Chapter Five

UNCERTAINTY-SENSITIVE PLANNING

Paul K. Davis

Consider some of the major strategic surprises that affected national security in past decades.[1] Some of these were negative; some were positive:

- Cuban missile crisis
- Sadat's peace mission to Israel
- Fall of the Shah of Iran and resulting hostage crisis
- Disintegration of the Soviet Union
- Peaceful reunification of Germany
- Iraq's invasion of Kuwait
- East Asian economic collapse of the late 1990s
- India's nuclear testing and Pakistan's response
- Terrorist attacks on the World Trade Center and Pentagon

Now consider some purely military surprises of the past 50 years:

- Torpedoes in U.S. submarines fail to detonate (World War II)
- Early air-to-air radar-guided missiles fail (Vietnam War)
- Egypt launches a surprise attack across the Suez canal (1973)

[1]The intelligence community provided what is called "strategic warning" in a few instances (i.e., warning days or weeks before the events).

- Israel's air force is stymied by surprisingly effective SA-6 batteries
- Israel achieves an astounding exchange ratio in air war over Lebanon's Bekka Valley
- Deployment to the Persian Gulf begins a week *after* the attack (Desert Storm, 1990)

These surprises form a long list because they have not been occasional annoyances in a generally predictable world but, rather, quite common. This chapter begins by discussing why addressing uncertainty is so important and difficult. It then discusses analytic methods for dealing with uncertainty in broad, conceptual strategic planning; in doing capability-based analysis of future forces; and in making choices within a budget. Some of these methods are now in use in the Pentagon and elsewhere; others are candidates for future implementation. Resisting the tendency to give short shrift to uncertainty requires both discipline and knowledge of the past. Conscious methodology can help provide some of that discipline.

WHY SO MANY SURPRISES?

Early in World War II, U.S. submarine commanders were horrified as their torpedoes—launched after dangerous approaches—passed harmlessly by their targets. The torpedoes had worked in laboratory testing; their failure in the field was so unexpected that the commanders' reports were initially not believed. In the Vietnam War, early radar-guided air-to-air missiles failed because engagements occurred in circumstances other than those planned for. Faith in the missiles had been so great that most aircraft were designed without backup gun systems. Both of these failures were, in a sense, "merely" technical and analytic, but they had major consequences for the prosecution of war.

Nor have historical surprises all been American. When Egyptian units seized the east bank of the Suez Canal early in the 1973 Yom-Kippur war, the Israeli Air Force was stymied by surprisingly effective SA-6 anti-aircraft batteries. In later years, the Israeli Air Force destroyed scores of Syrian aircraft over the Bekka Valley without losing a single aircraft, thanks to asymmetrically capable command and control (C2). This may not have been a surprise to the Israelis, but it certainly

got the attention of militaries worldwide, including that of the Soviet Union, which supplied the Syrians.

In more modern times, there have been different surprises. Even though official U.S. planning scenarios had almost always assumed that U.S. forces would be able to deploy well before the day war would begin, or D-Day, the Desert Storm deployment began six days after D-Day. More recently, in the war over Kosovo, NATO heads of state were reportedly surprised when Slobodan Milosevic was not brought to his knees immediately by NATO's bombing. Their confidence was so great that they prohibited the development of contingency plans involving ground-force operations until late in the campaign. To make things worse, the Yugoslavs did not "play fair," usually keeping their air-defense radars turned off. Destruction of their air defenses thus proved impossible, constraining operations, reducing their effectiveness, and increasing the mass of air forces needed. Serbian military forces dispersed in the woods and emerged from the war with little damage. The United States was badly stretched while prosecuting a one-sided war against a third-rate regional rogue. Ramifications of this unscheduled "small-scale contingency" echoed throughout the entire force structure (particularly for the Air Force, which bore a particularly heavy burden in this conflict).[2]

Why do so many predictions fail and surprises occur? The reasons include the constant competition of measures and countermeasures, the tendency to keep weaknesses out of mind only to have them attacked by the adversary, rather prosaic failures of design or execution, and a failure to appreciate the frictions of war celebrated in the 1832 writings of Clausewitz.[3]

The scientific way to look at uncertainty is to acknowledge that wars and military competitions are "complex adaptive systems," and that, as a result, even small events can and often do have large effects. Further, the "system" is not a constant for which one can prepare

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[2]As usual, not everyone was equally surprised. Some military leaders were pessimistic from the outset about the effectiveness of bombing conducted with the severe political constraints that applied in the early weeks of the campaign.

[3]Carl von Clausewitz, *On War*, translated by Peter Paret, Everyman's Library, Alfred Knopf, New York, 1993.

straightforwardly. Rather, it includes human beings and organizations that think, behave, and adapt to events in myriad ways.[4] Because of such complications, an accurate prediction of the course of events is sometimes not even feasible.[5] That is, uncertainty is not only ubiquitous and large, but also impossible to get rid of it by merely working hard to do so.

So what do we do about this burden of uncertainty? Do we just wring our hands? In a phrase, we should get on with business—learning to plan in a way that includes the expectation of surprises and the need for adaptations. Until recently, this admonition seemed radical to defense planners, but it is old hat in many other endeavors, ranging from professional sports to U.S. business.[6] It is also quite familiar to warfighters.

CONCEPTUAL STRATEGIC PLANNING

Uncertainty-Sensitive Strategic Planning

Strategic planning can be expensive, tedious, and counterproductive or lean, stimulating, and insightful.[7] The uncertainty-sensitive

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[4]For an excellent semipopular discussion of complex adaptive systems, see John Holland, *Hidden Order: How Adaptation Builds Complexity*, Addison Wesley, Reading, MA, 1995.

[5]The degree of unpredictability depends on circumstances and what is being predicted. If a massive opponent attacks a much smaller opponent in an "open field," the outcome is determined. When dealing with complex adaptive systems, a key is knowing the "envelope of circumstances" within which control is possible. For a sample discussion on the control of nonlinear complex adaptive systems, see Appendix B of National Research Council, *Modeling and Simulation*, Vol. 9 of *Tactics and Technology for the United States Navy and Marine Corps, 2010–2035*, National Academy Press, Washington, DC, 1997.

