Buying Tomorrow's Military: Options for Modernizing the US Defense Capital Stock

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CONTENTS

EXECUTIVE SUMMARY

Critical to the Bush Administration's ongoing review of national security requirements and strategy is the question of how much the Department of Defense (DoD) should spend on the development and procurement of new weapon systems. More than any other military in recent history, the US military has a tradition of investing in and relying upon advanced weapon systems and other equipment to give it a crucial edge in capabilities. Few doubt that the United States needs to continue relying on, and exploiting, its advantages in weapons technology.

There is, however, considerable disagreement over the speed with which the US military needs to "recapitalize" (i.e., replace) its existing inventory of weapon systems (i.e., its "defense capital stock"), the kinds of new systems that should be acquired, and thus, ultimately, the amount of money DoD needs to invest in research and development (R&D) and procurement. There is likewise considerable disagreement over how best to sustain a defense technology and industrial base (DTIB) capable of supporting these requirements.

THE CURRENT MODERNIZATION PLAN

Under DoD's current modernization plan—i.e., the last Clinton Administration defense plan—over the next several decades, the Services would buy a wide range of new weapons, including the F-22, F/A-18E/F and Joint Strike Fighter (JSF) fighters, the DD-21 destroyer, the Virginia-class submarine, the Comanche helicopter, and the Crusader artillery system. CSBA estimates that fully implementing these plans would require average annual procurement budgets of nearly $80 billion (fiscal year (FY) 2002 dollars) over the next 15 years. The cost would rise to some $95 billion if it is assumed that DoD would seek to replace its existing inventory of weapon systems with next-generation systems on a one-for-one basis over the longer term (i.e., on a "steady-state" basis). By comparison, DoD now spends about $60 billion a year on procurement.

It is far from clear whether such an increase in procurement funding is affordable. Prior to leaving office in January 2001, the Clinton Administration released a revised defense budget proposal. Under that plan, $310 billion would be provided for DoD in FY 2002 and an average of roughly $305 billion annually would be provided over the following five years. However, due to cost growth in weapons acquisition and operations and support (O&S) costs, the actual cost of the current plan is likely to exceed that funding level by an average of some $40 billion a year over the long term. Given the size of projected future federal budget surpluses, it is possible that funding for defense could be increased to this level. In February, the Bush Administration announced that it had adopted the same DoD topline included in the last Clinton plan for FY 2002, and that its proposal for later years would await completion of an ongoing defense reviews. President Bush certainly *could* recommend an increase for defense large enough to pay for the current plan when the administration's review is completed. However, both Republicans and Democrats appear to place higher priority on other competing policy initiatives, such as paying down the federal debt, cutting taxes and protecting or reforming Social Security and Medicare. Thus, enacting a large increase in funding for defense may be difficult.

AGING OF THE WEAPONS INVENTORY

Even if the current plan were fully implemented, the age of the Services' weapons inventory would increase substantially over the next 15 years. The average age of the Services' weapons inventory remained relatively constant throughout the 1990s, despite the fact that the quantity of weapons procured in the 1990s was relatively low. This is because the Services bought large quantities of new weapon systems in the 1980s, during the Reagan buildup, and then in the 1990s cut the size of the force structure by about one-third, with the oldest weapons usually retired first. However, the buildup of the 1980s is receding further into the past, and most of the planned post-Cold War force structure cuts were completed by the mid-1990s. As a result, the average ages of most major weapon systems are now projected to increase substantially. For example, over the next 15 years, the average ages of the Air Force's fighter force and the Navy's surface combatant fleet are projected to rise from 13 to 18 years and 13 to 20 years, respectively.

Notwithstanding the projected aging of the Services' weapons inventory, views differ considerably on the merits of the current modernization plan. Depending on one's perspective, it might be judged appropriate, too modest, too expansive, or too unimaginative. For example, a more sensible approach to recapitalization might involve reducing the planned procurement of next-generation weapon systems and relying more on production of new current-generation systems and modifications and upgrades of existing current-generation systems. In turn, the wisdom and feasibility of this approach depend in large measure on how one views the impact on and implications for equipment aging of a wide variety of other factors, including:

- **O&S costs:** Increasing equipment age can lead to much higher O&S costs and reductions in equipment availability and safety. However, age-related O&S cost growth can be prevented or at least mitigated through three different means. The old system may be replaced with a new *next*-generation weapon system, replaced with a new-production *current*-generation system, or substantially modified and upgraded to extend its service life. To decide which of these approaches makes the most sense, one has to look beyond questions about O&S costs and equipment availability and safety.

- **Modernization among potential adversaries:** Compared to the Cold War, most potential US adversaries appear to be modernizing their own forces more slowly. This may suggest that the Services can afford to take a slower approach. On the other hand, the rate of modernization by potential foes could accelerate, and, in any case, is by no means the only rationale for US weapons modernization.

- **Changes in expected standards of performance for US forces:** During the Cold War, the US military was expected to be capable of stopping a Warsaw Pact invasion of Western Europe. But it was assumed that casualties would be high and there was little expectation that NATO would win a quick, decisive victory. By contrast, today it is widely assumed that the US must win any future wars quickly, decisively and with few casualties. This may suggest that US forces must now maintain a greater edge in military capability than in the past.

- **Revolution in Military Affairs (RMA):** It is widely believed that we are in the midst of a RMA that will significantly change the way wars are fought in the future, with the driving forces being advances in technology, especially information technology, combined with

potential changes in military organization and concepts of operation. If this is true, there is a danger that many of the next-generation systems called for in current plans will became obsolete relatively soon after they are acquired. This may suggest that a slower approach to modernization would be preferable for at least the next decade or so.

- **Advances in weapons platforms:** Some observers argue that, with perhaps a few exceptions, over the next decade or two dramatic improvements in platform design and propulsion are unlikely. Instead, they believe the most critical advances are likely to involve "C4ISR" systems, which can be used to locate, identify and track targets, and precision-guided munitions (PGMs), that can be fitted onto existing weapons platforms. Others counter that dramatic improvements in platform design are in the offing, making it critical that the Services invest now in new generations of aircraft, ships and ground vehicles.

- **Precision-guided munitions:** The use of PGMs can increase the effectiveness of current-generation weapons platforms by an order of magnitude or more. Moreover, under current plans the variety and number of PGMs, as well as the number of PGM-capable aircraft and other platforms are projected to increase significantly over the coming decade.

- **Computers, sensors and communications systems:** Many observers believe that the most important advances in military capabilities likely to be made over the next several decades will involve improvements in these technologies. In some instances, it may be necessary to buy new platforms to fully take advantage of advances in computers, sensors or communications systems. However, in many cases advances in these areas can be incorporated into existing platforms through modifications and upgrades.

OPTIONS FOR MANAGING THE DEFENSE CAPITAL STOCK

A wide range of options exist for managing the defense capital stock in the future. Depending on one's views concerning the factors mentioned above, as well as a wide variety of other questions—such as the importance of the current plan's requirement that US forces be capable of fighting two major theater wars (MTWs) in overlapping timeframes—one of the following four illustrative options might appear more appropriate.

- **Current Plan:** Fully funding the force structure, readiness and modernization goals set out during the Clinton Administration would likely require DoD budgets of at least $345 billion a year over the long run, including $80 billion or more annually for procurement. In addition, some $14 billion a year would be required for Department of Energy and other non-DoD defense activities.

- **Place Greater Emphasis on Current-Generation Systems:** Buying fewer next-generation systems, and relying more on current-generation systems and modifications and upgrades of existing systems, could save some $15 billion a year. However, substantially greater savings would be unlikely absent cuts in force structure or readiness levels.

- **Cut Force Structure:** Cutting the size of the US military by some 15–20 percent, while moving ahead with current modernization plans, would yield average annual savings of some $30 billion.

