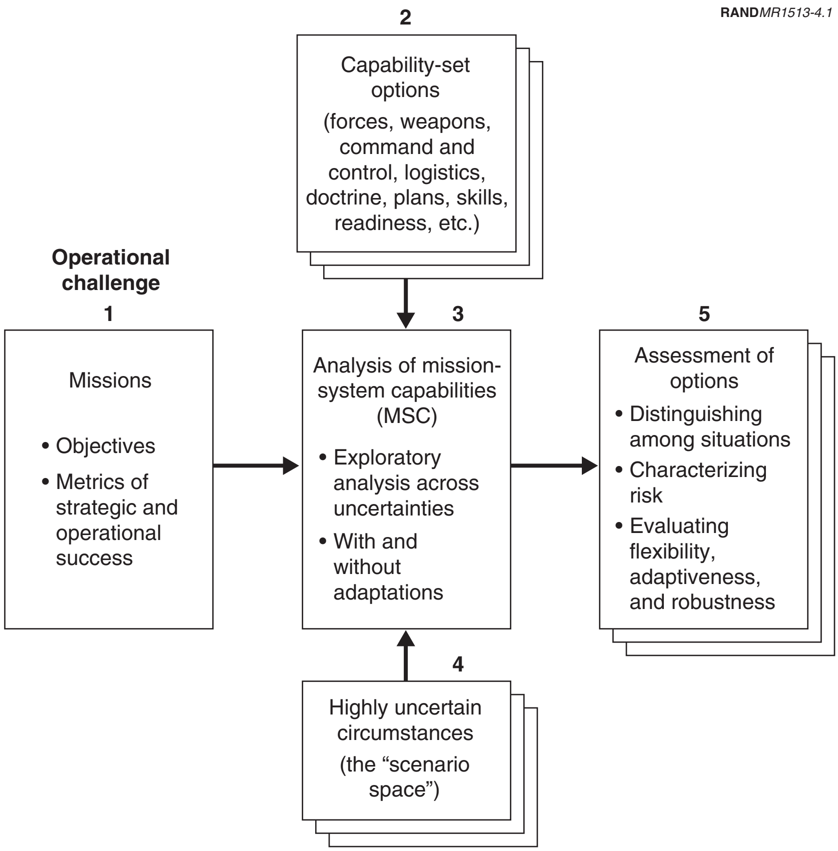
Mission-system analysis (MSA) is undertaken to guide mission-system planning (MSP), the purpose of which is to develop mission-system capabilities (MSC). The first tenet of mission-system analysis is to organize thinking around output. Doing so in the context of military transformation means organizing around mission capabilities. Aircraft, ships, and tanks can be referred to as "capabilities," but the capabilities of most interest in defense planning are the capabilities to accomplish key missions—i.e., capabilities to successfully conduct operations such as defeating an armored invasion, achieving control of the seas in a region, defending against a missile attack on the United States, or capturing a terrorist enclave—perhaps including mass destruction weapons hidden in mountain caves. Having platforms, weapons, and infrastructure is not enough: What matters is whether the missions could be confidently accomplished successfully. This is a system problem.

Mission-system analysis has much in common with other methods, notably the "strategies-to-tasks" approach,[1] and the idea of mission capability packages.[2] I have chosen to introduce a new name, however, because MSA's character appears rather different in practice—even though the underlying philosophy is similar. In any case, my concept of MSA construes the "system" broadly; emphasizes exploratory analysis under massive uncertainty with a family of models and games; and is comfortable with soft issues such as effects-based operations (EBO), analysis of which requires qualitative modeling (including cognitive modeling).[3]

Overall, the purpose of mission-system analysis is to give meaning to the goal of achieving flexible, adaptive, and robust capabilities for the missions at issue. This means no-excuse real-world capabilities, not just paper capabilities.

To elaborate, let us recall that the ultimate clients for defense planning's fruits include future commanders. Consider, then, that a future commander on the eve of battle will have little patience for being assured that the easily counted and measured factors are in good shape. He will be worried about all the factors that will determine the results of the next day's operations. Moving up the hierarchy, a future president will not be satisfied during a crisis to be told that the material factors are in line: Before deciding on a course of action, the president will want an assessment of whether the military operations being contemplated will be successful—with no hand-waving about the difficulty of knowing such matters. He will understand risks, and perhaps even the fog of war, but he will want assurance that the operations contemplated were planned in such a way as to be very likely to succeed despite the multitude of problems and uncertainties. Moreover, although he could tolerate uncertainties (perhaps in the number of casualties and the extent of unintended consequences or so-called collateral damage), he will want estimated bounds on them. Even with the best efforts, uncertainties will remain and some will not even be recognized, but mission-system analysis and associated decisions at the time of force planning can nonetheless go far in reducing operational risks years later.

Figure 4.1 sketches the process of mission-system analysis. Suppose that we want to develop clear requirements for, and to then develop capabilities for, a particular mission (left side). We consider a variety of capability-set options (top). For each option, we assess strengths and weaknesses across a wide range of operating conditions (i.e., a scenario space, with "scenario" understood here to include not just the political-military setting, but all of the key assumptions such as warning times, force sizes, coalitions, and effectiveness). This concept of exploratory analysis across a scenario space is fundamental to planning for adaptiveness, flexibility, and robustness.



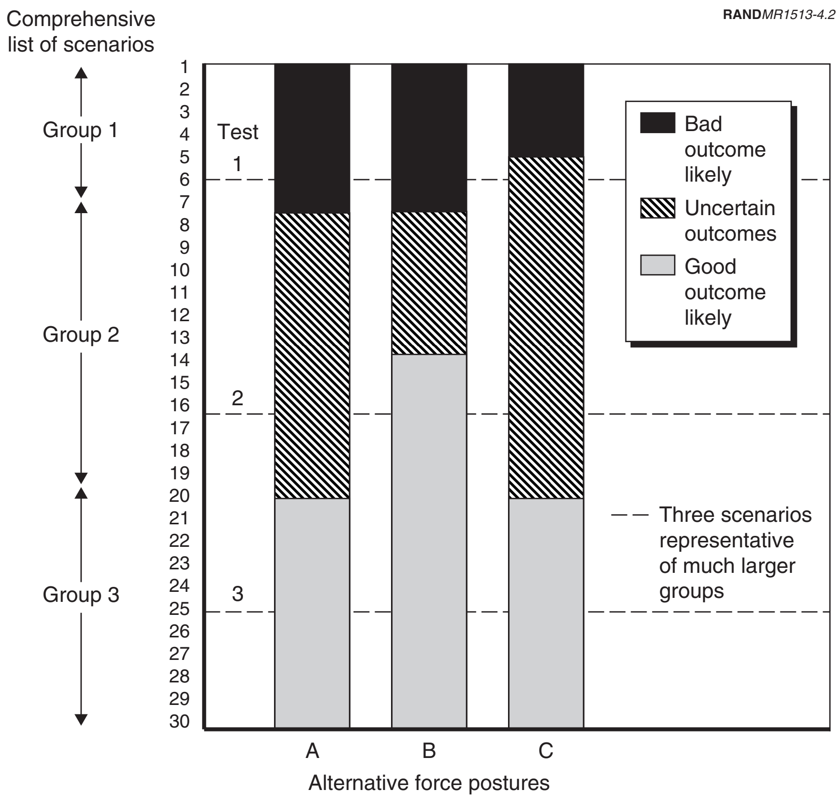
NOTE: For a given operational challenge (1), consider a set of options (2) for meeting the challenge; apply mission-system analysis methods (3) across a wide range of circumstances (4) to generate a comparative assessment of the options with appropriate metrics (5).

Figure 4.1—The Process of Analyzing Mission-System Capabilities

Depicting Results of Mission-System Analysis

The result of mission-system analysis, then, is—for each option considered—a characterization of how well the capability package would fare throughout a scenario space. That is, the capabilities would be quite adequate in some circumstances and inadequate in others.

The methods for displaying results of related analysis are still evolving. Before showing examples of what is feasible, it may be best to suggest what is often sought by those looking for simplicity. Suppose that we could put together a comprehensive set of scenarios (detailed sets of circumstances) and assess how each of several force-posture options would do in covering the cases. Also suppose that this could be done with a set of 30 scenarios and that we had only three force-posture options to evaluate. We could then construct something like Figure 4.2.



Group	Option		
	A	B	C
1	Bad	Bad	Marginal
2	Marginal	Good	Marginal
3	Good	Good	Good