[6]For earlier discussions that seemed more radical at the time, see Paul K. Davis (ed.), *New Challenges for Defense Planning: Rethinking How Much Is Enough*, MR-400-RC, RAND, 1994, Chapter 3, and Paul K. Davis, David C. Gompert, and Richard L. Kugler, *Adaptiveness in National Defense: The Basis of a New Framework*, IP-155, RAND, 1996. Planning for adaptiveness is now well accepted by Department of Defense (DoD) leadership (Donald Rumsfeld, *Report of the Quadrennial Review*, Department of Defense, Washington, DC, 2001).

[7]For an excellent but caustic review of failed strategic planning efforts, mostly in the business world, see Henry Mintzberg, *The Rise and Fall of Strategic Planning*, The Free Press, New York, 1994. Some of Mintzberg's criticisms of elderly strategic planning processes apply well to DoD's planning, programming, and budgeting process (PPBS).

planning method is designed for taking an occasional fresh look at the future's challenges and possible strategies—for rethinking matters such as grand strategy and higher-level defense planning. Variants of this method have been used at RAND since the late 1980s, as the Cold War was ending.[8]

Figure 5.1 indicates the basic ideas of uncertainty-sensitive planning. The first step is to characterize the "core" environment, sometimes called the *no-surprises future*. The next step is to identify uncertainties of two types related to *branches* and *shocks*.

Branches represent uncertainties that are taken seriously and monitored and that will be resolved at some point once events take us down one path rather than another. These uncertainties can be dealt

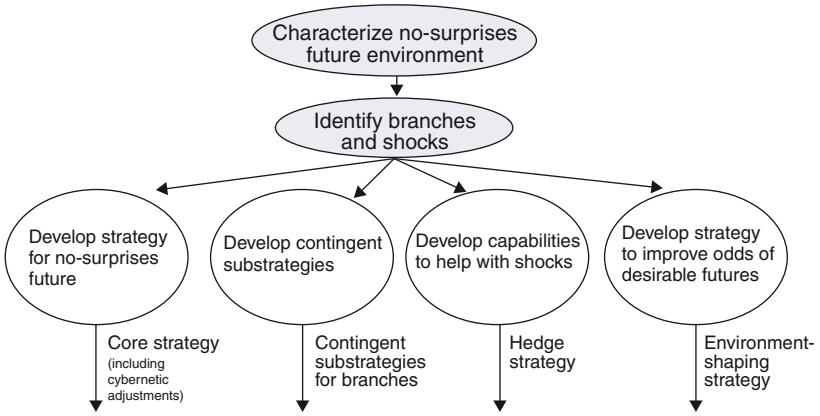

Figure 5.1—Uncertainty-Sensitive Planning

For an informal survey that discusses more strategic methods than can be mentioned here, see Paul K. Davis and Zalmay Khalilzad, *A Composite Approach to Air Force Planning*, MR-787-AF, RAND, 1996.

[8]For more details, see Davis, *New Challenges*, Chapter 6, which summarizes work done some years earlier in collaboration with Paul Bracken. James A. Dewar et al. (*Assumption-Based Planning: A Planning Tool for Very Uncertain Times*, MR-114-A, RAND, 1993) articulate well a variant method, assumption-based planning, that is especially useful for critical reviews of existing plans. It has been refined and applied extensively and James Dewar has recently published a book on the subject (James A. Dewar, *Assumption-Based Planning*, Cambridge University Press, Cambridge, UK, 2002).

with by in-depth contingency plans. Shocks, in contrast, involve plausible (i.e., not impossible) events that are heavily discounted by best-estimate wisdom and are given lip service, at best. Nonetheless, at least some of them will occur—even if they are individually unlikely. When they do occur, they will be disruptive, and there will be no detailed contingency plans for dealing with them. As suggested by the examples listed at the beginning of the chapter, such events not only occur, but occur frequently.

As of early 2002, some illustrative future branches for current U.S. strategic planning included whether

- Al Qaeda is eradicated.
- The U.S. takes military action to force a regime change in Iraq.
- Korea is unified.
- China engages in military actions against Taiwan.
- NATO expands to the Baltics.
- The long-term Chinese military buildup continues.

Some of the many shocks currently regarded as unlikely might be

- U.S.-China conflict arising from a Chinese attack on Taiwan.
- Revolution in Saudi Arabia.
- Collapse of Iran's Islamist government and movement toward normalization (or the opposite, a resurgence of virulent anti-American Islamist-driven actions).
- Disintegration of extremist Al Qaeda-like movements.
- Resolution of the Arab-Israeli conflict and emergence of a Palestinian state.
- Japan going independent.
- Russia moving against Baltic states, Ukraine, or Poland.

As Figure 5.1 shows, planners are to develop a broad strategy consisting of the no-surprises strategy, a series of contingent substrategies to deal with branches, a set of hedging actions laying the groundwork for more ad hoc adaptation to shocks when they occur, and an

environment-shaping strategy to affect favorably the odds of various futures. Three particular themes are crucial here:

1. *Operational adaptiveness* is the ability of U.S. forces to deal, at a given time, with a diversity of political-military scenarios and detailed circumstances—some of which can be planned against in detail and some of which will arise as shocks.
2. *Strategic adaptiveness* is the ability to change military posture quickly and easily in response to shifts of the geostrategic environment or national strategy. "Quickly" relates to the time scale of changes in the environment (years); "easily" relates to budgets and effectiveness. Again, some possible shifts can be anticipated and planned against; others will be surprises.
3. *Environment shaping* is influencing the future—e.g., by promoting international stability, economic integration, and universal democratic principles; controlling or mitigating international instabilities; and underwriting general deterrence through commitments, relationships, and credible military forces.