- **Focus on Transforming the US Military:** The largest savings would result from combining greater reliance on current-generation systems with cuts in the size of the force structure. Taken together, this approach might yield total savings of close to $35 billion a year, and still allow for the creation of a $5 billion funding wedge to be used to support R&D and experimentation with new kinds of weapons, forces and concepts of operation. Of course, though it would require the additional funding, such a transformation wedge could be included in any of the other three options as well.

SUSTAINING A HEALTHY DEFENSE TECHNOLOGY AND INDUSTRIAL BASE

Over the long term, the ability of the United States to field effective military forces depends critically on having access to a healthy defense technology and industrial base, one that is capable of developing and producing the right kinds of weapon systems, and doing so in a timely way. The difficulty for US defense planners lies in deciding what kind of access the US military needs to both defense and non-defense industries in order to ensure that it can meet this objective, and in judging how different approaches to recapitalization and modernization will affect that access. At the most basic level, DoD should attempt to foster and maintain an industrial technology and industrial base characterized by four different attributes:

- **Competition**: Some level of competition among defense contractors is important to maintaining an efficient and innovative defense technology and industrial base. Unfortunately, only two or three companies are now active in most key defense market sectors. Fortunately, there are alternative means of encouraging innovation, efficient production and other qualities typically associated with competition. For example, contracts can be written in such a way as to provide even sole-source producers an incentive for cutting costs. Nevertheless, it would be prudent to take steps in at least some market sectors to encourage greater competition.

- **Innovation**: To execute the current defense plan, over the long run some $40 billion a year would need to be provided for R&D. By historical standards, this is a lot of money. Still, the current defense plan may not effectively facilitate innovation within the defense industry. Among other things, it may focus too much funding on full-scale development of systems being readied for production rather than on the earlier stages of R&D, where major technological breakthroughs are generally made. If this problem is to be corrected, steps will need to be taken to ensure that defense contractors can make a reasonable profit even on programs that are limited to prototyping or earlier phases of R&D.

- **Production**: A number of steps should be considered which would facilitate maintaining a defense technology and industrial base that is effective in terms of peacetime efficiency, surge capability and mobilization potential. These steps include encouraging funding/program stability, greater use of multiyear procurement and designing more

commonality in systems. Some of these steps are more consistent with some approaches to modernization and recapitalization than others, but most such reforms would likely be broadly applicable to any of these approaches.

- **Profitability**: Judged by stock valuations, the US defense industry performed relatively well over the past decade. Nevertheless, there is some concern about its long-term prospects, in part because of a decline in stock value experienced between 1998 and early 2000. The rebound since then appears to have been spurred in part by a belief that procurement spending is likely to rise in the future and by declines in the performance of some other sectors of the economy. If there is a change in either of these assumptions, defense stocks may again experience a decline. In that case, consideration should be given to a variety of steps, such as accelerating progress payments or making greater use of multiyear procurement contracts.

The overarching goal of DoD's efforts related to the defense technology and industrial base should be to ensure that, over the next several decades, the United States is able to sustain a base that includes all of the most critical capabilities it might need in the future. Defining these core capabilities is far beyond the scope of this report. But doing so should not be beyond the abilities of DoD and the defense industry. Building on past efforts, DoD and the defense industry need to make a thorough review of the Services' programmatic requirements, as well as the defense industry's financial and other requirements, with the goal of identifying and preserving those unique research, development, production, maintenance, and repair capabilities which, if lost, would be difficult or impossible to replace in a timely manner. Given the contraction in the defense industry that has taken place over the past decade, the days when market forces alone could be trusted to ensure the protection of such critical capabilities are probably over.

I. INTRODUCTION AND OVERVIEW

Since at least the end of World War II, the US military has had a reputation for being the most technologically advanced military in the world. More than any other military in history, the US military has invested in and relied upon advanced weapon systems and other equipment to give it a crucial edge in capabilities. The cost of this investment in technology has been high. During the Cold War, the United States spent an average of about $33 billion a year on military R&D and some $85 billion annually on weapons procurement. But while the cost has been high, most would agree the approach has proven to be cost-effective. Combined with top quality troops and support personnel, realistic training and adequate equipment maintenance and repair, this emphasis on technology has made today's US military by far and away the world's most capable.

By its very nature, technology is a moving target. The US military cannot hope to maintain its current edge in military capabilities—so dramatically illustrated most recently in the war in Kosovo—without investing in the development and production of improved weapon systems. Few would dispute this sentiment. There is, however, considerable disagreement over just how quickly the US military needs to modernize its forces, precisely how those forces should be modernized, and thus, ultimately, how much the United States needs to invest in military R&D and procurement.

Similar disagreements existed during the Cold War. But at that time there was at least a consensus that the Soviet Union represented the most formidable and immediate security challenge confronting the United States. Thus, disagreements over the necessary rate of modernization or the types of new weapon systems that should be acquired were bounded within a narrower range. To support their arguments, all sides tended to focus in large measure on how quickly and extensively the Soviet Union was modernizing its own military. There was also a substantial amount of data available on these trends. Until the last years of the Cold War, the trend was essentially always upward. The Soviet military was progressively and steadily growing more technologically advanced. Moreover, the Soviet modernization program tended to focus on acquiring new generations of the same kinds of weapons it already possessed (e.g., tanks, fighters and submarines). In part reflecting these trends, US modernization efforts tended to follow a roughly similar path.

The relatively rapid rate at which the Soviet Union appeared to be modernizing its forces was by no means the only reason the US military pursued its own modernization plans during the Cold War. Even absent such trends, a substantial degree of modernization would likely have made sense. Other justifications for these modernization efforts include: the cost-effectiveness of trading off quantity for quality; the rate of technological progress; the prospect, at least in some instances, that next-generation systems would prove more reliable and could be kept in service for longer periods of time than existing systems; and the strategy of forcing strategic competition into an area—high technology—where the US military had an enduring edge. Nevertheless, while certainly not the only factor, the rate of Soviet modernization was certainly an important factor shaping DoD's Cold War plans.

It has now become more difficult to measure both what the US military should be buying and how much it needs to spend on modernization. This difficulty arises because there is much less of a consensus concerning a wide variety of important issues related to national security.

For the first time since the early period of the Cold War, the United States must now make hard decisions about a range of strategic issues. At the broadest level, there is disagreement over what the main goals and objectives of US national security strategy should be, how they should be pursued (e.g., by military or non-military means) and what constitutes the most significant threat to those goals and objectives. In more concrete terms, there is disagreement over whether the US military should accord primacy to countering rogue states such as Iraq and North Korea, conducting peacekeeping and forward presence missions, or preparing for the possible emergence of a peer or near-peer competitor. Most observers believe that each of these challenges needs to be addressed, but there is significant disagreement over the relative emphasis they should be given.

There is also disagreement over the extent to which future conflicts are likely to resemble those of today, or whether they will look very different. Some observers, including some members of the new administration, believe that we are in the midst of a revolution in military affairs that will significantly change the way wars are fought in the future, with the driving forces being advances in technology, especially information technology, combined with potential changes in military organization and concepts of operation. Furthermore, they believe that adapting to and exploiting this RMA will require substantially changing the current defense plan, especially plans for recapitalization and modernization. Others believe the current defense plan effectively addresses and reflects the RMA. In other words, more so than at any other time in the past half century, the United States may need to fundamentally reshape its defense plans.

Finally, compared to the Cold War, there is greater concern over the basic health, as well as the structure, of the US defense technology and industrial base—which includes both specialized defense firms and non-defense firms. Among other things, there is concern over whether the current recapitalization and modernization plans, or possible alternatives, will be adequate to sustain an industrial base that is competitive, innovative, capable of efficient production, and profitable over the long run. There is also concern over whether the defense technology and industrial base will be capable of responding effectively to unanticipated changes in the future and effectively meet the Services' needs for both traditional "legacy" systems and potential "RMA" systems.