Figure 4.2—A Hypothetical Comparison of Force-Posture Options

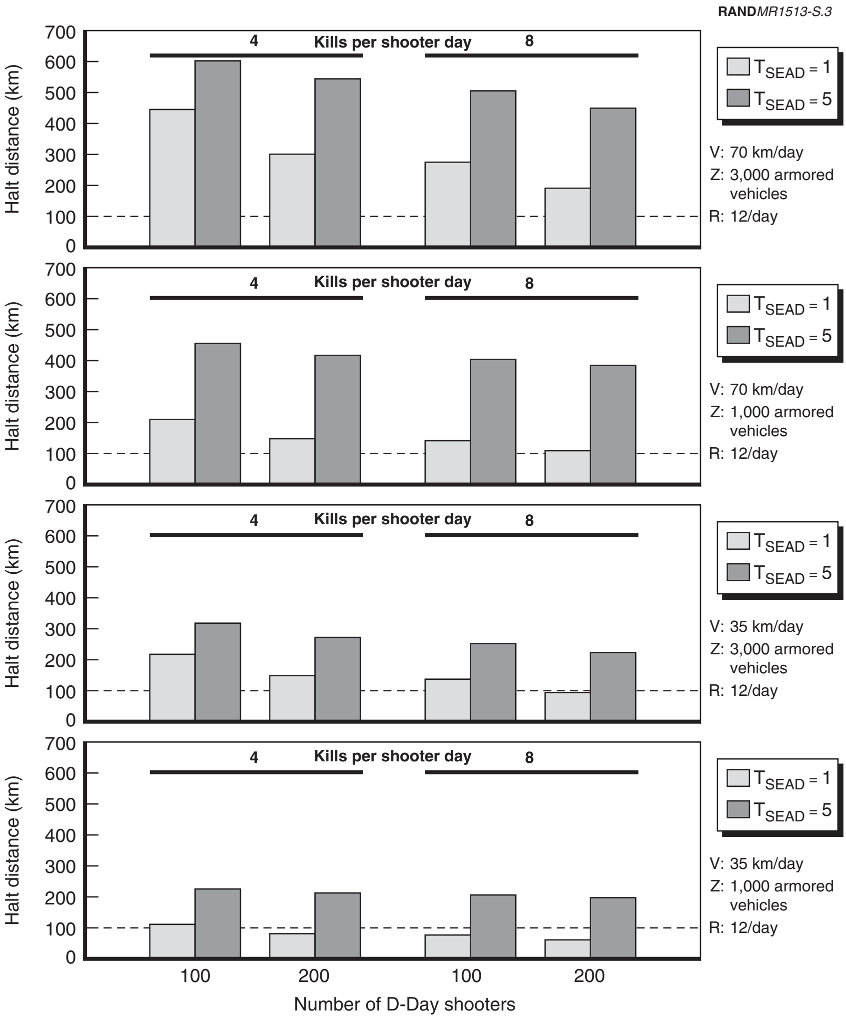
By observing the outcomes, we could also simplify the story. We could observe that the scenarios appear to fall into three rough groups with respect to stressing capabilities. Thus, we could use a mere three scenarios as test cases, one representative of each of three classes. In this imaginary analysis, then, we could reduce results to a simple table, as also shown in Figure 4.2. We could then make decisions about which posture provided the better set of capabilities under uncertainty.

Unfortunately, matters are not so simple. The circumstances of conflict are many and complex, as discussed earlier. Further, scenarios do not easily fall into just a few groups. Or, to put it differently, the groups that we might discern from studying outcomes depend on issues such as the objectives, the particular options chosen to study, and so on. Further, when we get into the issues, we discover that instead of needing 30 cases, we need to consider thousands, tens of thousands, or even millions of cases. This is why analysis so often proceeds by holding most of the factors constant.

What can be done, then? The answer is that quite a lot can be done, using modern analytical methods.

Figure 4.3 is a parametric summary of an extensive exploratory analysis of countermaneuver capabilities (see Davis, McEver, and Wilson, 2002), such as might be used to halt an invasion, defend friendly dissident forces from attack, or tie down enemy forces as U.S. ground forces maneuver. The metric used is how quickly an invading army could be halted by interdiction alone. A possible goal for the metric is capability sufficient to achieve a halt in less than 100 km, as indicated by the horizontal lines. What the goal "should" be is arguable, but the illustrative value of 100 km is consistent with the depth of Kuwait or, perhaps, the maneuver distance of enemy forces intending a sudden attack on the enclave of a hostile faction, which might be supported by the United States in its effort to overturn the regime.

Figure 4.3 can be used to suggest force options in the first place (i.e., to inform the choice of options considered in Figure 4.2) or to assess force options generated in other ways (e.g., the baseline force implied by the defense program). To see this, note that Figure 4.3 shows



NOTE: V=enemy speed; Z=effective enemy size (vehicles to kill for halt); R=deployment rate.

SOURCE: Davis, McEver, and Wilson, 2002.

Figure 4.3—Summary of Exploratory Analysis of Countermaneuver Capabilities

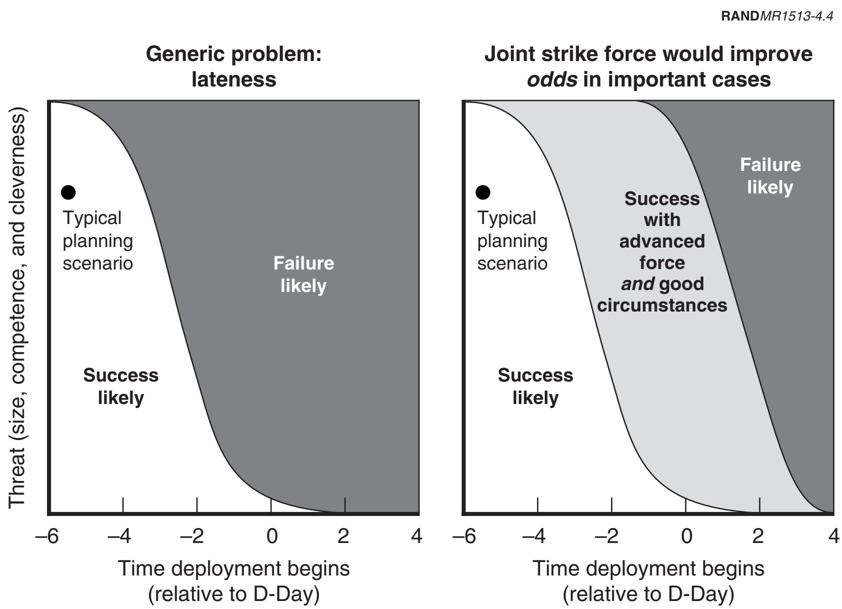
how the operational capabilities of the interdiction force depend on five high-level variables:

- The attacker's average speed.[4]
- A measure of the threat's effective size corresponding to the number of armored vehicles that must be killed to halt the attack.
- The delay T_{SEAD} at the outset of war (D-Day) during which the interdictors are unable to attack because of air defenses.
- The per-sortie or per-shot effectiveness of shooters once they are able to attack the invading army.
- The number of shooters available to be used in the theater as of D-Day.

These variables are not arbitrary. Rather, they can be shown by deeper analysis to be key aggregate variables that account indirectly for dozens of more-detailed variables. Thus, they are suitable for high-level summaries. In a sense, Figure 4.3 summarizes compactly what might be learned from running many thousands of individual cases—all of them in the context of Persian Gulf conflicts.[5]

We see from Figure 4.3 that the 100-km goal is achieved only when a *combination* of subordinate capabilities is achieved. Results for the light bars of the bottom row, for example, assume that air defenses are suppressed or evaded within a day; that the enemy's average speed can be kept small 35 km/day—perhaps because of early bombing of choke points; that the attacker can be stopped after only 1,000 armored vehicles are killed (e.g., 20 percent of those in a five-division attack with each division having about 1,000 armored vehicles but low cohesion, or 50 percent of those in a two-division attack by much more determined forces); that each shooter is able to kill four armored vehicles per day after a delay time T_{SEAD}; and that shooters equivalent to at least 100 F-16s (a mix of long-range bombers, naval and Air Force aircraft, and naval missiles) are available by D-Day. The converse conclusion from this analysis is that it is very difficult to achieve the goal in question. In particular, high-threat speeds or long initial delays for suppression of air defenses would rule out immediate defeat of maneuver. These results have many implications for force-capability options—i.e., for the value of forward presence, standing joint task force headquarters, standoff munitions, small smart bombs that increase per-sortie effectiveness, preemptive strikes on assembling forces or choke points, and so on.

Figure 4.4 illustrates the expected benefit of a new early-intervention force (sometimes called a joint strike force or joint response force).[6] The benefit is not characterized as resulting in a somewhat reduced halt distance or somewhat reduced casualties in a standard scenario, but rather as increasing substantially the range of operational circumstances (scenarios) in which the intervention would be successful in defeating an invasion. This is indicated visually by suggesting that much of the previously darkly shaded portion of the scenario space (the portion in which an intervention would likely fail—see, e.g., the left graphic in Figure 4.4) can be turned gray if the United States develops the early-intervention force. Why not white? Because



NOTE: Figures assume use of strategic warning.

Figure 4.4—Scenario-Space Depiction of How a Joint Strike Force Could Enhance U.S. Military Capabilities

other factors not explicit in the figure would matter a great deal. If the United States began operations on D-day (0 on the x-axis), for example, the outcome might be good or bad depending on the quality of the defended ally, geography, and many other factors.

Yes, But How Much Is Enough?

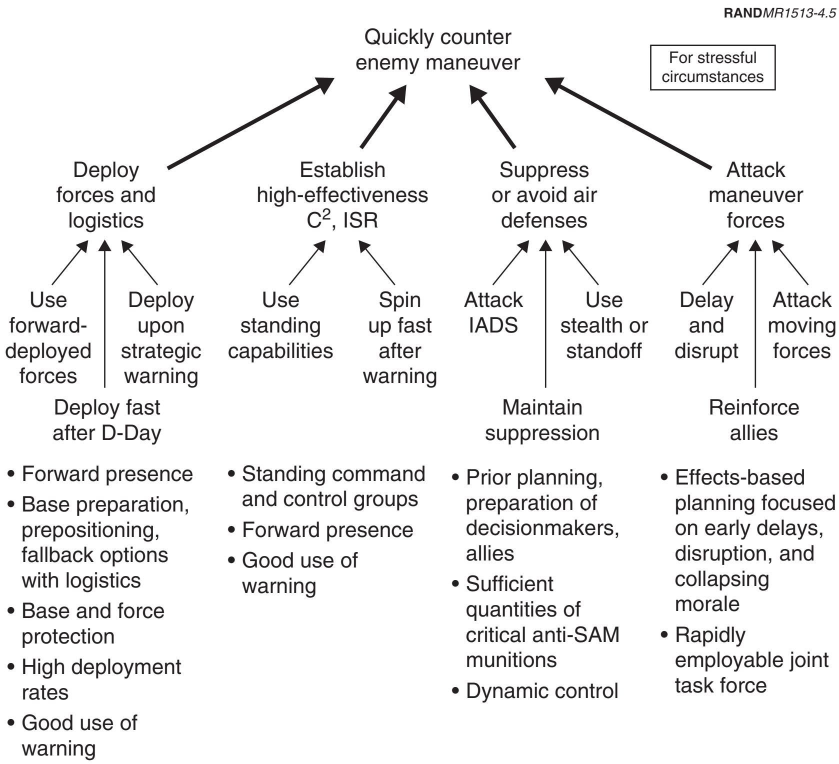
Understanding the potential benefits of a new capability is one thing; deciding how much of the capability is needed is another. That is, how much of the scenario space does one wish to cover given competing demands for available funds? Such questions should be discussed in a resource-allocation framework, such as in Hillestad and Davis (1998). They are largely outside the scope of the present monograph. However, a few observations can be made here.