Planning for adaptiveness is more easily said than done, but the United States appears to have often been rather good at it when viewed through the lens of what has been called effective "muddling through."[9] In the real world, the best that can be done is to move in the "right direction" and to adapt routinely without falling prey to the illusion that more precise planning is possible.

Environment shaping is perhaps best understood by considering its opposite: treating the future as an exogenous variable over which one has no influence. Doing so is common in strategic planning activities that spin alternative futures.[10] But the future obviously is not exogenous, or given—especially for a superpower. Humility about shaping efforts is one thing (such efforts can surely fail or be counterproductive), but just waiting to see what happens is quite another.

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[9]Charles Lindbloom, "On the Science of Muddling Through," *Public Administration Review*, Spring, 1959.

[10]A caricature here is a scenario-based approach that includes a rosy scenario, a bad scenario, and a no-surprises scenario. Sometimes participants emerge with few insights other than that they prefer the rosy scenario.

Surely, the United States should seek ways to improve the odds of favorable developments and circumstances.

Shaping has a positive side, such as seeking to expand the zone of peace; it also has a side that forestalls the negative, as in establishing general deterrence in a given region. It is here that environment shaping connects with the classic strategic concepts of *realpolitik*. Even an optimist about the arrow of human progress has to recognize that military vacuums do arise, malevolent leaders exploit them, and wars still occur. It is far better to deter such events by maintaining a manifest capability to deal with them should they occur, than to have to actually fight future wars. The shaping concept has become increasingly important over the last decade. It seems now to be well established in U.S. national strategy, although terminology changes with each administration, as does the relative emphasis on carrots and sticks.[11] As of late 2002, the United States was considering preventive war against Iraq. Such a war would likely have major longer-term shaping effects, for good or ill.

Operationalizing Strategic Planning in Portfolio-Management Terms

Conceptual strategic planning, then, can address uncertainty in the way suggested in Figure 5.1. The next issue, however, is how to move from that to something more formal, structured, and actionable—i.e., to seeing defense planning as an exercise in portfolio manage-

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[11]The first official embrace of the "environment shaping" idea was that of Secretary of Defense Dick Cheney, in 1993 (Dick Cheney, *The Regional Defense Strategy*, Department of Defense, Washington, DC, 1993). The early Clinton administration dropped the terminology, but embraced the related concept of engagement. The concept of preventive defense (Ashton B. Carter and William J. Perry, *Preventive Defense: A New Security Strategy for America*, Brookings Institution, 2000) is about certain types of environment shaping. The broad concept of environment shaping per se was reintroduced to official documents in 1997 (William S. Cohen, *Report of the Quadrennial Review*, Department of Defense, Washington, DC, 1997). For a region-by-region discussion of what environment shaping may involve, see Institute for National Strategic Studies (INSS), *Strategic Assessment 1998*, National Defense University, Washington, DC, 1998. The Bush administration referred early to a strategy of dissuading, deterring, and defeating enemies and of reassuring allies (Rumsfeld, *Report of the Quadrennial Review*). The implications of such a strategy clearly include what is called environment shaping here.

ment. The intention of this construct, when first proposed in 1996 as background for the 1997 Quadrennial Defense Review (QDR), was to

- Promote capabilities-based planning for diverse contingencies, both large and small.
- Give environment shaping and strategic adaptiveness the same visibility and status as warfighting.
- Emphasize the need for hedge capabilities permitting future adaptiveness.
- Deal with the potential synergy of and conflicts among portfolio components.

In this construct, planning is about judging how best to allocate investments across the three components of the portfolio. Figure 5.2 suggests schematically what this can mean.[12] The left component

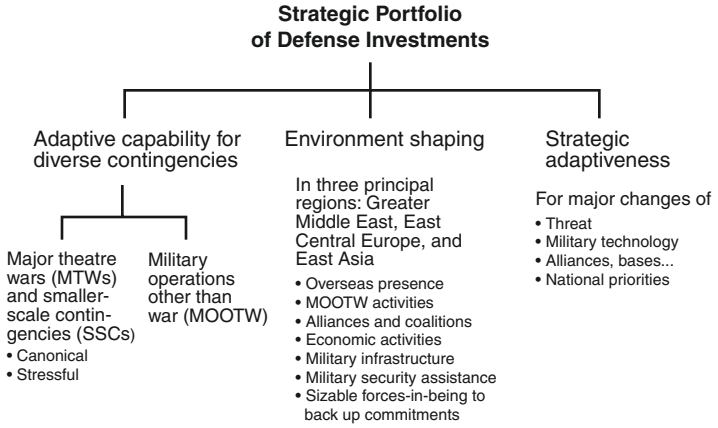

Figure 5.2—Defense Planning in a Portfolio-Management Framework

[12]Adapted from Davis, Gompert, and Kugler, *Adaptiveness in National Defense*, which also discusses similarities and differences between this type of portfolio management and that of the business world.

highlights capabilities planning, since that is DoD's core mission; the subsequent components deal with environment shaping and hedging activities to achieve strategic adaptiveness designed to prepare for an uncertain future.

Portfolio management has its limits. As in the investment world, actually doing portfolio management is by no means straightforward, but it is a coherent way to deal with inherent uncertainty and multiple objectives. Choices must be made because there are conflicts. Maintaining near-term readiness can conflict with building future-year capabilities. Worldwide shaping activities can shortchange modernization and transformation of U.S. military forces. Overzealous transformation efforts can mean low readiness until forces, doctrine, and the personnel system adjust.

Subtleties also abound. For example, many military capabilities (first component in Figure 5.2) add or subtract from environment shaping. Thus, environment-shaping investments are investments to *further* increase U.S. effectiveness beyond that stemming from capabilities. Similarly, many activities to enhance both conflict capabilities and environment shaping can add or detract from strategic adaptiveness (e.g., by creating options for using nations' ports and airfields in the future as others become unavailable or undesirable).