Given this lack of consensus on such fundamental issues, it is not surprising that there is considerable disagreement over the pace and shape of the US military's modernization plans. The purpose of this report is to inform and illuminate the current debate over the recapitalization and modernization of the US military, not resolve this debate. More specifically, the goal is to educate the reader on how to think productively about recapitalization and modernization issues, summarize a number of alternative approaches that might be taken, and provide rough cost estimates for those different approaches. In short, the report is essentially descriptive rather than prescriptive. Nevertheless, it is hoped that ultimately, by raising the level of debate, this report will help policymakers in their efforts to decide upon an effective capital stock management strategy.

This report comprises seven chapters.

- Chapter II provides an overview of the current national security strategy, drawing heavily on the 1997 Quadrennial Defense Review (QDR), the document that most clearly spelled out the Clinton Administration's view of US security interests, a strategy for dealing with them, as well as program and funding requirements. The Bush Administration is now engaged in its own review of these issues. It is possible that this review will lead to significant changes. Nevertheless, at the time this report was written, the QDR provides the best baseline from which to consider and judge alternative approaches.

- Chapter III discusses several different methodological approaches to estimating the cost of recapitalizing and modernizing the Services' existing capital stock of weapon systems and other equipment. Among other things, it distinguishes between efforts to simply sustain the capital stock and efforts to modernize it. The chapter also provides a brief overview of how the defense capital stock is projected to age over the next decade or two under current plans.

- Chapter IV explores a range of issues that might influence one's view as to the appropriateness of the current modernization plan. These issues include, for example, the effect of increasing equipment age on operations and support costs, the pace of modernization among potential adversaries, and the potential impact of the RMA.

- Chapter V describes and discusses four different options for managing the defense capital stock. These options include executing the current plan, relying more on current-generation systems and upgrades, cutting the size of the force structure, and focusing on a transformation strategy.

- Chapter VI examines the implications of these various options for the US defense industry, as well as some of the ways in which defense industry concerns might affect the different options. The chapter focuses on issues related to competition, innovation, production, and profitability in the defense industry.

- Chapter VII summarizes the insights gained in the preceding chapters of the report and provides some concluding comments on the various approaches to recapitalization that might be pursued.

II. THE CURRENT NATIONAL SECURITY STRATEGY AND DEFENSE PLAN

The 1997 Quadrennial Defense Review was the fourth major review of US defense requirements and strategy completed since end of the Cold War. The first review, conducted in 1991 by the administration of George H.W. Bush, resulted in the Base Force plan. The Base Force envisaged a military that was smaller, but very similar, to that which existed during the Cold War. The second study, the 1993 Bottom-Up Review (BUR), conducted during the first year of the Clinton Administration, called for a military which was smaller still, but again very similar to DoD's Cold War military. The third review, the 1995 Commission on Roles and Missions of the Armed Forces (CORM), focused primarily on making the BUR more affordable.

The administration of George W. Bush is now engaged in the fifth major review of US defense requirements and strategy. It is possible that this review will lead to significant changes in US defense strategy, plans and requirements. Among other things, during the presidential campaign, Bush pledged to increase funding for R&D by $20 billion over six years, consider "skipping a generation" of weapons (i.e., scale back the production of systems that promise only incremental improvements and focus more on new kinds of systems that could provide dramatic improvements in capabilities), and earmark 20 percent of the procurement budget for "leap-ahead" acquisition programs. Nevertheless, until this review is completed, the 1997 QDR provides the best baseline from which to consider and judge alternative force structure, readiness and modernization options.

The 1997 QDR concluded that the United States faces five major near-term and long-term challenges. These include: regional dangers, especially in Southwest Asia and Korea; the spread of advanced technologies, such as nuclear, biological and chemical weapons and advanced conventional weapons; transnational dangers from terrorists, drug traffickers and others; asymmetric threats, such as the use of unconventional warfare; and the emergence of a peer competitor perhaps by 2015. In to protect these interests in the face of the full range of potential challenges, the QDR recommended a strategy of shaping, responding and preparing.

Shaping: According to the QDR, the United States must be able to use its military forces to help shape the international security environment in ways that are favorable to US interests. Doing so involves the use of forward-stationed troops, the deployment of forces in exercises, overseas presence by naval forces, and various cooperative programs. The QDR describes the goals of these efforts as promoting regional stability, preventing or reducing the threat and likelihood of conflict, and deterring aggression and coercion.

Responding: The QDR states that the US military must be capable of responding to crises in order to protect our interests in those instances where efforts to shape the international environment fail or fall short. According to the QDR, the US military must be capable of executing the full spectrum of military operations, including both smaller-scale contingency (SSC) operations (such as show-of-force, peacekeeping, peace enforcement, humanitarian, and limited strike operations) and major theater wars. This MTW requirement is essentially the same

as the major regional conflict (MRC) requirement articulated in the BUR. The QDR states that US forces must be capable of carrying out two MTWs "in close succession" (as compared to the BUR's "nearly simultaneous" requirement).

Preparing: Finally, the QDR concludes that, in addition to shaping and responding to the security environment through the 2015 time frame, the United States must use this period to transform its military so that it is prepared to meet the very different kinds of threats that may develop over the long term, including the possibility that a peer competitor might emerge.

1997 QDR PLAN

The QDR also laid out a defense plan intended to meet the requirements of its proposed strategy. The recommended military includes about 1.37 million active duty troops, 835,000 reserve personnel and some 640,000 civilian DoD employees. Its major force structure elements are presented in Table 1. According to the QDR, these forces are necessary and sufficient to carry out its strategy of shaping, responding and preparing. Put in more concrete terms, the Clinton Administration believed that these forces were capable of carrying out a range of forward presence and contingency operations in peacetime, fighting and winning two MTWs in close succession in wartime, and meeting the kinds of threats likely to emerge over the long term—if those forces were modernized along the lines proposed in the QDR.

If the Bush Administration significantly changes US national security strategy as a result of its ongoing review, it may well also substantially change DoD's long-term plan. On the other hand, as noted earlier, until the new administration's review is completed, the 1997 QDR represents the best baseline from which to consider alternative options.

In terms of force structure, the QDR proposed only modest changes from the plan recommended in the BUR. Likewise, it included no major changes related to near-term readiness. Like the BUR and Base Force plans, the QDR placed a high priority on keeping US forces highly "ready"—i.e., well trained and with equipment kept in good repair. The most significant changes from the BUR in the QDR involved modernization programs.

Table 1: Military Force Structure Summary

	1990	2000	BUR goal	QDR goal
Army				
Active Divisions	18	10	10	10
Reserve Personnel	736,000	555,000	575,000	530,000
Navy				
Active Carriers/Training	15/1	11/1	11/1	11/1
Attack Submarines	97	55	52	50
Surface Combatants	175	116	131	116
Active Wings/Reserve	13/2	10/1	10/1	10/1
Air Force				
Active Wings	24	13	13	12+
Reserve Wings	12	7.6	7	8
Marine Corps				
Marine Expeditionary Forces	3	3	3	3

MODERNIZATION

The QDR recommended scaling back a number of different modernization programs. The main modernization programs scaled back as a result of the QDR were the Services' three new tactical fighter programs: the F-22, F/A-18E/F and Joint Strike Fighter (JSF). The QDR recommended that the Air Force's purchase of new F-22 fighters be reduced from a total of 438 to 339, that the Navy's buy of new F/A-18E/F fighters be cut from 1,000 to between 548 and 785, and that the JSF program be reduced from 2,978 aircraft to 2,852. In addition, the QDR recommended reducing the planned purchase of Joint Surveillance Target Attack Radar System (JSTARS) aircraft from 19 to 13.[1] In the case of the Marine Corps new V-22 tilt-rotor aircraft, the QDR recommended cutting the total program from 425 to 360 aircraft, but accelerating the production rate from a maximum of about 24 a year to a more efficient rate of 30 per year.[2]

Notwithstanding these cuts, the QDR left a substantial modernization program intact. Table 2 lists a range of major weapons programs included under the current plan, along with the quantities to be procured and DoD's estimate of the cost of those plans. (The total cost of DoD's current modernization plans is discussed in Chapters II and III).