The first observation is that how much of a given capability is enough depends on the value seen in being able to conduct related operations of different sizes. To use an example that has been addressed many times over the decades, having some capability for parachute operations is clearly very desirable, but the DoD has apparently concluded that it is sufficient to have the capability for a brigade-level drop rather than for, say, a division's worth. This is largely the result of the DoD having found it difficult to identify circumstances in which larger drops would be appropriate[7] and recognizing the high costs of maintaining a larger capability. Similarly, the DoD has long believed that having the capability for two amphibious operations by Marine Expeditionary Brigades (MEBs) was sufficient. Why? The answer relates to wanting capabilities for simultaneous demands to the east and west of the United States, to the way in which the Marine Corps is organized,[8] and to the substantial costs in lift and operations to move beyond the two-MEB level.

A second observation is that one cannot answer the how-much-is-enough question by looking at the alleged probabilities of various conflicts, nor at a combination of those and consequences. The problem is that the probabilities are often quite low precisely because the United States has the capability to deal with them. If it is important to keep the probabilities low, then it may be important to maintain the related capabilities. That is, deterrence requirements play a critical role.

Highlighting the System Aspects

The "system" aspect of mission-system analysis becomes more evident if one develops characterizations such as those shown in Figure 4.5, which indicate critical components of the overall capability—i.e., components such that the system will fail if the components fail. This is not a standard decomposition into subordinate missions and tasks (although there may be considerable overlap) because the breakdown in Figure 4.5 is organized by the purpose of the components—not by or-



NOTES: Thick arrows are individually critical components ("and conditions"). Thin arrows may represent alternatives ("or conditions").

Not shown: Peacetime preparations such as training, and prevention of fait accomplis.

ISR = intelligence, surveillance, and reconnaissance; IADS = integrated air defense systems; SAM = surface-to-air missile; C^2 = command-control.

Figure 4.5—Critical Components of the System for the Early-Halt Mission

ganizational considerations (i.e., Air Force, Navy, Army, and Marine Corps)—and by criticalness—not by a desire for logical completeness or by the desire to cover all of the physical systems involved in the operation. Figure 4.5 is more like a success tree—the inverse of a fault tree (to use the terminology often associated with nuclear engineering studies).

Enablers of Mission-System Analysis

Exploratory Analysis for Confronting Uncertainty

As mentioned above, exploratory analysis is a key element of mission-system analysis. Its purpose is to confront uncertainty head-on, rather than downplaying its magnitude. It is quite relevant to capabilities-based planning because—however bitter the pill may be to swallow for those who ask their analysts to make predictions and cut out the complications—uncertainty is fundamental and often large (e.g., will warning time be an hour or a week?).

Fortunately, technology is rapidly catching up with theory, and exploratory analysis is now possible with personal computers. Figure 4.6 illustrates a display from a countermaneuver study that examined halt distance as a function of about a dozen variables, including variables related to the enemy's anti-access efforts and to the interdictor's attempts to conduct effects-based operations (see Davis, 2001a). When used, the display is interactive and shows instantaneously the effects of changing assumptions about any of the dozen variables. Within a matter of hours, a good analyst can have a strong sense—explainable to others—about what combination of factors is necessary for success, what combination of factors would lead to failure, and so on. This is much more powerful information—when measuring capabilities—than merely how far the enemy advanced in a particular scenario with a huge database of assumptions that cannot easily be changed.[9]

Using a Family of Models and Games

Exploratory analysis such as that mentioned above requires relatively simple models with only a modest number of variables. Such models

RANDMR1513-4.6

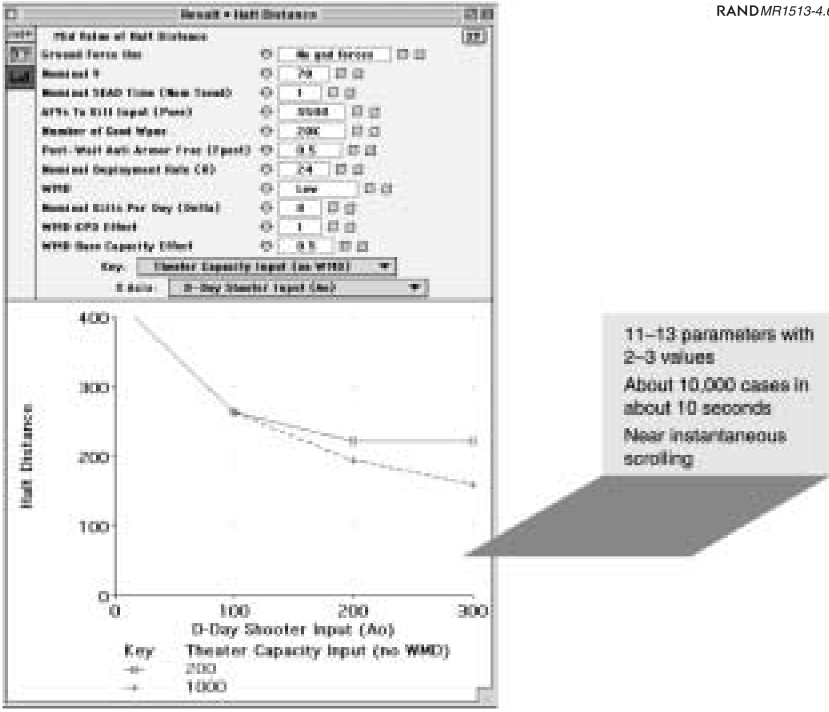


Figure 4.6—An Example of Exploratory Analysis

are referred to as having “low resolution” or as being abstracted or aggregated. The reason these are needed is that more-detailed models bring down the curse of dimensionality upon the analyst and prevent systematic exploration. This is not a computational issue but something much deeper.[10]

Simple models, however, are at best simple and at worst simplistic. Mission-system analysis should draw on a family of models, games, and empirical work to achieve a balance among breadth and depth to assure that the phenomena at issue are understood and to connect with the real world. Figure 4.7 indicates the strengths and weaknesses of the various members of such a family with simple analytical models indicated as being preferred for broad, agile, and flexible exploration. In contrast, human games are very good for representing human actions

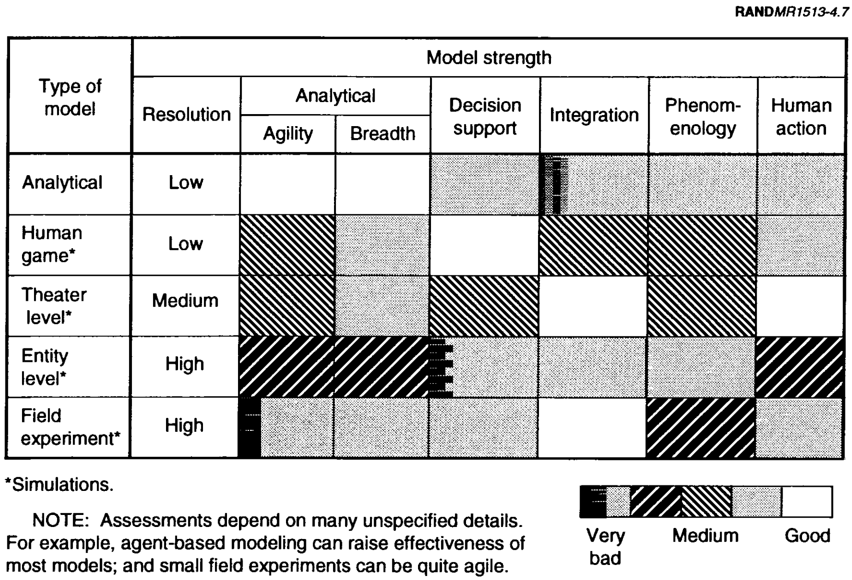


Figure 4.7—Strengths and Weaknesses of a Family of Models and Games

and at least fair for representing underlying phenomena (especially command and control).

How such a family is built and used is beyond the scope of this monograph, but in Davis, Bigelow, and McEver (2001) a set of short papers describes work that used a combination of detailed simulation, mid-level simulation, and very simple simulation.

The Need to Address Probabilities

Fortunately, the theory and methods for exploratory analysis have advanced dramatically in recent years. Exploratory analysis can help a great deal in finding ways to stack the odds as favorably as possible, although it cannot eliminate uncertainty. Indeed, the proper language to use in discussing mission capabilities necessarily involves probabilistic considerations. The objective in planning should not be seen as assuring success, but rather as assuring as high a likelihood of success as possible given the circumstances.

This is not as radical as it may at first appear. After all, ground-force commanders have long been taught that a 3:1 force ratio in the attack of a prepared defense is essentially a break-even point and that to have a high probability of success with relatively small losses, a commander wants overwhelming force, on the order of a 6:1 ratio. Such matters can be represented in some detail in simulation—including configuration of forces, their physical capabilities, and their qualitative attributes.

Summary

In summary, mission-system analysis is the appropriate level for most capabilities-based work. It is enabled by methods such as exploratory analysis using families of models and games.

Endnotes

[1]For an early discussion, see Warner and Kent (1984). Also see Pirnie (1996). As applied, strategies to tasks goes into much more detail than indicated in these publications.

[2]Alberts, Garstka, and Stein (1999).

[3]Deptula (2001) is a good introduction to EBO issues. Davis (2001a) gives a fairly extensive biography and addresses the analytic challenges posed.