Another subtlety is that merely labeling some activity with a positive, such as "increased presence improves environment shaping" may confuse intent with reality. A forward presence can have negative effects when it is too intrusive and runs afoul of independence, sovereignty, or pride. So it was that the United States lost its base in the Philippines. Similar problems have arisen in Korea, Okinawa, and the Persian Gulf. It would not be surprising if the U.S. presence in Saudi Arabia were significantly reduced in the years ahead.

As Chu and Berstein observe in Chapter One, the DoD has, in the course of the last three administrations, substantially altered its concept of higher-level strategy to the needs of the modern era. This has often been obscured in debates over hearty perennials, such as whether to cut forces, cancel high-visibility weapons systems, or drop the requirement that the United States must be able to fight and win two major theater wars (MTWs) simultaneously. From the per-

spective of this chapter, however, a great deal of progress has been made. DoD's (and the nation's) strategy is explicitly multifaceted, as discussed here in portfolio-management terms. Attention is paid separately to current operations, recapitalization, transformation, and environment shaping. Force needs are assessed not in terms of a simplistic warfighting formula, but in terms of diverse worldwide requirements. There should be no doubt, then, about DoD's attention to the special challenges of planning under manifest uncertainty.

At the heart of those changes is the shift to capabilities-based planning of future forces, referred to above as DoD's core mission (and shown at the left in Figure 5.2).

CAPABILITIES-BASED PLANNING

Capabilities-based planning is planning, under uncertainty, that aims to provide capabilities suitable for a wide range of future challenges and circumstances while working within an economic framework. Today's defense planning, then, is about building capabilities that will be available perhaps three to 20 years from now, when future presidents, defense secretaries, and combatant commanders face the challenges of their own eras. Only sometimes will those challenges have been anticipated, and even less often will they have been planned for in detail despite all the trying. This implies that the capabilities provided to those future leaders should be designed for flexibility and adaptiveness.

Capabilities-based planning stands in contrast to what had become DoD's approach to planning, an approach based on official planning scenarios for major theater wars that not only identified adversaries, but also laid out scenario details, such as warning time and roles of allies. Figure 5.3 shows schematically the kind of scenario used. DoD's routine analysis processes had become so focused on these official scenarios, along with official databases for running official models, that the result was the virtual opposite of capabilities-based planning. It was as though the illustrative scenarios had become specifications serving to define both necessary and sufficient characteristics of the force structure. In practice, as so often happens when strategic planning processes age, the constrained analyses consistently supported current programs—i.e., they "caused no trouble."

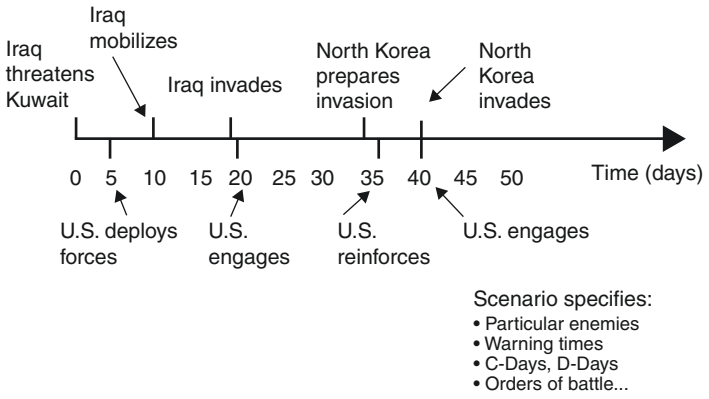

Figure 5.3—An Illustrative Threat-Based Scenario

They were not, however, useful for dealing with uncertainty or for assessing transformation concepts.[13]

It is important to emphasize that the problem with the approach was not that it identified particular threats, but that it considered only conventional-wisdom threats and, to make things worse, considered only point versions of detailed scenarios, as though the circumstances of future conflict could be predicted.

Key Features

The essence of capabilities-based planning is to deal with future uncertainty by generating "capabilities" usable for different purposes and circumstances. Its key features are

- An emphasis on modular (building-block) capabilities usable in many ways
- Assembly capability

[13]For an extensive discussion of capabilities-based planning and suggestions for its implementation, see Paul K. Davis, *Analytic Architecture for Capabilities-Based Planning, Mission-System Analysis, and Transformation*, MR-1513-OSD, RAND, 2002. Appendix A of that document lists numerous past examples of capabilities-based planning, mostly from the 1960s and 1980s.

- Goals of flexibility, adaptiveness, and robustness, rather than "optimization"
- Multiple measures of effectiveness (MOEs)
- Explicit role for judgments and qualitative assessments
- Economics of choice
- Recognition that "requirements" are the result of high-level choices that should be based on broad capabilities-based analysis.

Building blocks are central in capabilities analysis. When developing capabilities, one quickly discovers the importance of modularity: of having the capacity to take a bit of this and a bit of that, and to do something for which one had not previously planned explicitly. This approach is familiar in everyday life. Suppliers to builders, for example, do not stockpile materials fine-tuned to particular homes that may be built; rather, they stockpile bricks, mortar, and studs.

Building blocks in the military domain come in many forms and at many levels. In particular, there are multiple levels of building blocks in four dimensions:

- Units (e.g., battalions)
- Operations (or missions) and related suboperations
- Weapons systems and subsystems
- Support structures (e.g., logistics systems and, within them, individual systems such as prepositioning ships or tactical airlift).

Flexibility, adaptiveness, and robustness depend on skills in assembling building blocks for at-the-time purposes and circumstances. They are undercut by overspecialized acquisition, by not achieving the interoperability that allows the blocks to fit together easily, and by refining detailed operations plans rather than honing skills for rapid at-the-time assembly. Part of the assembly challenge is having the capacity for at-the-time tailoring—e.g., creating special hybrid units and unique types of support, rather than using only large, preexisting support structures.

The U.S. military does capabilities-based planning now at lower levels—e.g., military systems typically have specifications assuring usability in a wide variety of conditions. Similarly, lower-level operations planning tends to be quite adaptive (that is part of what makes being a young officer attractive). In contrast, higher-level operations planning is often ponderous, especially in peacetime. Although Desert Shield succeeded, the original plan had many shortcomings, and rapid plan modifications were difficult to make. Fortunately, the United States had six months before its shooting war began.