[1] Due to congressional action, a total of 15 JSTARS have been procured through FY 2001.

[2] In addition, the Air Force is projected to buy 50 and the Navy 48 of the V-22 variants.

Table 2: Cost of Selected Modernization Programs[3]

Program	Quantity	Cost (billions of current dollars)
Comanche helicopter	1,213	$48.1
Crusader artillery system	480	$4.3 (R&D only)
F/A-18E/F fighter	548	$47.0
SSN-774 attack submarine	30	$65.7
destroyer DD-21	32	$47
LPD-17 amphibious ship	12	$10.7
V-22 Osprey	458	$38.1
F-22 fighter	339	$61.9
Joint Strike Fighter	2,852	$152.5 (billions of FY 2000 dollars)
National Missile Defense	100–250 interceptors	$18.6–35.0

The judgment of the Clinton Administration was that if the QDR's recommended force structure were sustained over the long term, and modernized with these new weapon systems, it would be capable of carrying out the QDR's strategy through the next several decades.

[3] The cost estimates include acquisition costs only (primarily R&D and procurement). They are based on DoD data, except for the JSF and National Missile Defense (NMD), which are based on Congressional Budget Office (CBO) estimates. In the case of the JSF, the figure represents CBO's low-end (i.e., optimistic) estimate.

III. Thinking About Recapitalization and the Current Defense Plan

The purpose of this chapter is to help the reader think about defense recapitalization issues at the macro level. In this analysis, the term "defense capital stock" refers essentially to the US military's inventory of weapon systems (e.g., tanks, aircraft, surface combatants, submarines, and helicopters) and other equipment (everything from radios and trucks to expendable launch vehicles and satellites). For the most part, development of this hardware is funded through DoD's R&D budget and production is funded through DoD's procurement budget. Procurement funding in particular was cut substantially through the mid 1990s. It is widely believed that this funding must be increased significantly over the coming decade if DoD's current modernization plans are to be implemented. Thus, this report, and this chapter in particular, focus primarily on future procurement funding requirements.

Consistent with this definition of the defense capital stock, the term "recapitalization," as used in this report, refers to the need to periodically replace the Services inventory of weapon systems and other equipment, as these systems reach the end of their effective service lives. Like personal decisions about when to buy an new car, or what kind of new car to buy, there is usually no simple answer to the question of when to buy a next-generation weapon system or how capable the next-generation system needs to be. For someone with an old car, the options range from getting the existing car overhauled, to buying a new car of the same type, to buying a much more capable and expensive car. The Services face a similar set of options. This chapter seeks to educate the reader on how to think about DoD's recapitalization requirements, not prescribe any particular approach to meeting those requirements. A range of options for managing these requirements are discussed later in chapter VI.

DoD's recapitalization costs can be only roughly estimated given disagreement and uncertainty over a broad range of factors, including the cost of next-generation weapon systems and the age at which various weapon systems must be retired. Nevertheless, it is important to attempt to estimate these funding requirements to facilitate effective planning. In terms of methodology and basic data, this report draws heavily on a wide variety of sources. Among the most important of these is the Congressional Budget Office, which has published a wide variety of reports concerning defense modernization and recapitalization issues over the past decade, including, most recently, *Budgeting for Defense: Maintaining Today's Forces*.[4]

Sustaining the Defense Capital Stock

CSBA estimates that the total value of all of the weapon systems and other equipment in the US military's inventory today is roughly $1.9 trillion dollars.[5] More precisely, this is how much DoD paid to procure all of the equipment in its current inventory, with those expenditures

[4] Lane Pierrot, *Budgeting for Defense: Maintaining Today's Forces*, (Washington, DC: CBO, September 2000).

[5] Unless otherwise stated, all cost and funding figures provided in this report are expressed in FY 2002 dollars.

inflated into FY 2002 dollars. If one assumes a weighted average service life of some 30 years, consistent with recent history, this suggests that DoD would need average annual procurement budgets of some $65 billion a year to support the current force structure on a "steady-state" basis.[6] In other words, if the goal were to keep the US military indefinitely equipped with the same quantity and the same kinds of ships, aircraft, armored vehicles, and other hardware it has today, DoD would need to spend an average of some $65 billion a year on procurement. On the other hand, if one assumes that equipment can be kept in service for the longer periods projected in current plans—an average of roughly 40 years for major weapon systems—the steady-state procurement requirements for the current force structure would fall to some $50 billion a year.

There is, of course, a certain unreality about this cost estimate. Many of the systems in the current inventory are no longer in production. Indeed, many of these systems, such as the B-52 bomber, the KC-135 tanker, and a number of ship classes, have been out of production for decades. Moreover, even forgetting what would likely be substantial start-up costs, no one would seriously suggest that, over the long term, the most cost-effective way to maintain the capabilities we currently get with the B-52 and the KC-135 would be to buy new production models of those same aircraft.

On the other hand, it seems reasonable to assume that in most cases, *if the Services wanted to*, they could design and produce new systems with comparable capabilities at comparable prices—vice the traditional approach of replacing each generation of weapon system with a next-generation system that is both far more capable and far more costly. In fact, given cost trends in information technology in particular, if the goal were simply to match, rather than improve upon, current capabilities, in many instances one would expect that new-production versions of existing systems could be constructed for *less* than the cost of the original systems.

In practice, no one would seriously propose this approach. Historically, the US military has been well served by an approach which has sought to achieve significant—and sometimes dramatic—improvements in capabilities through force modernization. Successive generations of hardware have consistently cost more to procure than the systems they have replaced, but the increase in capabilities has consistently outpaced the rise in costs. In other words, though costly, over time this approach to modernization has proven to be cost-effective.

Nevertheless, this estimate of the cost of simply maintaining current capabilities is a useful starting point for any analysis of defense capital stock management. Too often, analyses confuse the cost issues associated with *sustaining* the existing capital stock and those associated with *modernizing* the capital stock. These are related, but distinct issues. For example, in recent years, Service testimony regarding the need to buy next-generation fighters, such as the F-22, the JSF and the F/A-18E/F, has often focused on the higher O&S costs and declines in equipment availability (e.g., mission-capable rates) and safety commonly associated with the aging of current-generation systems.[7] However, by itself, such an argument really only makes the case for

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[6] This estimate is weighted for weapon system cost and is based on service lives of major weapon systems, such as ships, aircraft and armored vehicles.

[7] O&S costs include those costs directly related to manning and operating weapon systems, such as the cost of fuel, spare parts, and maintenance and repair activities. O&S costs also include military pay and many indirect and direct

why a particular weapon system has grown too costly or undependable to continue to operate in its current condition. Once that determination has been made, the question remains whether the best solution is to replace it with a new *next*-generation weapon system, to replace it with a new-production *current*-generation system, or to substantially modify and upgrade the existing system to extend its service life.

All three of these paths offer a means of preventing O&S cost growth due to equipment aging, with the latter two approaches having much lower R&D and procurement costs.[8] Thus, to make the case for modernizing, rather than simply sustaining, the existing capital stock, one has to look beyond questions about O&S costs, equipment availability and safety. The case needs to be made that, for example:

- improvements in the capabilities of potential adversaries make the acquisition of a more capable and costly next-generation replacement necessary to *maintain* the US military's current edge;

- the US military needs to *increase* its edge over potential adversaries, and the acquisition of a next-generation system represents the most cost-effective way of doing so;

- the next-generation system, though more costly, would be so much more capable than the existing current-generation system that it could perform the same mission, even if procured and deployed in smaller numbers; or

- unless peacetime production is shifted to next-generation systems, the defense technology and industrial base will be weakened and prove substantially more difficult to mobilize for such production in a timely fashion in the future.