[4]This is the average speed after taking into account effects of delaying actions such as attacking choke points and interdiction generally. Logically, it might be thought of as an output of a model, rather than as an input. However, the relationship between an army's average speed and the extent of interdiction cannot be credibly calculated. Thus, it is treated as an independent element to be varied parametrically.

[5]All of these, however, were relevant to interdiction in the deserts of Kuwait, Saudi Arabia, and Iraq—the focus of the study cited. The applicable variables would change somewhat if the theater of interest were Korea.

[6]See Defense Science Board (1998) or, for elaboration, Gritton et al. (2000). The new QDR contains a good deal on related matters (Rumsfeld, 2001b, Ch. 4).

[7]A factor in U.S. reasoning was the very high casualty rate of some parachute operations in World War II, such as Operation Market Garden.

[8]The Marine Corps plans around operations with MEUs, MEBs, or MEFs—corresponding loosely to battalion, brigade, and division-sized activities with substantial air forces and other support. MEUs are too small for many important contingencies, but MEBs have proven suitable to quite a wide range.

[9]To be truly convincing, of course, the analysis must be reproducible by other analysts. Further, it is desirable to have different individuals reviewing the same material because reducing multidimensional analysis to a small number of conclusions and graphs requires many judgments. The quality of results, then, can benefit from debate.

[10]A version of exploratory analysis can be accomplished with large models by holding many assumptions constant. However, it is not unusual for uncertainties in some of the constant variables (sometimes ones deeply buried in data) to be quite important.

Chapter 5
Dealing with Vertical and Horizontal Complexity of Capability

A key element of any analytical architecture for capabilities-based planning must be an approach for moving from assessment of a relatively narrow capability to assessment of how much is enough of that capability when viewed against competing demands for resources.

This, of course, is one of the fundamental problems of planning and management generally. There are no general solutions, nor is there any way to be rigorous. The causes of difficulty here are (1) system complexity, (2) the need for numerous subjective judgments, (3) the many legitimate considerations other than combat capability that affect defense expenditures, and (4) a constantly changing environment.

Let us suppose that the DoD has done a first-rate job in conceiving and evaluating alternative capability sets for some particular mission (e.g., an early halt, or an intervention on the ground to stop the killing in the next Kosovo). Given a constrained budget, the DoD must still decide how much that mission capability is worth in comparison with others. In other words, "How much of that mission capability is needed, relative to other needs?" To evaluate that question, the DoD might assess the mission within the framework of an overall theater-level or multitheater campaign. The assessment, however, would depend on the strategy assumed to be used for that campaign—and, indeed, on the many other variables identified in the scenario-space construct mentioned earlier. Thus, no "optimizing" would be possible in the usual sense. Instead, the DoD would want enough of the mission capability to "do the job" (perhaps with room to spare) in a range of circumstances as judged from exploratory analysis. Even if this analysis is accomplished, however, the next question might be, "What is the relative importance of the particular type of wars in which the mission's significance was assessed?" And, even if that is answered, it would remain unclear how important an increment of the mission-system capability was in comparison with proposals for other components of the defense program altogether—pay raises, stockpiling of spare parts, overseas presence, foreign-military assistance, and R&D on new weapons or even on the underlying science and technology that makes new weapon systems feasible.

The point here is that the concept of design space introduced earlier is hierarchical and multifaceted. Actually, many design spaces are needed, including ones to support high-level integration. Tradeoffs, after all, must be made at each of many levels, across components at a given level, and so on. It cannot be a neat process unless the issues are trivialized in the vain hope of using mathematical methods such as linear programming.

The best available approach to this dilemma is a combination of strategic thinking, exploratory analysis, heuristics, and portfolio management, as suggested by Figure 5.1. It is not possible in this mono-

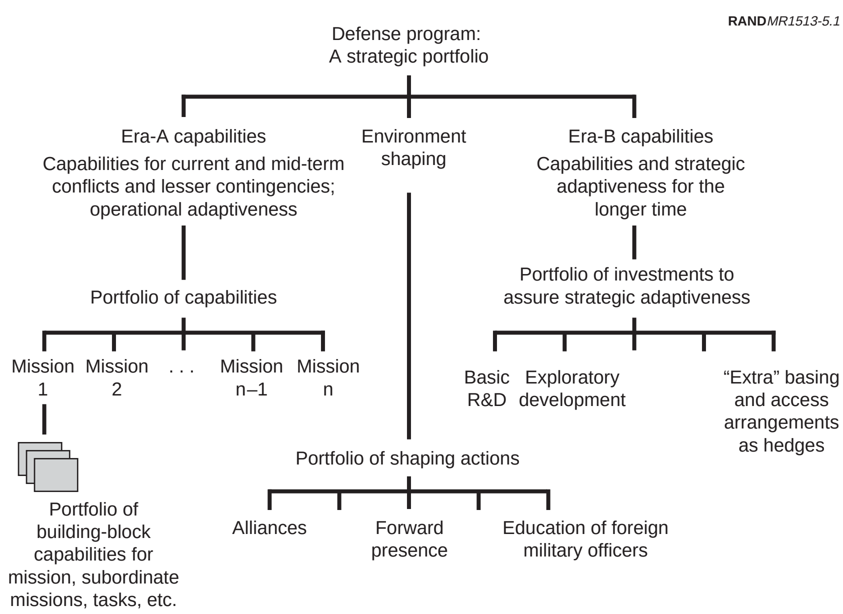


Figure 5.1—Integrating Horizontally and Vertically

graph to do justice to such cosmic matters. Instead, let it suffice to have highlighted the issue and to note briefly that some analytic methods have been developed to assist decisionmakers with the complex portfolio-management task while operating within a strategic framework. One such method is the DynaRank tool developed at RAND (Hillestad and Davis, 1998). It is a tool for marginal analysis within a portfolio framework. It cannot be applied "mechanically," but it has proven useful both for organizing discussion and for cost-benefit analysis.

Choosing Among Options in a Portfolio

At any level at which tradeoffs are being considered, making choices can be assisted by characterizing the relative benefit gained by funding candidate improvement measures "on the margin." There is no way to do this rigorously, because the assessments depend on many judgments. Nonetheless, making choices cannot be avoided, and structures of the sort indicated in Table 5.1 can be useful (see Hillestad and Davis, 1998).[1] The first column is a list of candidates for marginal funding. The next set of columns describes benefits of the given candidate in several categories. The next to last column is the candidate's cost, and the last column is the ratio of effectiveness over cost (or it is "not applicable" in cases where the ratio makes no sense). Initial results of using such a spreadsheet tool will typically have "good" and "bad" options intermingled, but software can then reorder the options in a preference ranking for funding. This goes beyond comparing ratios, because some candidates may accomplish nothing except saving money (ratio is zero), may have some negative effect but save a great deal of money (small negative ratio), and so on.[2]

For the example shown in Table 5.1, software would generate the following priorities for funding:

> Small bomb package, standing Joint Task Force (JTF) headquarters, support for independent brigades, an additional F-22 squadron, support for C^4ISR package 1, and support for C^4ISR package 2.

That is, the small smart-bomb package would have the biggest payoff on the margin. Note, however, that the order would depend

Table 5.1
A Notional Scorecard for Assessing Alternatives in a Portfolio Framework

Candidate Option for Funding	Capabilities in Conflict: Class-A Conflicts	Capabilities in Conflict: Class-B Conflicts	Force Manage-ment	Reassurance, Dissuasion, and Deterrence	Net Effec-tiveness	Marginal Cost ($B)	Ratio: Effectiveness over Cost
Weight	1/3	1/6	1/4	1/4	N.A.	N.A.	N.A.
Baseline	5.0	5.0	5.0	5.0	5.0	0.0	N.A.
Small bomb package 1	7.0	5.0	5.0	7.0	6.2	0.05	123
Standing JTF headquarters	7.0	7.0	5.0	8.0	6.8	0.25	27
Support for independent brigades	6.0	8.0	8.0	7.0	7.1	0.30	24
Extra F-22 squadron	7.0	5.0	5.0	7.0	6.2	0.60	10
C^4ISR package 1	7.0	5.0	5.0	8.0	6.4	1.00	6
C^4ISR package 2	8.0	8.0	5.0	7.0	7.0	2.00	4

NOTES: The options, values, and costs shown are purely notional. N.A. = not applicable. The meaning of the effectiveness scores is as follows: 0–2 very bad, 2–4 bad, 4–6 marginal, 6–8 good, and 8–10 very good. These are relative to the baseline force with scores of 5 in all categories. The baseline force is assumed to have no critical omissions. If it did, some of the table's scores might be quite different. Columns for Class-A and Class-B conflicts are intended to summarize much more extensive exploratory analyses. The table implicitly assumes a date for the assessments (e.g., five years from now). A variant table might contrast assessments for the near, mid, and long terms.

strongly on the baseline force. For example, if the baseline had no F-22s, then the first F-22 squadrons might have exceptionally high value—compensating for the high price.

Similarly, results depend on the weights assigned to the various categories and the way in which the value is assessed in each category. Again no objective and definitive way to make such choices exists. The issue has nothing to do with mathematics or computers and everything to do with complexity and uncertainty. How, then, can a structure such as this be useful? The answer is that it can be particularly useful if the prioritization turns out to be relatively robust to changes of assumption. This, in fact, happens in many instances of strategic choice. By forcing debate into this type of structure—and by doing the appropriate sensitivity analysis—it is sometimes possible to show that some improvement measures are so valuable on the margin that it would be "embarrassing" not to fund them—even for individuals championing other measures. These measures may have gone unfunded previously because they seem mundane or because they are cross-cutting items that do not compete well in any particular organizational stovepipe. Past examples include large buys of precision munitions or spare parts for airlifters.