Information Technology and Mission-System Analysis

A critical issue in capabilities planning is assuring that assembly of the right capabilities can be accomplished quickly and can draw on resources that may be physically distant and that come in variously labeled packages—e.g., Army, Air Force, Navy, and Marines. At least as challenging is the task of ensuring that theater commanders will be able to draw on civilian expertise back in the United States or elsewhere when needed and to coordinate activities with those of coalition partners and nongovernmental organizations (NGOs). All of this will require excellence in the use of modern information technology, as Martin Libicki stresses in Chapter Four.

A related issue is mission-system analysis, which seeks to assure that *all* components necessary to an operation will be successful—e.g., that there will be immediately effective joint command-control; missile defense; defense suppression; reconnaissance and targeting; fire delivery; and orchestration of ground force maneuvers. Such matters are extremely important and are becoming more so.[14]

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[14]See National Research Council, *Network Centric Naval Operations: Transitional Strategy for Emerging Operational Capabilities*, Naval Studies Board study, National Academy Press, Washington, DC, 2000; David S. Alberts, John J. Garstka, and Frederick P. Stein, *Network Centric Warfare: Developing and Leveraging Information Technology*, CCRP Series of National Defense University, Washington, DC, 1999; Paul K. Davis, James H. Bigelow, and Jimmie McEver, *Analytical Methods for Studies and Experiments on "Transforming the Force,"* DB-278-OSD, RAND, 1999; David Gompert and Irving Lachow, *Transforming U.S. Forces: Lessons from the Wider Revolution,* IP-193, RAND, 2000; and Davis, *Analytic Architecture.*

Multiple Objectives and Measures

When making assessments in capabilities analysis, multiple objectives are customary. That may seem straightforward, but defense analysis too often focuses instead on what amounts to a single objective. It is worth illustrating why this matters.

Figure 5.4 shows two ways of comparing four options: A, B, C, and D. The left panel compares them on the basis of least cost for equal effectiveness for a single measure of effectiveness, MOE 1. Perhaps this is something like the ground lost in a simulated war for a particular detailed scenario. In this comparison, option C looks best. In contrast, the right panel makes equal-cost comparisons using a range of measures (MOEs 1, 2, 3, and 4). Perhaps MOE 2 represents results for a different scenario, MOE 3 represents results for an entirely different mission, and MOE 4 assesses the relative extent of U.S. losses that would be expected over a variety of missions and scenarios. Option C may still be best with respect to MOE 1, but not by very much. As a result, its score (as indicated by shading, with lighter being better) is essentially the same as that of the other options. More importantly, option C is distinctly inferior to option D under the other measures. Overall, then, it would probably be better to choose option D. This, in miniature, is what it means to focus on flexibility and robustness rather than on optimizing (e.g., minimizing cost) for a point problem.

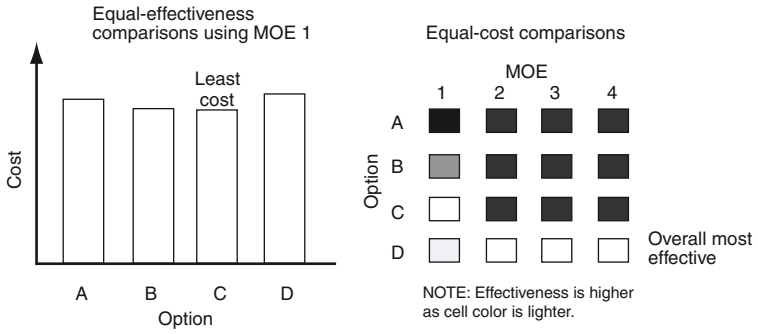


Figure 5.4—Contrasting Types of Analysis

The Concept of a Scenario Space (an Assumptions Space)

Having multiple MOEs can improve flexibility, adaptiveness, and robustness. Yet we must also recognize how sensitive force effectiveness is to highly uncertain variables often treated as if their values were known. Figure 5.5 shows how defense planning could be broadened, in two steps, from one or two threat-based point scenarios. The first step is to expand the list of name-level scenarios (i.e., scenarios specified only to the extent of giving their name, as in "China invades a unified Korea"). Recognizing this need for scope, DoD began in the mid-1990s to consider a broad range of generic threats, although most public attention still focused on threats from Iraq and North Korea.

What has not yet systematically occurred is the second step shown in Figure 5.5: for each name-level scenario, evaluate capabilities for a broad range of operational circumstances that would stress capabilities in very different ways. Ultimately, capabilities assessment requires an examination of outcomes for the entire *scenario space* (i.e., for all the combinations of factors that matter or for a truly representative distribution). This is *exploratory analysis under uncertainty*.

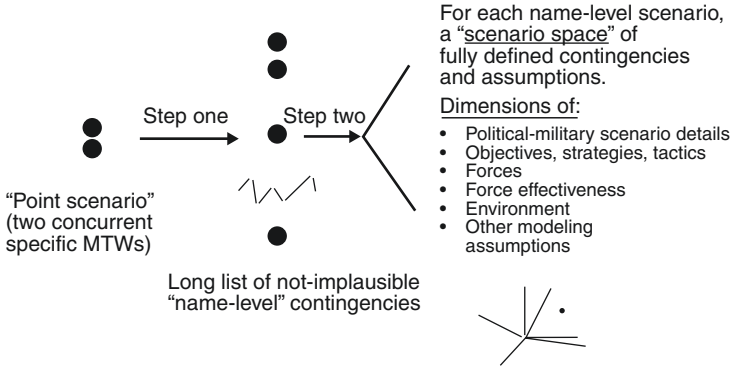


Figure 5.5—Exploratory Analysis in a Scenario Space

As the right side of Figure 5.5 indicates, it is useful to formalize this construct by recognizing that these factors can be grouped into six dimensions of scenario space:

- Political-military scenario (what is usually meant by "scenario")
- Objectives, strategies, and tactics
- Forces
- Force effectiveness (taking into account frictions and personnel quality)
- Environment
- Other modeling assumptions (e.g., feasible rates of advance and break points).