The purchase of more advanced and costly next-generation weapon systems might be justified by any one of these arguments. In the past, these and similar arguments have generally proven persuasive. The point here is simply that these kinds of arguments do, indeed, have to be made to justify modernizing, rather than simply sustaining, the existing capital stock. Reaching judgments about these questions is, in many ways, far more difficult and subjective than making judgments about how long an aircraft, ship, combat vehicle, or other piece of equipment should be kept in service before escalating O&S costs, or declines in availability or safety, make it more economical to buy a replacement.

MODERNIZING THE DEFENSE CAPITAL STOCK

Rather than simply sustaining the existing defense capital stock, as noted earlier, the current defense plan calls for substantially modernizing it. CSBA estimates that fully implementing the

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overhead costs, such as pay for civilian DoD employees, health care, family housing, and military construction costs.

[8] At some point, of course, any weapon system or other equipment will become so old that service life extension is no longer a viable option.

Services' current modernization plans over the next 15 years would require average annual procurement budgets of some $80 billion. By comparison, DoD currently spends about $60 billion a year on procurement. This $80 billion-a-year figure is based on CSBA's best estimate of what the Services' plan to buy over the next 15 years. It also assumes that, consistent with historical experience, the next-generation weapon systems called for under current plans will end up costing substantially more to procure than initially projected by the Services. If the Services could meet their cost goals for next-generation weapons programs, $65 billion a year might actually be sufficient to pay for current modernization plans. Thus, DoD should continue to vigorously pursue acquisition reform. However, if history is any guide, it would be unwise to bank on such efficiency savings.

If such efficiency savings cannot be achieved, over the longer term DoD might have to increase procurement funding substantially above $80 billion per year. This is because, under the Services' current modernization plans, DoD would buy fewer weapon systems each year over the next 15 years than it would need to fully support the QDR force structure on a steady-state basis. For example, under the current plan no bombers, and an average of about 7.6 warships a year would be procured through FY 2015. By contrast, assuming average service lives of some 50–70 years and 35 years, respectively, an average of about 3–4 bombers and 8.6 ships would have to be procured each year to maintain the current inventory goals for these systems on a steady-state basis.

There is no way of estimating precisely how much it would cost to maintain the Services' current weapons inventory goals on a steady-state basis, assuming modernization of that inventory. This is because, in many instances, the Services have not yet specified the new systems with which they plan to replace existing weapon systems. For example, the Air Force has not yet specified the system or systems with which it ultimately expects to replace the exiting fleets of B-52 and B-1B bombers. This is not surprising, since under current Air Force plans neither of these bombers would be replaced until around 2037. But it makes estimating the cost of those replacement systems especially speculative.

In this analysis, cost estimates for systems for which the Services have not yet identified replacements were derived based on historical rates of cost growth between successive generations of similar weapon systems in the past, and a variety of other factors. Using this approach, CSBA estimates that if the current force structure were to be equipped entirely with next-generation weapon systems, the total value of DoD's capital stock would eventually amount to some $3.7 trillion dollars. Even assuming the relatively long service lives projected under the current plan, the steady-state procurement costs of such a modernized force would amount to some $95 billion a year. This is similar to CBO's estimate of the long-term, steady-state costs of the current modernization plan.[9]

[9] CSBA uses a methodology similar to that employed by CBO to project future procurement funding requirements and, in many cases, relies on CBO's estimates of the cost for major next-generation weapons programs. Thus, it would be surprising if the two estimates differed substantially.

AGING OF THE DEFENSE CAPITAL STOCK

Under the Defense Department's current modernization plan, the age of the Services' weapons inventory would increase substantially over the next 15 years. For most of the 1990s, the average age of the Services' inventory of major weapon systems increased modestly, if at all. Even today, the average age of many major weapon systems remains relatively close to what it was a decade ago (See Table 3). The reason the Services' weapons inventory aged relatively little during the 1990s—despite the fact that relatively few weapons were procured during the decade—is because the Services bought large quantities of new weapon systems in the 1980s, during the Reagan buildup, and then in the 1990s cut the size of the force structure by about one-third, with the oldest equipment generally retired first.

Table 3: Average Ages of US Inventories of Major Weapon Systems

Weapon System	1990	2000	2015
Air Force Fighters	11	13	18
Navy/Marine Fighters	10	12	13
Bombers	21	23	38
Attack Submarines	14	13	17
Surface Combatants	16	13	20
Amphibious Ships	19	20	19

Sources: DoD and CBO data.

However, the situation has changed considerably over the past several years. The buildup of the 1980s is receding further into the past, and most of the planned post-Cold War force structure cuts were completed by the mid-1990s. As a result, even assuming the current modernization plan is fully implemented over the next 15 years, the average age of most major weapon systems would be projected to increase substantially.

IV. Judging the Current Modernization Plan and Alternatives

Whether DoD's current modernization plan represents the best, or even an effective, approach to recapitalization and modernization is debatable. Depending on one's perspective, the current plan might be judged appropriate, too modest, too expansive, or too unimaginative. In this section, a number of different issues and factors are considered that bear on this question. However, no attempt is made to provide a definitive answer to this question. Rather, the reader must decide for herself or himself whether these various factors, taken as a whole, suggest that the current modernization plan should be implemented as is, expanded, scaled back, or otherwise changed. Specifically, this chapter considers the:

- effect of increasing equipment age on O&S costs;
- pace of modernization among potential adversaries;
- changes in expected standards of performance for US forces;
- impact of the RMA;
- advances in weapons platforms;
- advances in precision-guided munitions; and
- advances in computers, sensors and communications systems.

Effect of Increasing Equipment Age on Operations and Support Costs

Given the substantial aging projected for the Services' weapons inventory under the current defense plan, it is reasonable to ask what impact that aging is likely to have on O&S costs. As noted earlier, O&S costs include those associated with operating, maintaining and repairing weapon systems and other equipment, such as the cost of fuel, spare parts and engine overhauls. It is widely recognized that, at some point, increasing equipment age tends to lead to higher O&S costs. However, it is difficult to generalize about just how much equipment aging affects O&S costs or the point at which increasing O&S costs make it more cost-effective to pay the substantial up-front costs associated with replacing a given weapon system. The effects of aging on equipment O&S costs, availability and safety vary greatly depending on a wide variety of factors, including the type of weapon system, the intensity with which it has been used and the level of care that has gone into repairing, maintaining and overhauling (i.e., preserving) the system over time.

Existing data concerning the impact of equipment aging on O&S costs is relatively sparse. To be sure, the Services have provided examples of particular weapon systems which have experienced

significant O&S cost growth in recent years, and for which they believe increasing equipment age is a substantial factor. But there is very little publicly available analysis that attempts to relate equipment aging with O&S cost increases on anything like a systematic and comprehensive basis. One exception is a 1999 RAND analysis of Air Force aircraft programs. According to this study, as a result of the increasing age of the Air Force's overall aircraft inventory (which includes not only fighters, but bombers, transports, tankers, trainers, and other support aircraft), Air Force annual O&S costs are likely to increase by $5–6 billion by around FY 2020,[10] with most of that increase projected for the years beyond FY 2010. This cost increase is projected to result from growth in programmed depot maintenance (PDM) costs and engine support costs.

The RAND analysis also points out that there is considerable uncertainty about the magnitude of O&S cost growth likely to result from the projected aging of the Air Force's aircraft fleet.