An interesting mechanism for bringing about such "embarrassment" is to apply the methodology with a set of alternative "views." This is the logical equivalent to sensitivity analysis in ordinary operations analysis. The idea is to identify about three perspectives that cover the waterfront of relevant and respectable opinions, but that lead to substantially different weightings of categories, assessments of effects within particular cells of the table, and so on. One view might correspond roughly to how someone would proceed if his passion is for near-term readiness for "real" contingencies; the second and third might correspond to individuals more concerned about preparing for future high-end conflicts—primarily to assure continued deterrence, but also because such a conflict might occur. One variant would emphasize recapitalization and then modernization; the other variant would emphasize modernization and transformation at the expense of some recapitalization (i.e., it would sacrifice some numbers for qualitative advances).

It is naive to believe that the three views will generate drastically different priorities. Those who recognize that readiness, recapitalization, modernization, and transformation are all important, may also disagree about the importance of reassurance, dissuasion, deterrence, and decisive war fighting or overseas presence, projection forces, and sustained war-fighting capability, for example. Because all of the three views represent sensible, serious opinions, the net effect of using the portfolio structure can be to generate consensus on a number of issues ("yes, we should definitely fund X,Y, and Z even though they're not my favorites, and yes, even I can agree that we shouldn't fund the second batch of Q systems even though they are terrific and we should try to get the necessary increase in budget").

Analysis such as that shown in Figure 4.4 can help motivate choices about test cases for Class-A and Class-B conflicts. A poor man's version of the same logic can be seen in the search for "low hanging fruit" (high-leverage improvement measures) without the formality of comparisons such as those shown in the table. In my own experience, the poor man's version is often quite adequate if decisionmakers can be convinced qualitatively of the leverage. In such instances, too much formality can delay straightforward decisions and create opportunities for mischief.[3] This said, there are many other instances in which sober reflections of the sort facilitated by marginal analysis can be quite informative—and even nonintuitive. A key to such success, in my experience, has been clever packaging of the candidates. It may happen, for example, that collecting a number of low-expense low-consequence measures together can generate an efficiency package with significant overall effect at low cost. Individually, the measures might have been below the horizon of interest (and would therefore not have been funded), but when packaged together, they make eminently good sense. As another example, it may happen that one of the candidates unquestionably represents a superb new system and a cost that is reasonable for what it is. Going into discussion, it may seem evident that it is desirable. On the margin, however, it may prove to rank poorly because its value shows up in only one category and, even then, under very unusual circumstances. In retrospect, then, the perceived value was biased by having overfocused initially. The flip side of this same issue can occur when—after discovering that an attractive system fares poorly in cost-effectiveness—analysts agonize about the methodology and conclude that even though the special circumstances at issue are "unlikely," they are so important that the capability of competitors should be judged lower than previously recognized. The result, then, can be to reinstate the candidate, but with a better-understood rationale.[4]

To be less abstract, consider now some of the more controversial current candidates for more or less funding. The style of thinking discussed might lead to the following hypothetical examples (that should in reality depend on detailed analysis not yet done):

- F-22: Some number of F-22s are highly valuable, even critical; larger buys rank low in relative effectiveness for the marginal dollar because the F-22's strengths are most important early in the campaign, not after forces have built up.

- Joint Strike Fighter (JSF): Larger buys have the benefit of reducing unit cost, which has the benefit of making the JSF's purchase by allies attractive, which has the effect of reducing cost further and improving effectiveness of alliance operations.[5]
- C^4ISR: Some C^4ISR packages might be inexpensive and very useful in small-scale contingencies (e.g., Predator), but not robust enough to survive in large wars. Procuring some number of them might be quite attractive, even though they would lose out in any head-to-head competition with better systems (e.g., Global Hawk, DarkStar, or Discoverer satellites) when evaluated in high-end future conflicts.
- A standing joint command and control headquarters might rank extremely high because of its low cost and its high value early in a variety of important conflicts. Its value would be high because—when assessments of the baseline are made realistically—early joint command and control capabilities are poor except in instances in which there has been a lengthy period of strategic warning and preparations taken.

In summary, portfolio-style scorecards can be quite helpful in structuring analysis. Sometimes, the underlying issues are so clear that even strong-willed "barons" can reach consensus after seeing the results. In other instances, the success of such methods depends on the integrity of the process, the existence of an objective and powerful organization that "owns the analytic typewriter" (and cost shop), and the willingness of the decisionmakers to make decisions without rigorous proof or consensus. The single most important point here is that in approaching capabilities-based planning as a new paradigm (or an old paradigm being rediscovered), the Department of Defense should look first and foremost for high-leverage, moderate-cost initiatives. Then it should require that the Planning, Programming, and Budgeting System be reformed so as to highlight the kinds of comparisons discussed above. Recent transformation funding announced by Depuy Secretary Wolfowitz has precisely this character.[6]

Endnotes

[1]The methods are not pie-in-the-sky theorizing. The methods described in Hillestad and Davis (1998) have been applied successfully in a number of problem areas ranging from transportation policy in the Netherlands to Air Force acquisition priorities. Moreover, there is an extensive literature on related support methods in the business world. A less rigorous version of the same kind of reasoning proved successful in internal Navy decisionmaking instigated by the vice chief of Naval Operations (Johnson, forthcoming). In the mid-1990s, a comparable methodology was used by Richard Kugler to assist the Joint Staff's J-5 (then Lt. General Wesley Clark) in assessing priorities for a wide variety of environment-shaping measures ranging from forward presence to the funding of international military students attending U.S. war colleges.

[2]The methodology depends on linear mathematics. In practice, the problem is seldom linear at the outset. However, the options can often be repackaged and the scores normalized and scaled so that the problem becomes linear.

[3]To draw upon a personal experience, when the Rapid Deployment Joint Task Force (RDJTF) was initiated in 1979–1981, successive secretaries of defense made decisions to fund the efforts because the capabilities at issue would make a huge difference in a region (the Persian Gulf) in which the United States then had virtually no capability and to which it would take months to deploy more than token forces. This was seen as low-hanging fruit because value was high and costs were relatively modest. The actions taken included buying new mobility forces valuable in many circumstances, creating a new headquarters, and paying the cost of miscellaneous measures such as upgrading airfields at Diego Garcia. No detailed formal comparison was ever made. Had one been attempted, the "mischief" I have in mind would have related to claims that reorienting two to three divisions away from Europe would cause NATO to lose the war in the central region (a result that could in fact be generated from model runs). When hearing such claims, the Office of the Secretary of Defense took the view that NATO had roughly 40 equivalent divisions, the Persian Gulf had almost nothing, and that shifting some forces on the margin would be unlikely to make the difference claimed in Europe—where the larger military issues related to qualitative effectiveness, warning time, and cohesion of our allies. The RDJTF evolved into the U.S. Central Command. The capabilities used in the Gulf War were directly traceable to decisions made a decade earlier, as noted in 1991 by Secretary Cheney.

[4]I am indebted to colleague Richard Hillestad for examples, from his own projects, in which these phenomena were observable.

[5]A reviewer observed that the likely economic benefits of allied purchases have been a point of some controversy.

[6]Testimony of Paul D. Wolfowitz to Senate Defense Appropriations Committee, February 27, 2002. Discussed in William New, "Defense Official Lays Out 'Transformation' Budget Details, *National Journal's Technology Daily*, February 27, 2002.

Chapter 6

The Central and Multifaceted Role of Building Blocks

General Comments

Modularity concepts are at the heart of building capabilities amid uncertainty.[1] After all, capabilities-based planning applies when we do not know precisely what challenges will arise. Thus, we develop relatively generic capabilities that can be combined suitably to meet the needs. This is familiar from everyday life. Consider again the home builder mentioned earlier. He knows that he can order bricks, studs, pipes, and many other supplies that come in standard forms. If he specializes in housing developments, he may think in terms of higher-level modules (i.e., building blocks), such as standard ways of laying out streets, sewage, lighting, and so on; and he may even have standard house designs from which he can start, adding such customization as paint trims, facades, and trees. And he knows standard ways in which to proceed. For example, he cannot leave roads and sewage until the end; nor can he put the final touches on paint jobs too early. There are routines to follow.

These preparations are "relatively generic," but not entirely so. For example, a home builder in one region of the country may focus on building brick houses, while one in another region will focus on building frame dwellings. There will also be regional specializations related to architectural style.

Another example might be even more apt. Consider the general manager of a football team as he talks with the coach and scouts about what kind of talent to recruit. He must think in terms of building-block capabilities such as offense and defense; offense breaks down into ground plays and passing plays; ground plays depend on success of the offensive blockers as well as appropriate backs; and so on. Within each of these categories, there are alternative concepts of operation, each requiring for its success an orchestration of lower-level actions such as blocking the other side's rushers. There are play books and there are alternative campaigns consisting of a sequence of plays intended to achieve a touchdown.

A critical observation is that building blocks exist in a number of different forms, not all of which receive equal and adequate attention in planning. These are

- units
- operations to accomplish missions
- concepts of operations
- resources to employ.

Overall, the syntax is "Who does what, in pursuit of what goals, according to what concept, using what assets?"

Types of Building Blocks

If we now apply this notion to the military problem, we see building blocks as follows:

- Units (e.g., battalions and brigades).
- Operations to accomplish missions (e.g., halt an invading army; or, as a component of that, suppress air defenses).
- Operational concepts with which to accomplish operations (e.g., suppress air defenses by first disabling the integrated air defenses and then proceeding to attack the most threatening long-range surface-to-air missile batteries, and later the more numerous but less capable ones).
- Resources in the form of platforms (e.g., aircraft), physical systems (e.g., radars), and enabling infrastructure (e.g., the global information grid).