For every scenario space, an exploratory analysis covering the key uncertainties can be designed, and computers can then be used to "fly through the outcome space" to see under what assumptions war outcomes would be favorable, unfavorable, or uncertain. The purpose is to gain insight about how to avoid being in the bad regions of scenario space.[15]

To conduct an exploratory analysis, one can use the scenario-space dimensions explicitly, designing experiments to cover combinations of variables that span the relevant case space. The choice of which variables to hold constant depends on whether the application involves a military-balance assessment, an arms-control analysis, an evaluation of a new weapons system, operations planning, or something else.

Table 5.1 shows an experimental design for a hypothetical mid-1990s study assessing U.S. and allied capabilities to defeat an invasion. The abstractions, such as political-military scenario, are narrowed to specifics. In this case, the political-military scenario is represented simply by varying the time at which the United States and its ally begin mobilizing and deploying (i.e., at D–10, D–5, D, or D+5). As an-

[15]For more details, see Chapter Nine, "Exploratory Analysis and Implications for Modeling."

Table 5.1

Illustrative Experimental Plan: Scenario-Space Analysis of Defense Capability for a Given Name-Level Scenario

Political-military setting	Alliance reacts at C (when deployment begins) = D–10; D–5; D; D+5.
Strategies	Fixed: invasion to specific objectives; defender attempts to halt advance. One measure of outcome is where alliance is able to hold.
Forces	Enemy: 15, 20, 25, 30, or 35 divisions; 10 or 20 tactical fighter wings. Ally: 8 or 12 divisions; no significant tactical air forces. U.S. commitment: 0, 5, or 8 tactical fighter wings; 0 or 5 divisions.
Weapons systems	Ally does or does not have MLRS/DPICM.[a] U.S. does or does not buttress the ally's ground forces with reconnaissance, surveillance, and targeting information. U.S. does or does not have the BAT munition for its MLRS launchers.[b] U.S. aircraft may achieve 1, 2, 5, or 10 kills per day after air defenses are suppressed. U.S. has capability to suppress (either destroy or prevent use of) air defenses in 1, 4, or 8 days.
Environment	Normal weather.
Algorithms and other model assumptions	Attacker's nominal ground force effectiveness (based on equipment) is multiplied by 0.75 or 1 to reflect uncertainties about competence and dedication. Ally's nominal ground force effectiveness is multiplied by 0.5 or 1 to reflect uncertainties about preparation, competence, and dedication.

[a]The MLRS is a multiple-rocket launcher system that can launch a variety of munitions, one of which is abbreviated DPICMS.

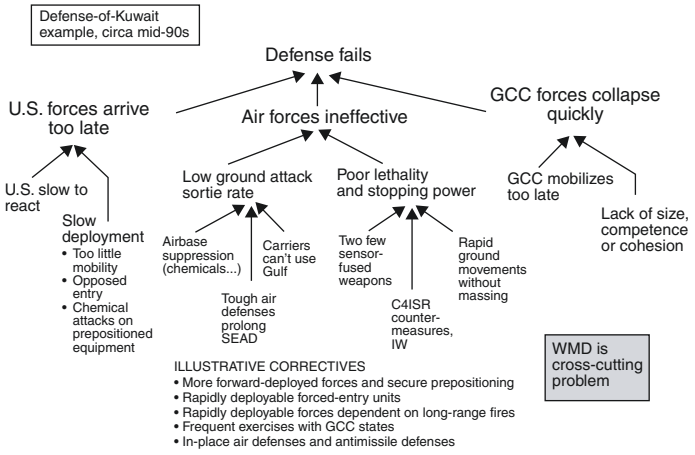
[b]The MLRS can also launch the Army's Tactical Missile System (ATACM) missile, which will be able to carry brilliant anti-tank (BAT) munitions.

other example, the design includes cases in which the United States does and does not assist the ally's ground forces by providing timely reconnaissance, surveillance, and targeting information. This can have a factor-of-two effect. Overall, this analysis design would entail running 200,000 cases. This is not traditional sensitivity analysis.

My colleagues and I have used such experimental designs in studies related to NATO's defense capability, the defense of Kuwait and Saudi Arabia, and the defense of Korea. Each design was tailored to the problem at hand. In a mid-90s study, for example, the future Russian threat to Poland was quite hypothetical, and the only issue was to understand how difficult it might be for NATO to defend Poland if

Poland joined NATO. For such a study, we were careful to avoid worst-casing that postulated not only a future malevolent Russia, but also a large and supremely competent Russian army. Instead, we considered somewhat larger-than-expected Russian threats that were reasonably credible for the period under study, but did not ascribe to them advanced, U.S.-like capabilities. We also considered a range of Polish self-defense capabilities, and so on. In contrast, when studying what capabilities might be needed in the more distant future to deal with a regional peer competitor, we drew on intelligence estimates, Defense Science Board studies, and other efforts to define a range of more stressful but *plausible* (i.e., not incredible) threats—just to explore under what circumstances various U.S. capabilities would be especially valuable.

The design of such analyses can benefit from a method called "fault trees" (see Figure 5.6) that was used in a mid-1990s study that examined the defense of Kuwait and Saudi Arabia.[16] The purpose of the



NOTE: GCC = Gulf Cooperation Council; SEAD = suppression of enemy air defenses; WMD = weapons of mass destruction; C4ISR = command, control, communications, computers, intelligence, surveillance, and reconnaissance; IW = information warfare.