> Cautious observers argue that the Air Force will encounter new flight-safety, cost, and readiness challenges as it seeks to extend the service lives of its existing fleets. In particular, major problems may result from corrosion, insulation cracking, composite delamination, and other material degradation processes for which there are no scientific aging models or relevant experience. For examples, one need look no further than the C-141 weephole, the VC-137 corrosion workload, and the more recent C-5 horizontal stabilator tie box fitting. If this were to continue to occur, workload growth rates could exceed our high PDM and engine support cost-growth estimates.
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> . . . Production obsolescence for uniquely military components may drive up costs even further. In general, the declining market for military aircraft and related materials has combined with the rapid technological advances of the past few decades to make production of many older military components unprofitable, thereby causing vendors to leave the marketplace entirely. Some older components simply cannot be manufactured any longer. Functionally equivalent replacement components must be designed, tested and produced at considerably higher costs than the originals.[11]
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> . . . Most important, many of the problems associated with aging material have emerged with little or no warning. This raises the concern that unexpected phenomenon may suddenly jeopardize an entire fleet's flight safety, mission readiness, or support costs, and that an extended time period may be required to design, test, and field a replacement aircraft."[12]

On the other hand, the RAND analysis notes that the effect of equipment aging on Air Force PDM and engine support costs could be less than projected in their estimates.

> Optimistic observers hold out the promise that maintenance and modification initiatives (e.g. new corrosion-prevention compounds and

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[10] Raymond A. Pyles, Statement before House Armed Services Committee's Subcommittee on Military Procurement, February 24, 1999, p. 1.

[11] Ibid., pp. 2–3.

[12] Ibid.

> procedures, improved failure tracking) now underway will successfully control age-related and many other support costs. Several one-time, semi-permanent fixes currently taking place (e.g., selective rewiring, selective component replacement, and redesign of obsolete components) aim to substantially reduce the likelihood of future technical surprises while offsetting some effects of age. In addition, improved information systems that compile historical data on maintenance workload should provide additional insights about how the phenomena of aging are affecting specific fleets of aircraft.[13]

Unfortunately, there are no publicly available estimates of the likely impact of equipment aging on the overall O&S funding requirements of the other Services or its impact on other categories of weapon systems, such as ships and combat vehicles. However, assuming the other Services face similar cost growth due to their aging weapons inventory, total annual O&S costs might be expected to increase by as much several tens of billions of dollars by FY 2020.

While certainly speculative, an estimate of this magnitude may not be unreasonable. Aircraft-related O&S costs also account for a large share of Navy, Marine Corps and Army O&S costs. In the case of depot maintenance, for example, for every dollar spent on Air Force aircraft, about 75 cents is spent on the airplanes and helicopters of the other Services. Since the age of aircraft in these other Services is also projected to increase substantially, it might be reasonable to assume that their O&S costs would grow at a similar rate, adding perhaps another $4 billion or so to annual O&S costs by FY 2020. More speculative is the likely impact of aging on O&S costs for ships, combat vehicles and other weapons and equipment. Currently these systems account for more than half of Service-wide spending on depot maintenance. If it is assumed that the O&S costs for these systems would be similarly affected by projected increases in their age, total O&S costs might be expected to rise by another $10 billion a year, bringing total age-related O&S cost growth to some $20 billion a year by FY 2020.

In some sense, this estimate may even understate the potential impact of the aging of the Services' weapons inventories on O&S costs. This is because increased workloads for equipment maintenance and repair may not only cause O&S costs to rise but also decrease equipment availability rates, as aircraft, ships, combat vehicles, and other equipment spend an ever higher proportion of their time at depots and other maintenance facilities.

The fact that O&S costs are likely to grow substantially over the next several decades, due to the aging of the Services' weapons inventory, raises concerns about the wisdom of DoD's current modernization plan. However, the implications of this projected cost growth for defense planning are ambiguous. As noted earlier, age-related O&S cost growth can be prevented or at least mitigated through three different means. The old system may be replaced with a new *next*-generation weapon system, replaced with a new-production *current*-generation system, or substantially modified and upgraded to extend its service life. To decide which of these approaches makes the most sense, one has to look beyond questions about O&S costs and equipment availability and safety.

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[13] Ibid., p. 3.

PACE OF MODERNIZATION AMONG POTENTIAL ADVERSARIES

In judging the merits of the current modernization plan, another factor that should logically be considered is the rate at which potential adversaries appear to be modernizing their own forces. During the Cold War, the United States modernized its forces by buying successive generations of weaponry that often cost two-to-three times more than the systems they replaced.[14] It did not, however, do so because of some immutable law of nature.

Its modernization plans were driven, in part, by the fact that during the Cold War the United States faced a superpower competitor that was rapidly modernizing its own forces, along with a range of potential Third World adversaries that were modernizing their forces with similar speed. That is, the number and type of performance improvements sought by DoD and administration officials throughout the Cold War, and thus the cost paid for successive generations of weapon systems, *were in part based on an appreciation for how rapidly potential adversaries were modernizing their own forces*. In other words, conscious decisions—based, and justified to a great extent, on evidence that potential adversaries were at the same time rapidly modernizing their own forces[15]—played an important part in determining DoD's past level of spending on procurement and R&D.

The relatively rapid rate at which potential adversaries appeared to be modernizing their forces was by no means the only reason the US military pursued its own modernization plans during the Cold War. Even absent such trends among potential adversaries, a substantial degree of modernization would likely have made sense. Other justifications for these modernization efforts include the cost effectiveness of trading off quantity for quality, the rate of technological progress, and the prospect, at least in some instances, that next-generation systems would prove more reliable and could be kept in service for longer periods of time than existing systems. In the case of aircraft, higher unit procurement costs were also made more acceptable by the fact that, as reliability improved, far fewer aircraft needed to be procured to offset normal peacetime attrition due to accidents. Nevertheless, while certainly not the only factor, the rate of modernization among potential adversaries was clearly an important factor shaping DoD's Cold War plans.

An analysis of foreign military spending trends suggests that, taken as a whole, the level and pace of modernization by potential US adversaries has slowed significantly over the past decade. To be sure, defense spending trends represent at best an imperfect proxy for military modernization efforts. Rather than simply looking at foreign defense spending levels, or even foreign procurement spending, it would be better to consider the pace at which various potential

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[14] Comparing unit procurement costs between generations of weapon systems is complicated somewhat by the fact that production rates have generally declined from generation to generation, and lower production rates are often associated with higher unit costs. If procurement rates were held constant, the cost growth experienced between successive generations of weapon systems would be reduced. However, just how much of the cost growth experienced historically can be attributed to the impact of decreasing production rates is difficult to ascertain. As discussed later in this report, low production rates need not lead to substantially higher unit costs if the low production rates are *planned*—that is, if the production facility is built and the workforce assembled with low production rates in mind from the outset.

[15] As evidenced both by spending trends (procurement and R&D) and weapons programs.

adversaries are acquiring new weapon systems, the effectiveness of those new systems, the operational concepts likely to be used by potential adversaries employing these new systems, and the effectiveness of these new forces compared to possible future US forces. Nevertheless, short of such a broad assessment—which is far beyond the scope of this report—an analysis of defense spending trends among potential adversaries would seem to represent at least a reasonable first-cut means of measuring the pace of modernization by those states.

During the Cold War, spending on weapons procurement by potential US adversaries increased substantially. Most importantly, through at least the mid-1980s, Soviet spending on weapons procurement grew at a steady and disconcerting pace. Between 1965 and 1985, for example, DoD estimated that Soviet spending on weapons procurement increased at an average annual rate of some 3 percent in real (inflation-adjusted) terms.[16] Moreover, according to DoD, throughout most of this period, the Soviet Union actually spent more on weapons procurement and R&D than the United States. By the mid-1980s, DoD estimated that the Soviet military was annually spending a total of about $100 billion on procurement[17] and some $50 billion on R&D.[18]

During roughly this same time period, military spending by potential Third World adversaries also grew significantly. According to Arms Control and Disarmament Agency (ACDA) data, between 1967 and 1983 military spending by the developing world increased by some 50 percent in real terms, while the value of arms imports by the developing world more than tripled.[19] In the case of potential adversaries such as Iran and Iraq, both overall military spending and spending on arms imports grew significantly through the late 1970s and early 1980s, respectively.