A nation's military building blocks are neither inevitable nor permanent. Until World War II, the Navy's capital formations were built around battleships; the Army depended significantly on horse and infantry; the Air Force was merely a supporting arm of the Army; the Marines had not yet conducted amphibious operations; and long-distance communications depended on telegraph. U.S. forces are said to be undergoing a large-scale transformation; the key issue is whether the transformation will be appropriate and well executed. The answer will depend in large part on whether the building blocks that emerge are appropriate for future conflicts and other operations. This implies that much more attention should be paid in force planning to the nature and composition of those building blocks. Are divisions, wings, and carrier battle groups the "right" modules for next-generation U.S. forces? Even if they are, how big should they be and of what should they be composed? If, as seems more likely, the basic modules need to change, what mix would be appropriate? It may be, for example, that the future Army should be more centered on smaller units and that the future Navy should have even more major "groups" than it has today, but with some of these focused on air and missile defense, rather than carrier operations. Debate about such matters has been much more muted and uncommon than the red-herring debate about whether the United States needs to have capability for simultaneous major regional conflicts. Analysis to support such a debate will necessarily require higher-resolution models, simulations, games, and field exercises than are usually used for DoD-level force planning.

Capability for Rapid Assembly

Building blocks are necessary but are not sufficient alone. Without the ability to assemble the building blocks suitably, capabilities are very limited. In a competitive environment, rapid and flexible assembly capability is particularly important. This may seem straightforward, but it is not. All of the services understand task organization and use it over time during wars, but the Marine Corps is perhaps unique in having placed building-block planning at the core of its organization and doctrine. This is why Marines typically bristle when asked to define a Marine Expeditionary Brigade: The definition depends strongly on the mission.

Assembling the building blocks suitably for operations, then, is old hat, but having the organization, doctrine, command and control, and training for rapid and flexible assembly is not. And, as the history of military conflicts reveals clearly, commanders are not always able to organize as they wish. At the strategic level, for example, the nature of U.S. forces for Kosovo were argued about fiercely until the very end in a process that was anything like that intended by the Goldwater-Nichols legislation. The problem there was not merely command and control, but also a lack of consensus on a wide range of issues, such as the usability of attack helicopters, ways in which to prepare for a ground offensive through difficult terrain with poor roads, and the ability to launch the Army Tactical Missile System (ATACMS) missiles from Navy platforms (Clark, 2001). Rapid assembly was not necessary, but if it had been, the United States and NATO would probably have flunked the test.

Characterizing assembly capability is a challenge for analysis as well. Most models used in DoD-level force planning gloss over command-control issues and the kinds of supportability problems that arise when task-organizing units. The expertise for that type of analysis resides largely in the military services and operational commanders. However, assembly capability is an issue deserving of attention from the Secretary of Defense. This has been recognized to some extent by the QDR's emphasis on a standing Joint Task Force headquarters.

Special Tailoring

Reliance on building blocks can only be taken so far. It almost invariably happens that what is needed is not quite what can be provided off the shelf. Therefore, building-block operations also require special tailoring. This might involve creating a unit that never before existed, creating a communications network to meet the particular needs of the commander, or, for example, inventing a new type of logistics such as the "Desert Express" created during the Gulf War to provide critical parts more or less overnight (by analogy with the service Federal Express provides).

Readiness for Rapid Assembly and Adaptation

A hallmark of organizations adept at assembling and employing the right combination of building blocks, and doing the additional tailoring needed to create the right force, is readiness for doing so—something that comes from a combination of doctrine and practice. This is a familiar matter when talking about a given military service, because all of the services have well-established routines, which they practice and for which they have well-developed measures of readiness. If the Air Force must mount an emergency air lift to a particular trouble spot, it knows how to do so very quickly. If the naval forces must launch a small rescue mission deep in the interior of a nation or continent, they can do so with planning times measured in hours. If the Army needs to deploy elements of the 82nd Airborne, it can do so within hours. The services practice their skills in stressful circumstances, with many variations, and sometimes with no notice.

In contrast, for higher-level joint operations, rapid-assembly capabilities are currently lacking. The invasion of Panama—regardless of its merits under international law—was a model of next-generation U.S. military maneuver: highly parallel, joint operations designed for maximum and decisive effects. That invasion, however, was planned for many months, as was the coalition counteroffensive against Saddam Hussein's forces. Recognition that the United States lacks skills for faster action has led a number of studies by RAND, the Defense Science Board, the U.S. Joint Forces Command, and the recent McCarthy panel to conclude the following:

> The United States needs to put a priority on developing and honing rapidly adaptive joint command and control.

The rapid-assembly issue has important implications for the choice of people and their training. It is notable, in this respect, that American industry has come increasingly to favor generalists and cross-cutters, rather than narrow specialists (although some specialists remain essential).

Support Structure, Building Blocks, and Flexibility

A special problem with assembly and adaptation arises when an organization fails to provide sufficient support structure to fully exploit its potential building blocks. This routinely occurs as the result of attempts to achieve economy of scale by moving support units to higher echelons of the organizational structure. That is perfectly sensible if the entire organization operates as expected, but if various challenges arise simultaneously that might be readily dealt with by a lower-level building-block unit, then that unit should take on a substantial share of the entire support structure of the higher-level organization. Thus, the remaining "building blocks" cannot really be used.

This phenomenon partly explains why deploying a brigade can virtually incapacitate a division. Although a brigade might appear to be a natural building block in today's world, it lacks the independent structure to be used in that way without serious repercussions. Similar problems occur in the other services and in many organizations generally. If we want real flexibility, then we must pay the bill for the additional support structure that would give building blocks autonomy.

The Problem of Hierarchies and Networks

At this point it is important to discuss again an issue that consistently proves confusing. That is the issue of hierarchy. The hierarchical concept is fundamental to building-block planning and, indeed, to the effectiveness of complex adaptive systems generally. The building blocks, tailoring, and assembly discussed above must occur at different levels of organizations—often many levels. The joint-force commander may think of building blocks such as brigades and squadrons, but the brigade commander thinks of how to organize his brigade with standard battalions, plus special units, less others that are not really needed. And a battalion commander must think about how best to organize his unit.

To make things even more complicated, the world of military operations is no longer organized merely through hierarchies. Increasingly, network structures are a dominant factor. Today, we think about joint long-range fires, not merely about bombing. Even in what may seem like a quintessential single-service mission, such as suppression of air defenses, we think about joint operations that may call upon a combination of attack helicopters; naval missiles; Air Force, Navy, and Marine fighter aircraft; Army missiles, and long-range bombers. Moreover, while the scheduling of platforms may be done many hours in advance, their employment may need to be adjusted as targets appear and disappear. Ideally, command and control will allow near-real-time dynamic control so that the best platform can be used to attack a target that has just shown itself.

The reason that the hierarchies and networks are "problems" from a defense-planning perspective is that when tradeoffs are made in allocating resources, they must be made not only at a given level and within a given concept of operations, but also across levels and configurations. Anyone who imagines that analysts can readily compute the relative worth of an additional fighter aircraft, missile launcher, or company of tanks probably has a simplistic and rigid notion of military operations and a correspondingly simple-minded way of comparing worth (e.g., by their relative lethality in a duck-shooting contest). It is better to adopt the spirit of portfolio analysis and recognize the role of multidimensional tradeoffs and subjective judgments. This view may be heretical to operations researchers, but it is true nonetheless.

A key component of capabilities-based planning, then, is a modular, building-block approach to deal with the complications of both hierarchy and networking. Identifying the "right" modules or the next era of conflict is no easy matter. So also, it is sometimes difficult for organizations to transition from old to new units. Necessity (such as for the Afghanistan war) can be quite helpful.

Endnote

[1]For an excellent modern reference to modularity in design work, see Baldwin and Clark (1999).

Chapter 7
Implications for Force Transformation

Broad Observations

One of the most important issues facing the DoD is the need to "transform the force" for the needs of the future. Transformation has been and continues to be controversial—in part because it sometimes seems to be just another fad—but in fact it is a strategic imperative for the United States.[1] Transformation can be seen as having a near- to mid-term component and a long-term component. The former can be seen as reengineering, in the same sense as that term is used in the business world. How do we determine whether an organization is transforming or merely recapitalizing? If the changes are transformational, they will be evident in the building blocks and in the capability to assemble them and tailor them appropriately. As an analogy, consider a company that recapitalizes all of its equipment for making its traditional products, while another company reconceives its business as being able to manufacture a variety of products depending on market forces and technological developments. The second company implements "flexible manufacturing" in which changes in software permit drastic changes in what the company manufactures—virtually overnight. The second company has new building blocks (both software and machinery able to be redirected by changes of software) and a new infrastructure. A measure of effectiveness here is whether the second company correctly identified what its new building blocks should be. This requires judgments, but judgments are not too difficult to make. For example, it requires no genius to recognize that non-stealthy short-range fighter aircraft are likely to be ill-suited for the demands of dangerous theaters.

Applying this analogy to defense, we should judge the appropriateness of transformation activities—by the services, U.S. Joint Forces Command, and others—in large part by asking questions such as the following:

- Are the programs well tuned to the reality of inexorable changes in the nature of military operations? Have they recognized the "new dangers," as well as the continuing presence of old dangers?
- Can the programs be used to hedge in recognition of uncertainties about emerging threats, and in recognition of economic considerations? That is, is there a positive emphasis on flexibility and adaptiveness? Is this true strategically as well as tactically? In particular, do the programs implicitly assume a particular type of future conflict?[2]
- Are potential capabilities judged by their usefulness in an appropriate diversity of missions or contexts?
- Are the programs manifesting the "seriousness" that comes when we undertake a reengineering in recognition of major changes? In particular, are the programs identifying new building blocks: new capital formations, new operational concepts, new doctrinal processes, and so on? Or do they seem overintent on using existing building blocks, supplemented only by changes on the margin, to accomplish the new challenges?
- Do the organizations have sharp concepts for mid-term change, concepts that include a hierarchy of operational challenges to be addressed in both depth and breadth over a period of years until the challenges have been met?
- Do the organizations have a sufficiently diverse and innovative approach to the longer term? Is a diversity of inquiry and a diversity of innovations encouraged? At the same time, are the ideas that appear to have special merit being supported with prototyping—not just in the laboratory, but even in the operational force? That is, are transition mechanisms being pursued?