Figure 5.6—Fault Tree for Defense of Kuwait and Saudi Arabia

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[16]For a more recent study that addresses anti-access issues in some detail, see Paul K. Davis, Jimmie McEver, and Barry Wilson, *Measuring Capabilities for Interdiction: Exploratory Analysis to Inform Adaptive Strategies for the Persian Gulf*, MR-1371, RAND, 2002.

diagram, which can be created in brainstorming sessions, is to organize thinking so as to highlight the factors worth varying in analysis. Figure 5.6 does this by indicating different ways in which the United States and its allies could fail—e.g., U.S. forces could arrive too late, U.S. air forces might not be effective enough to bring about an early halt, or the local Persian Gulf–state (GCC in the figure) forces might collapse quickly because they are outnumbered and outgunned. Lower on the tree are ways these subfailures might occur, and at the bottom of the tree are natural connections to model inputs. For example, in the middle there is reference to tough air defenses prolonging SEAD (suppression of enemy air defenses) operations . In model terms, this means varying the "SEAD time" by considering different values—say, 1, 3, and 8 days.

Figure 5.6 also shows (bottom) a list of illustrative corrective measures for avoiding failed defense. Again, such lists lead to decisions about what model parameters to vary.

Figure 5.7 illustrates a "slice" through the outcome space of a theater-level simulation. Instead of seeing results for one detailed scenario, we see outcomes for a wide range of cases packaged in a way

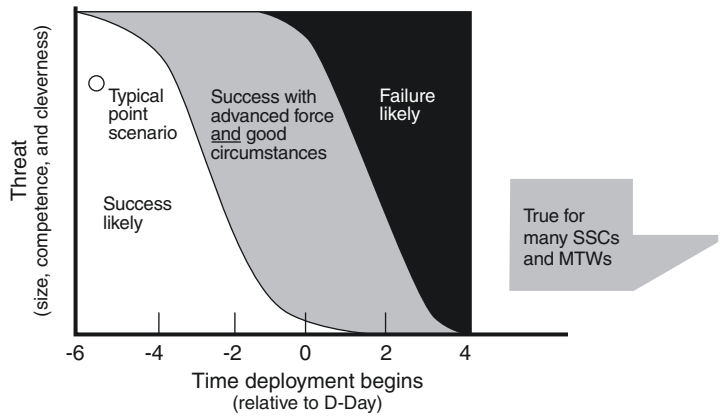

Figure 5.7—One Slice Through Outcome Space, Showing Envelopes of Capability for Defense

that tells an important story. Because we are seeing only a slice through the space, many inputs are held constant, but we do see the effects of varying threat size (y axis) and varying start time for the U.S. force deployment (x axis). Outcome is indicated by white (good), gray (uncertain), and black (likely failure). The principal point is that immediately employable force is particularly critical because fully actionable warning times may be quite short, even though strategic warning usually exists.

This depiction of analysis puts pressure on the observer to favor planning options that would put resources where they are most needed, rather than continuing to work on marginal improvements for cases in which the United States already has good capabilities. In other words, the obvious implication of such a display is to put emphasis on turning more of the shaded region to white and more of the black region to white or shaded. That is, the premium is on *early* capabilities.[17] This is in contrast to spending more money to obtain an even better outcome for scenarios already in the white region.[18]

Choices and Resource Allocation

The last topic of this chapter is how to move from a portfolio construct of overall strategy, capabilities assessment, and assessments of environment shaping and strategic adaptiveness to informing resource allocation choices. After all, capabilities-based planning cannot simply provide a blank check to prepare for any and all possibilities.[19] A portfolio framework helps, but additional methods and tools are needed, some of which already exist.

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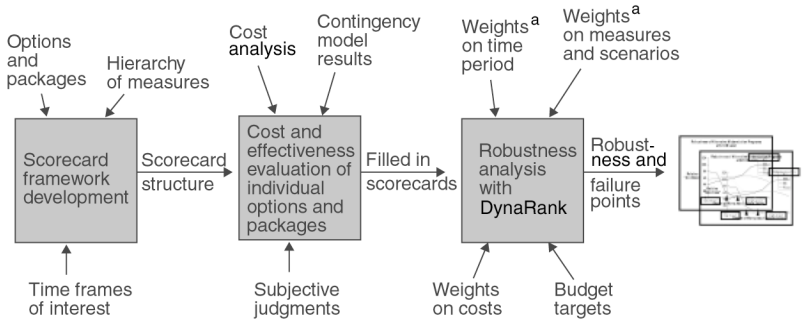
[17]Many options for improving *early* capabilities are discussed in Paul K. Davis, Richard Hillestad, and Natalie Crawford, "Capabilities for Major Theater Wars," in Zalmay Khalilzad and David A. Ochmanek (eds.), *Strategic Appraisal, 1997: Strategy and Defense Planning for the 21st Century*, MR-826-AF, RAND, 1997, and in Gritton et al., *Ground Forces*.

[18]As discussed by E. C. Gritton et al. (*Ground Forces for a Rapidly Employable Joint Task Force: First-Week Capabilities for Short-Warning Conflicts*, MR-1152-OSD/A, RAND, 2000), a generic version of this chart applies well in thinking about capabilities for both MTWs and SSCs (such as the Kosovo conflict).

[19]The blank-check problem is one of those raised by people who are skeptical of capabilities-based planning by "uncertainty hawks" (Carl Connetta and Charles Knight, *Dueling with Uncertainty: The New Logic of American Military Planning*, Project on Defense Alternatives, Commonwealth Institute, Cambridge, MA, 1998).

Figure 5.8 suggests that a portfolio-structured decision-support analysis should have the following inputs: multiple objectives, multiple options, many scenarios and variations (distilled from exploratory analysis), "objective" MOEs (e.g., results of simulations), multiple cost and budget measures, and subjective judgments about effectiveness. Bluntness is appropriate here about a controversial matter: Those who reject subjectivity in methodology have no place in higher-level planning, since the most important decisions are inherently subjective. Further, most allegedly objective measures derive from models with many uncertain assumptions influenced by judgments, or from data that may be a poor proxy for what is needed (e.g., Vietnam-war body-count data). The challenge is not to make things "objective," but to structure subjective judgments so that they are well defined and meaningful as part of an analysis.