By contrast, over the past decade or so, overall military spending, and spending on weapons modernization in particular, has fallen dramatically both in Russia and among the most likely US adversaries in the developing world. In 1998, Russia spent only about 16 percent of what the Soviet Union spent on its military in 1985,[20] and the decline in weapons modernization has been even greater.[21] Thus, today Russia spends only a small fraction of what the Soviet Union spent on procurement and R&D during the Cold War.

Similarly, both overall military spending and arms imports by potential adversaries in the Third World have declined dramatically over the past decade-and-a-half. Between 1985 and 1999 the

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[16] Casper W. Weinberger, *Annual Report to Congress, Fiscal Year 1987* (Washington, DC: DoD, February 1986), p. 16.

[17] Ibid.

[18] Thomas P. Christie, Director, Program Integration, Office of the Under Secretary of Defense, Letter to Sen. William Proxmire, Chairman, Subcommittee on National Security Economics, Joint Economic Committee, April 1, 1988.

[19] ACDA, *World Military Expenditures and Arms Transfers (WMEAT)*, *1967–1976* (Washington, DC: US GPO, July 1978), p. 28; and ACDA, *WMEAT, 1990* (US GPO, November 1991) p. 47.

[20] International Institute for Strategic Studies (IISS), *The Military Balance*, *1999/2000* (London: Oxford University Press, 1999), p. 300.

[21] Stuart D. Goldman, *Russian Conventional Armed Forces: On the Verge of Collapse?* (Washington, DC: Congressional Research Service (CRS), September 4, 1997), pp. 8–10.

value of arms deliveries to the developing world fell by about 60 percent.[22] According to International Institute for Strategic Studies, North Korean defense spending declined by some 65 percent between 1985 and 1998. Likewise, IISS estimates that military spending has fallen by some 70 percent in Iran and 90 percent in Iraq over this same period.[23]

The only significant potential US adversary that has not experienced a dramatic reduction in military spending, and weapons modernization spending in particular, over the past decade or so appears to be China. The size and rate of growth of China's military budget can be only roughly estimated. Most experts seem to agree that Chinese military spending has increased significantly over the past decade, perhaps by as much as 50 percent in real terms.[24] Estimates of China's current military budget generally range from roughly $40 billion to $90 billion a year.[25] Trends in Chinese spending on military procurement and R&D are even more difficult to ascertain. However, a reasonable estimate of current Chinese spending might be $10–30 billion on weapons procurement and $2–5 billion on military R&D.[26]

These trends in Chinese military spending overall, and modernization spending in particular, obviously paint a less benign picture than do the trends for post-Soviet Russia and the so-called rogue states in the Third World. Just how worrisome they are, however, and just how much these trends should be seen as offsetting the dramatic downward trends in spending among most other potential US adversaries, is unclear. Among other things, in considering recent Chinese military spending, it is important to remember that it is building from an extremely low base. During the Cold War, China—though its military was roughly the same size as the Soviet Union's—spent only a fraction of what the Soviet Union spent on modernization. Indeed, in 1985, for example, the Soviet Union probably spent at least three times as much on weapons procurement and R&D as China spent on its entire military budget.[27] Even today, Chinese spending on weapons procurement and military R&D pales in comparison to Soviet spending in these areas during the Cold War.

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[22] The value of arms deliveries to the developing world decreased by 59 percent between 1985 and 1995. ACDA, *WMEAT, 1997* (Washington, DC: US GPO, October 1997), p. 100. Between 1995 and 1999, arms deliveries to the developing world fell by about 7 percent from 1995 to 1998. Richard F. Grimmett, *Conventional Arms Transfers to Developing Nations, 1992–1999* (Washington, DC: CRS, August 18, 2000), p. 75. This suggests that overall, arms deliveries to the developing world remain about 60 percent below their 1985 level.

[23] IISS, *The Military Balance, 1999/2000*, pp. 301–02.

[24] Bates Gill and Michael O'Hanlon, "China's Hollow Military," *The National Interest*, Summer 1999.

[25] The lower estimate is IISS's estimate for 1998 Chinese military spending. IISS, *The Military Balance, 1999/2000,* p. 302. The higher estimate is ACDA's 1990 estimate for China increased by 50 percent.

[26] The procurement estimate assumes that roughly 30 percent of Chinese military spending is allocated to equipment purchases. *China: Arms Control and Disarmament* (Beijing: State Council Information Office, November 1995), p. 31. The R&D estimate is based on the assumption that R&D spending accounts for about 6 percent of Chinese military spending. See, Bates Gill, "Chinese Defense and Procurement Spending: Determining Intentions and Capabilities," in *China's Military Faces the Future,* ed. James R. Lilley and David Shambaugh (Washington, DC: American Enterprise Institute for Public Policy Research, 1999) p. 212.

[27] As a result of China's relatively low spending on modernization over most of the past several decades, by one estimate, the value of China's weapons inventory is currently only about one-tenth that of the US military's. Gill and O'Hanlon, "China's Hollow Military," p. 3.

Moreover, while it is certainly prudent to hedge against China's potential to emerge as an adversary, in this case, the term "potential" should perhaps be underlined. Notwithstanding some recent conflicts over human rights, Taiwan, the mid-air collision of a US reconnaissance aircraft and a Chinese fighter, and several other issues, overall US-Chinese relations remain significantly less hostile than US-Soviet relations during much of the Cold War era.

This is not to argue that the pace of DoD's modernization efforts should be dictated by the level of resources our potential adversaries are putting into modernizing their own forces, or that recent trends clearly and unambiguously point to a slower pace of modernization among all important potential US adversaries. Rather, it is simply to note that modernization trends among potential adversaries represents one important factor for policymakers to consider in determining future US modernization funding levels, and that, in stark contrast to most of the past 50 years, recent trends among potential adversaries no longer clearly or unambiguously point to a need to rapidly modernize US forces.

CHANGES IN EXPECTED STANDARDS OF PERFORMANCE FOR US FORCES

Even if most potential US adversaries are modernizing their own forces more slowly than they did during the Cold War, a case can be made that US forces must still be modernized at a relatively fast pace because, by comparison to the Cold War period, today the US military is held by policymakers and the public to much higher standards of performance. During the Cold War, it was expected or hoped that the US military, working with its NATO allies, would be able to stop a Warsaw Pact invasion across the inter-German border, should such an attack be attempted. But it was assumed that casualties among both NATO and Warsaw Pact combatants, as well as civilians, would be high. Moreover, there was little expectation that NATO, even if it was ultimately successful, would win a quick, decisive victory.

By contrast, today the standards of performance for US forces appear to be much higher. Among other things:

- the QDR specifies that the US military should be capable of winning two major theater wars quickly, decisively and in close succession;

- the US military must now be prepared to project power into theaters where it has relatively little peacetime presence (vice the Cold War, when large US forces were deployed forward in central Europe, the expected major theater of operations); and

- it is widely believed by policymakers that the US military must be capable of waging future wars while suffering few casualties among US forces, inflicting few casualties among non-combatants or even enemy military forces and limiting damage to the physical infrastructure of the adversary's state.