It is of interest to note, as have many before me, that successful transformations have often occurred not by radical restructuring, but rather with special activities that were grown and nurtured until—when the time came (e.g., Pearl Harbor)—they could bloom and become the core of very rapid transformation. It is also of interest to note that great damage has been done to organizations by overly aggressive transformations that proved to be not quite right, or that destroyed the human capital of the organization. Fortunately, the recent QDR (Rumsfeld, 2001b) appears to have steered a sound course on this matter.

Transformation Goals as Described by the QDR

The 2001 QDR specified what it termed "operational goals" for transformation. The six goals were (Rumsfeld, 2001b, pp. 42ff):

1. Protect bases of operation at home and abroad and defeat the threat of chemical, biological, radiological, nuclear, and enhanced-high-explosive weapons.
2. Assure information systems in the face of attack and conduct effective information operations.
3. Protect and sustain U.S. forces in distant anti-access and area-denial environments.
4. Deny enemies sanctuary by providing persistent surveillance, tracking, and rapid engagement.
5. Enhance the capability and survivability of space systems.
6. Leverage information technology and innovative concepts to develop interoperable joint C^4ISR.

One way to think about this list is that the DoD leadership, after reviewing all of the current capabilities and activities, wished to highlight these areas as demanding special attention and investment. The list is not directly analogous to the various lists described in this monograph, but rather it is the leadership's way of summarizing priorities. The strength of the list is that it clearly identifies where the priorities should be. All indications are that the DoD intends to enforce these priorities.

What the QDR did not attempt was to translate the goals into management-level action items, or to provide analytic justification or context. That was left for follow-on work. An important question, then, is, "How does the methodology of this monograph relate to the QDR's transformation goals?" The answer, it seems to me, is that there is a strong and natural relationship. Table 7.1 illustrates this relationship, using only a single operational challenge in the sense in which I have used that term: the challenge of quickly countering maneuver forces.

For this operational challenge, Table 7.1 arrays the QDR's goals (column one) against the critical components (columns two through

Table 7.1
Relating the QDR's Goals for Transformation to Operational Challenges

	Critical Component				
QDR Goal	Deploy Forces and Logistics	Establish C^2 and C^4ISR	Suppress or Evade Air Defense	Attack Maneuver Forces	Illustrative Implications
Protect bases and defeat CBRNE		●	●		Counterforce attacks, passive defense, use of distant bases and naval systems
Assure information systems and conduct information operations		●	●	●	Immediate survivable ISR; fast spinup for C^2 competence; offensive IW attacks on IADS
Project forces in presence of anti-access and area-denial environments	●	●	●	●	Defend allies from missile attack and related coercion; sustain operations from long-range or secure naval platforms
Deny the enemy sanctuary		●	●	●	Preempt attacker as he stages for invasion; Conduct strategic bombing vs. C^2 and IADS
Enhance space capability		●	●	●	Maintain GPS precision and communications; enhance survivable ISR from space
Leverage information systems for interoperable joint C^4ISR	●	●	●	●	Networking, standards, standing joint command and control groups

NOTES: Bullets indicate where a QDR goal is particularly important to one of the critical components. IADS=integrated air defense system; GPS=global positioning system; ISR=intelligence, surveillance, and reconnaissance; C^2=command-control; C^4ISR=C^2, communications, computers, and ISR; CBRNE=chemical, biological, radiological, nuclear, and enhanced high-explosive weapons; IW=information warfare.

five). Accomplishing the critical components of the mission (i.e., the operational challenge) would be much facilitated by substantial improvements in the areas highlighted by the QDR's goals. Thus, this mission-system decomposition gives context to the QDR's goals, making evident the fact that they were not chosen arbitrarily. Further, as suggested in much of this monograph, the systematic decompositions, exploratory analysis, and mission-system approach lead naturally to metrics and to ways in which potential goals for those metrics can be contemplated and decided. The analysis discussed in previous chapters illustrates how this can be accomplished.

Endnotes

[1]My own views on transformation are described in Davis et al. (1998), in Davis (2001a), and in as-yet unpublished work by me, Paul Bracken, Brett Steele, and Richard Hundley.

[2]One reason for concern here is historically motivated: Nations have often prepared for the wrong next war. After World War I, for example, France worked hard to perfect an army dependent on prepared defenses and deliberate, firepower-intensive offense—not at all like Blitzkrieg. The Germans developed Blitzkrieg, but failed to prepare for a long war of attrition and mass.

Chapter 8
Conclusions and Recommendations

The Department of Defense has begun the process of transitioning to capabilities-based planning. This monograph suggests principles that might be used in that transition. These principles should lead to markedly different terms of reference for major studies, measures of effectiveness for evaluating programs, and criteria for balancing objectives. The department will need a new analytical architecture, arguably one along the lines of the one presented here. The suggested architecture places more emphasis on mission-level work and will emphasize such concepts as mission-system analysis, exploratory analysis, and hierarchical portfolio methods for integration and tradeoffs in an economic framework. These, in turn, will require different models and styles of analysis than have been customary. Many of the conceptual and technical foundations have been laid, but the transition of analytic style will be difficult because of organizational inertia. Fortunately, the principal concepts of the new approach are intuitively appealing to American military officers, who grow up believing in the very concepts that capabilities-based planning emphasizes.

Appendix

Some Historical Examples of Capabilities-Based Planning

Capabilities-based planning is not at all new, to either the Department of Defense or elsewhere. Many historical instances of related reasoning can be found, albeit sometimes by different names. I offer the following as a short set of examples.

Nuclear Planning in the 1960s

One of the most influential analyses ever conducted for the DoD was *Strat-X*, a study concluded in 1967. It was conducted under the auspices of the Institute for Defense Analyses, but involved heavy participation by many of the best and brightest from industry and other federally funded research and development centers. Although the analysis reflected nuclear-war scenarios and included numerous rough designs of specific strategic-nuclear systems, the authors made a point of transcending the myriad details in which they could have become embroiled. One of the enduring conclusions, for example, was that the assured-retaliation aspects of U.S. nuclear forces should be designed with an emphasis on "arriving reentry vehicles (RVs)." This high-level metric incorporated effects of platform reliability, platform survivability, bus reliability, RV reliability, RV penetration through defenses, and RV survivability to so-called fratricide effects.

Interestingly, this metric—which proved useful in a wide range of scenarios—did not highlight accuracy or yield because analysis had demonstrated that the vast majority of the targets to be attacked were vulnerable to almost any RV that the United States was considering. This and concerns about air defenses and future intercontinental ballistic missile survivability influenced the decision to move to multiple-independently-targeted-reentry vehicles and submarine-launched ballistic missiles (SLBMs) with small weapons (rather than SLBMs with only a few, large weapons).[1]

The POMCUS Decision

In the 1970s, DoD's analysis of the NATO-Pact balance demonstrated that NATO's most serious problem in many respects was the lack of operational reserves (forces that would reinforce frontline units as needed). It concluded that capabilities for conventional defense would be *qualitatively* improved if this shortfall could be remedied. Because of assessments of plausible Soviet and NATO mobilization times (and also a sense of the possible), a metric was established that focused on NATO's force levels ten days after mobilization was ordered. A goal was established of having ten U.S. divisions ready to fight in ten days, which then was used by the Secretary of Defense to monitor development and implementation—despite resistance—of remedial measures. These turned out to be the POMCUS divisions (U.S.-based divisions with duplicate equipment prepositioned in Europe so that the personnel could deploy by air, fall in on the equipment, and move expeditiously to fighting positions).[2]

Capabilities for the Persian Gulf

In the late 1970s, the National Security Council under Zbegniew Brzezinski concluded that a hole in U.S. strategic planning involved possible conflicts in the Persian Gulf. A study was commissioned, which led to the 1979 "Wolfowitz report," entitled *Capabilities for Limited Contingencies in the Persian Gulf* [OSD (PA&E), unpublished (b)]. That report, of which I was lead author, led directly to a series of program initiatives over the next several years (spanning administrations). These included developing the maritime prepositioning ships, which were sized for three new kinds of Marine Expeditionary Brigades (MEBs)—units that required new operational concepts and new equipment that would permit some degree of mechanized conflict. From the outset, it was emphasized that the MEBs could be used anywhere in the world. The metric used (although not referred to as such) was forces deployable to the Persian Gulf versus time, with an emphasis on capabilities deployable in the first days (light units), first ten days or so (MEBs), and first month to six weeks (sea lift). Over time, additional programs were initiated to enhance this capability. They included (1) fast sea lift, (2) spare parts to improve the utilization rates of airlift, (3) regional diplomatic initiatives to gain access in crisis, and (4) Army afloat prepositioning.

The study and subsequent analysis also led directly to creation of the Rapid Deployment Joint Task Force, which evolved into U.S. Central Command. Especially notable in the present context is the fact that the study and program initiatives were conducted with an explicit disdain for particular scenarios except as concrete examples of what the United States might face. Regrettably, this fact was not particularly visible to the outside world (or to much of DoD), because briefings and public materials illustrated points with specific scenarios that seemed useful and credible. In 1979, the scenario used was a future Iraqi invasion of Kuwait; after the invasion of Afghanistan, the scenario shifted to defense of Iran, which was then overemphasized in much subsequent work until Secretary Cheney directed revived attention to the Iraqi threat. During this decade of development, however, the capabilities came along to be used as needed.

Strategic Mobility

The Office of the Secretary of Defense's analysis of strategic mobility issues has been particularly important over the years because funding of related systems has never been a natural organizational priority. No example of planning has ever been more obviously "capabilities based" than mobility planning, in that everyone has always understood that our strategic-mobility systems would be used in a vast range of circumstances. Scenario-based studies were clearly seen (by the mobility professionals) as useful in defining worst-case challenges helpful in answering the how-much-is-enough question. The scenarios were not something to be narrowly optimized against. It was concluded that the metric of millions of tons of miles per day was broadly useful; a sequence of studies generated reasonable goals that were then used to monitor and enforce program initiatives.[3]

Naval Presence

For decades, the Office of the Secretary of Defense has treated "carrier coverage" of an area as a key metric. Thus, one region might have a deployed carrier 100 percent of the time; another might have only 70 percent coverage. Decisions on such matters have had a strategic basis and major implications for naval force posture. This metric, however, was independent of precisely what the carrier battle groups were expected to do: It has long been recognized that, once again, the range of possibilities is enormous. This said, counting *carrier* battle groups, rather than surface action groups, was a strategic decision that recognized that surface action groups have not, historically, had the capabilities that might be needed. How to characterize naval presence in the future is a subject of current research, since many surface ships (and submarines) have substantial striking power with missiles. They also can host theaterwide air and missile defenses.