Figure 5.9 is a top-level view of a desirable planning structure. The first column lists some of the policy options (these are discrete program-level options, not high-level strategy alternatives); other columns are for their different MOEs. The scorecard approach allows decisionmakers to see the component assessments, rather than forcing them to buy into any particular combining rule for overall utility.



[a]Combining rules may also be nonlinear, as in taking the worst component score rather than using a weighted score.

Figure 5.8—Factors to Be Reflected in Portfolio Analysis

Option (vs. baseline)	Capabilities		Environment Shaping	Strategic Adaptiveness	Net Effect	Cost
	MTWs	SSCs				
+20 B-2s						
+1,500 SFWs						
+Allied package						
+150 UAVs						
CEC acceleration						
+1 CVBG						
More home-porting						
Many others						

NOTE: CEC = cooperative engagement capability; CVBG = carrier battle group; SFW = sensor fused weapon; UAV = unmanned aerial vehicle.

Figure 5.9—Basic High-Level Scorecard Structure

Three of the columns in this illustration correspond to the portfolio construct (capabilities, environment shaping, and strategic adaptiveness). Of these three, capabilities has two subcolumns, one for MTWs and one for SSCs, whereas environment shaping and strategic adaptiveness have none. In another application, they might have several. For other applications, there might be another column for force-management effectiveness (measuring, e.g., effects on operational tempo and ability to recruit and maintain forces). Such matters can easily be changed using a spreadsheet tool such as RAND's DynaRank.[20]

The value in any cell of the scorecard may be generated from subordinate spreadsheets that use simple models or have databases arising from more simulation or empirical work. The top-level assessment of MTW capability, for example, might be the result of numerous subordinate-level calculations for different MTWs with different assumptions, such as those about warning. Those discrete cases, in turn, would have been chosen after broad exploratory analysis in the relevant scenario space revealed the most important

[20]See R. J. Hillestad and Paul K. Davis, *Resource Allocation for the New Defense Strategy: The DynaRank Decision Support System*, MR-996-OSD, RAND, 1998.

factors. Still other subordinate spreadsheets and notes may elaborate on the reasoning used in subjective judgments.

Performing this type of analysis permits us to order policy options by effectiveness, cost, or cost-effectiveness. This requires a rule on how to combine the shaping, capabilities, and preparing-now components. Given such a rule, the analysis determines how to cut costs with minimal impact on effectiveness (left side of graph in Figure 5.10) or how much additional effectiveness can be achieved by buying the entire set of policy options (right side of graph).

Exploratory analysis is as essential to cost-effectiveness analysis as it is to capabilities assessment. It helps to construct different "views," which combine assumptions used in the portfolio assessment with those about the relative weights of shape, respond, and prepare now; the weights of subordinate measures such as MTW and SSC capability; and even assumptions in underlying analyses—e.g., how bad to make the worst-case scenarios. These assumptions should reflect differences in how significant people think about the issues (e.g., the weight of readiness versus modernization).

With such views established, portfolio assessment can determine how the rank orderings of options change from view to view (Figure 5.11). Options that rise to the top for all views are, by definition, ro-

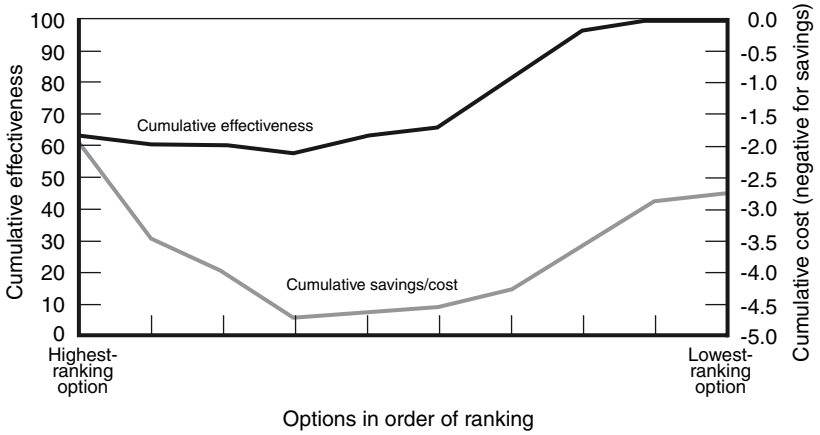


Figure 5.10—DynaRank Outputs in Cost-Effectiveness Analysis

View Emphasizing Warfighting	View Emphasizing Shaping	View Emphasizing Cost
New BRAC	25% fewer F-22s	-1 active division
Double surge sortie rates[a]	New BRAC	-1 CVBG
Allied defense package (helos, ATACMS, advisors)[b]	Allied defense package (helos, ATACMS, advisors)	25% fewer F-22s
Equip F-22s for anti-armor missions	Forward deployed wing	-2 FTWs
Rapid SEAD (HPM)	Mediterranean home-port	New BRAC
Forward deployed wing	Arsenal ship plus allied package	Forward deployed wing

NOTE: BRAC = base realignment and closure; FTW = fighter tactical wing; HPM = particular mechanism involving high-power microwave weapons.
[a]Double surge sortie rates have to do with a program that would permit temporary doubling of air force sortie rates.
[b]An allied defense package consists of specialized units and equipment that would be deployed early to help

Figure 5.11—Exploratory Analysis Showing Rank-Ordered Preferences Under Different Views

bust. Such options usually exist because big organizations have many inefficiencies that make no sense under any sensible view. In the example, all three views recognize the need for another series of base closings (a new base realignment and closure [BRAC] round). As long as the viewpoints are reasonable rather than zealous (e.g., as long as a modernization view still recognizes that shaping is significant), such analysis can help elicit agreement among people who would otherwise argue vociferously in the abstract. For example, in other work of a similar nature, the need to modernize information systems emerged as a consensus view across "stovepipe czars."

This discussion, then, has suggested how it is possible to go from the high concepts of grand strategy down to the nitty-gritty issues of economic choice using one intellectual framework. There is no guarantee that this process of working up and down the ladder of choice will be easy. But it is both feasible and desirable—given strong management, good will, and participation by senior leaders of the defense community.