Endnotes

[1]Contemporaneous analysis by William Schultis of the Institute for Defense Analyses also demonstrated that a Soviet planner working on the same problem would arrive at different conclusions because many key U.S. targets were in areas that could be efficiently attacked with very large weapons. This fact, technological considerations, the Soviet cultural propensity for "big" things, and Soviet interest in counterforce capabilities all contributed to the large asymmetry of postures dramatized by side-by-side plastic models of the SS-9 and Minuteman missiles.

[2]For discussion embedded in a much broader treatment of cold-war planning for Europe, see Kugler (1993).

[3]Some of the mobility studies remain classified, but one of the early and influential reports is available in OSD (PA&E), 1980.

Bibliography

Alberts, David, John Garstka, and Frederick Stein (1999), *Network Centric Warfare: Developing and Leveraging Information Technology*, 2nd edition, CCRP Publication Series, Department of Defense, Washington, DC.

Aspin, Les (1993), *Report of the Bottom Up Review*, Department of Defense, Washington, DC.

Baldwin, Carliss Y., and Kim B. Clark (1999), *Design Rules: The Power of Modularity*, M.I.T. Press, Cambridge, MA.

Bennett, Bruce W., Samuel Gardiner, and Daniel Fox (1994), "Not Merely Planning for the Last War," Chapter 15 of Davis (1994).

Binnendijk, Hans (ed.) (forthcoming), *Military Transformation*, National Defense University, Ft. McNair, Washington, DC.

Binnendijk, Hans, and Richard Kugler (2001), *Adapting Forces to a New Era: Ten Transforming Concepts*, Center for Technology and National Security Policy, National Defense University, Ft. McNair, Washington, DC.

Bush, George W. (1999), "The Citadel speech," at the Citadel, South Carolina, September 23.

Carlucci, Frank, Robert Hunter, and Zalmay Khalilzad (co-chairs) (2001), *Taking Charge: A Bipartisan Report to the President-Elect on Foreign Policy and National Security*, RAND, Santa Monica, CA.

Cheney, Richard (1993), *The Regional Defense Strategy*, Department of Defense, Washington, DC.

Clark, Wesley (2001), *Waging Modern War, Public Affairs*, Perseus Press, Cambridge, MA.

Cohen, William (1997), *Report of the Quadrennial Defense Review*, Department of Defense, Washington, DC.

Davis, Paul K. (forthcoming), "Assessing and Integrating Transformation Programs," Chapter 7 of Binnendijk (forthcoming).

Davis, Paul K. (2001a), *Effects-Based Operations: A Grand Challenge for the Analytical Community*, RAND, Santa Monica, CA.

Davis, Paul K. (2001b), "Transforming Military Forces," in Carlucci et al. (2001). Available online at http://www.rand.org/personal/pdavis.

Davis, Paul K. (ed.) (1994), *New Challenges for Defense Planning: Rethinking How Much Is Enough*, RAND, Santa Monica, CA.

Davis, Paul K., James H. Bigelow, and Jimmie McEver (2001), *Exploratory Analysis and a Case History of Multiresolution, Multiperspective Modality*, RP-925, RAND, Santa Monica, CA, papers reprinted from Jeffrey A. Joines, Russell R. Barton, K. Kang, and Paul A. Fishwick (eds.), *Proceedings of the 2000 Winter Simulation Conference*, 2000, and *Proceedings of the SPIE*, Vol. 4026, 2000.

Davis, Paul K., David C. Gompert, Richard J. Hillestad, and Stuart Johnson (1998), *Transforming the Force: Suggestions for DoD Strategy*, RAND, IP-179, Santa Monica, CA.

Davis, Paul K., David Gompert, and Richard Kugler (1996), *Adaptiveness in National Defense: The Basis of a New Framework*, RAND, IP-155, Santa Monica, CA.

Davis, Paul K., Richard Hillestad, and Natalie Crawford (1997), "Capabilities for Major Regional Contingencies," in Khalilzad and Ochmanek (1997).

Davis, Paul K., and Richard Kugler (1997), "New Principles for Force Sizing," in Khalilzad and Ochmanek (1997).

Davis, Paul K., Jimmie McEver, and Barry Wilson (2002), *Measuring Interdiction Capabilities in the Presence of Anti-Access Strategies: Exploratory Analysis to Inform Adaptive Strategies for the Persian Gulf*, MR-1471-AF, RAND, Santa Monica, CA.

Defense Science Board (1998), *Joint Operations Superiority in the 21st Century: Integrating Capabilities Underwriting Joint Vision 2010 and Beyond*, two volumes, Office of the Under Secretary of Defense for Acquisition and Technology, Washington, DC.

Defense Science Board (1996), *Capabilities for 21st Century Operational Superiority*, Office of the Under Secretary of Defense for Acquisition and Technology, Department of Defense, Washington, DC.

Deptula, BG David (2001), *Effects-Based Operations: Changes in the Nature of Warfare*, Aerospace Education Foundation, Arlington, VA.

Doyle, John (1997), "Virtual Engineering: Toward a Theory of Modeling and Simulation of Complex Systems," Appendix B of National Research Council (1997).

Flournoy, Michèle (ed.) (2001), *QDR 2001: Strategy-Driven Choices for America's Security*, National Defense University, Ft. McNair, Washington, DC.

Gritton, Eugene C., Paul K. Davis, Randall Steeb, and John Matsumura (2000), *Ground Forces for a Rapidly Employable Joint Task Force: First-Week Capabilities for Short-Warning Conflicts*, RAND, Santa Monica, CA.

Hillestad, Richard, Jr., and Paul K. Davis (1998), *Resource Allocation for the New Defense Strategy: The DynaRank Decision-Support System*, RAND, Santa Monica, CA.

Johnson, Stuart (forthcoming), "Decision Tools to Aid Defense Planners," a chapter in a forthcoming book, RAND, Santa Monica, CA.

Khalilzad, Zalmay, and David Ochmanek (eds.) (1997), *Strategic Appraisal 1997: Strategy and Defense Planning for the 21st Century*, RAND, Santa Monica, CA.

Kugler, Richard (2000), "Replacing the 2-MTW Standard: Can a Better Approach Be Found?" presented at the 2000 Joint Operations Symposium, *Quadrennial Defense Review 2001*, November, National Defense University, Ft. McNair, Washington, DC.

Kugler, Richard (1993), *Commitment to Purpose: How Alliance Partnership Won the Cold War*, RAND, Santa Monica, CA.

Larson, Eric V., David T. Orletsky, and Kristin Leuschner (2001), *Defense Planning in a Decade of Change: Lessons from the Base Force, Bottom-up Review, and Quadrennial Defense Review*, RAND, Santa Monica, CA.

Larson, Eric V., and John E. Peters (2001), *Preparing the U.S. Army for Homeland Security: Concepts, Issues, and Options*, RAND, Santa Monica, CA.

McCarthy, General James (USAF, retired) (2001), *Transformation Study Report. Executive Summary: Transforming Military Operational Capabilities*, prepared for the Secretary of Defense, April 27.

Metz, Steven (ed.) (2001), *Revising the 2-MTW Paradigm*, U.S. Army War College, Strategic Studies Institute, Carlisle, PA.

Miller, Roger, and Donald R. Lessard (2001), *The Strategic Management of Large-Scale Engineering Projects: Shaping Institutions, Risk, and Governance*, MIT Press, Cambridge, MA.

National Defense Panel (1997), *Transforming Defense: National Security in the 21st Century*, Department of Defense, Washington, DC.

National Research Council (1997), *Modeling and Simulation, Volume 9 of Technology for the United States Navy and Marine Corps: 2000–2035*, Naval Studies Board, National Academy Press, Washington, DC.

National Research Council (2000), *Network Centric Naval Forces*, National Academy Press, Washington, DC.

OSD (PA&E) (1980), *Congressionally Mandated Mobility Study (CMMS)*, Department of Defense, Washington, DC.

OSD (PA&E) [unpublished (a)], *NATO Center Region Military Balance Study, 1978–1984*, Department of Defense, Washington, DC.

OSD (PA&E) [unpublished (b)], *Capabilities for Limited Contingencies in the Persian Gulf*, Department of Defense, Washington, DC.

Pirnie, Bruce R. (1996), *An Objectives-Based Approach to Military Campaign Analysis*, RAND, Santa Monica, CA.

Rumsfeld, Donald (2001a), "Defense Secretary-Designate Rumsfeld Outlines Policy Objectives," U.S. State Department, International Information Programs, *Washington File*, January 11, http://usinfo.state.gov/topical/pol/arms/stories/01011201.htm.

Rumsfeld, Donald (2001b), *Report of the Quadrennial Defense Review*, Department of Defense, Washington, DC, September.

Unites States Commission on National Security (1999), *New World Coming: Studies and Analysis*, the Rudman-Hart commission, Washington, DC.

Unites States Commission on National Security (2001), *Road Map for National Security: The Imperative for Change, Phase III Report*, the Rudman-Hart commission, Washington, DC.

United States European Command (EUCOM) (1989), *Airborne Operations: A German Appraisal, Historical Division*, CMH Pub 104-13. Available from the U.S. Government Printing Office, Washington, DC.

Warner, Edward, and Glenn Kent (1984), *A Framework for Planning the Employment of Air Power in Theater War*, RAND, N-2038-AF, Santa Monica, CA.