The perceived need to avoid US casualties has received perhaps the greatest attention over the past decade. The US military suffered 383 casualties during the 1991 Gulf War. By comparison, in the two major theater wars of the Cold War, in Korea and Vietnam, US forces suffered,

respectively, some 140,000 and 212,000 casualties. In Somalia, the loss of 43 US service members killed or wounded, most of them in a single firefight, played a critical part in persuading the Clinton Administration to withdraw US forces from that country. Most recently, in 1999, US air forces waged a 78-day campaign against Serbian forces in Kosovo and targets throughout much of Yugoslavia without suffering a single combat fatality. The casualties inflicted on Serbian military units and civilians in Yugoslavia were also far lower than those resulting from US air attacks in the Korean and Vietnam Wars.

Given these trends, and the high standards of performance spelled out in the QDR and elsewhere, there is certainly something to the argument that simply maintaining the technological edge US forces enjoyed during, or even at the end of, the Cold War, may not be sufficient in the future. However, it is also possible that at least some of these standards are unnecessary or excessive. For example, is it really necessary that US forces be prepared to win even a second MTW quickly and decisively? Or might it be sufficient that US force be capable of simply stopping the forward progress of an attack in a second MTW until after US forces have successfully concluded the first MTW?

There is also some reason to question the extent to which US policymakers and the public actually suffer from casualty phobia. For example, an argument can be made that the US public was unwilling to tolerate even minimal casualties in Somalia because the US interests involved in that operation also seemed so minimal. Conversely, if US stakes are perceived to be high, as they generally were perceived to be during the 1991 Gulf War, and as might expected in a future major theater war, the public's tolerance for US, and especially enemy, casualties might be much greater.

Lastly, even assuming higher standards of performance are necessary and appropriate for the US military of the post-Cold War world, it is still not clear that the current modernization plan is necessary, or appropriate to achieve that higher standard. Without such wholesale modernization, it is possible that US forces would be unable to carry out the two-MTW requirement and other goals set out in the QDR. On the other hand, as discussed later in this chapter, the deployment of PGMs and the incorporation of advanced electronics into current-generation weapon systems may offer a more cost-effective approach to modernization than the current plan and still provide for the maintenance of a sufficient technological edge over potential adversaries. Moreover, the prospects of an RMA may mean that even fully implementing the current modernization plan could leave US forces ill-prepared to meet the most serious future challenges.

IMPACT OF THE RMA

It is widely believed that we are in the midst of a revolution in military affairs that will significantly change the way wars are fought in the future. The driving forces behind this RMA are advances in technology, especially information technology, combined with potential changes in military organization and concepts of operation. There is, however, little agreement on precisely how the RMA will change the way wars are fought, what the implications are for the organization of the US military and its concepts of operation, or how dramatic the changes in warfare will be. The Services claim that their current modernization plans not only continue to make sense in light of the RMA, but that those plans will effectively exploit the RMA.

Some observers, however, question this assertion. The Joint Chiefs of Staff's vision document, *Joint Vision 2010*, states that "power projection, enabled by overseas presence, will likely remain the fundamental strategic concept of our future force." However, the RMA may dramatically reduce the US military's access to forward bases (e.g., ports, air bases and major fixed supply points). The proliferation of increasingly accurate ballistic and cruise missiles, and the growing access of many countries to satellite imagery, is likely to make such bases increasingly vulnerable to attack. Moreover, this vulnerability may make countries more reluctant to grant US forces use of their bases. Likewise, improvements in long-range strike capabilities, combined with advances in anti-ship mines and submarines, could significantly increase the dangers posed to US surface combatants operating in littoral waters.

Advocates of this view of the RMA do not argue that these trends will necessarily make it *impossible* for US tactical air forces, naval forces or ground forces to be brought into threatened regions during a crisis or wartime. But they do believe that these developments are likely to substantially increase the difficulty and cost of such deployments, as well as greatly limit the effectiveness of those forces once they are deployed. If this is an accurate forecast of trends in warfare, it may make sense to adopt a different approach to force planning and modernization. In particular, these trends might call into question the current plan's focus on the very costly modernization of the US military's already large and effective fleet of tactical combat aircraft, as well as aircraft carriers, relatively large surface combatants and heavy armored forces.

In addition to the emerging anti-access challenge, the US military may encounter a number of other serious operational challenges in the post-transformational world. In its 1997 report, the National Defense Panel (NDP), an independent group of experts appointed to critique the QDR and offer their own view of future security requirements, identified the following challenges:

- projecting power in the absence of forward bases or far inland;
- defending US assets in space and denying enemy access to space;
- defending the US homeland from nontraditional forms of attack, including irregular force use of weapons of mass destruction (WMD), and attacks on the information infrastructure; and
- evicting enemy forces from, and controlling, urban terrain.

Assuming these new, and possibly very serious, challenges are likely to emerge over the next several decades, the US military might seek to exploit for itself the potential the RMA appears to hold for the development of new forms of military operations, including precision and electronic strike, information superiority, and space control. According to some advocates of the RMA, this would mean devoting greater resources to, for example, missile firing ships (e.g., naval surface combatants with vertical launch system (VLS) capabilities, converted Trident ballistic missile submarines, and other submersibles); land-based, extended-range precision artillery (e.g., Army Tactical Missiles (ATACMs) follow-ons); long-range bombers; extended-range PGMs; and unmanned combat aerial vehicles (UCAVs).

Although some advocates of the RMA believe greater resources should be allocated to the development of these systems than called for in current DoD plans, given the high level of uncertainty surrounding the pace, shape and implications of the RMA, at this stage it would certainly be inappropriate to commit to the large-scale production of many of these systems. Likewise, although tactical air forces and other traditional weapon systems and forces may play a less central role as instruments of power in the future than they do today, these forces are likely to continue to play a critical role for many years to come. Thus, even assuming the RMA is likely to develop along the lines discussed above, the best strategy would probably be to adopt a hedging approach to modernization.

Such an approach would likely combine two key elements. One element would consist of a robust program of R&D and experimentation with new technologies, such as converted Trident submarines, extended-range PGMs and UCAVs, and new organizations and concepts of operation. The other element would involve taking a slower approach to the modernization of tactical fighters, surface combatants, and other, more traditional, weapon systems. In place of these next-generation systems, the Services could rely on new production of current-generation systems or substantial upgrades of existing systems to extend their service lives. This approach, along with several other options, is discussed in more detail in the next chapter of this report.

As noted earlier, there is substantial disagreement over the pace, shape and implications of the RMA among military planners and analysts. Among other things, the various schools of thought on the RMA differ in terms of the timing of the RMA and the extent to which it is likely to involve advances in weapons platforms, or be focused primarily on advances in PGMs and computers, sensors and communications systems. As such, some other schools of the RMA support substantially different approaches to acquisition than the one outlined above.

ADVANCES IN WEAPONS PLATFORMS

Whether the projected aging of DoD's capital stock is deemed problematic is likely to rest in part on one's view of whether new weapons platforms (e.g., ships, ground vehicles and aircraft) offer significant enough advances in capabilities to justify their very high costs. At various periods in history, dramatic advances have been made in the design and propulsion of weapons platforms. At other times, improvements have been more gradual and limited. Some observers argue that, with perhaps a few exceptions, over the next decade or two dramatic improvements in platform design and propulsion are unlikely. Instead, they believe that the most critical advances are likely to involve C4ISR systems,[28] such as satellites and various support aircraft, that can be used to locate, track and identify enemy targets, as well as electronics and precision-guided munitions that can be incorporated into existing weapons platforms. Such a precision-strike architecture might revolutionize the way wars are fought, but it would do so primarily because of improved C4ISR support capabilities and PGMs, rather than because of the acquisition of new weapons platforms. Others argue that substantial or even revolutionary improvements in platform design

[28] C4ISR refers to a broad range of command, control, communications, computers, intelligence, surveillance, and reconnaissance systems.

are in the offing, making it critical that the Services invest now in new generations of aircraft, ships and ground vehicles.

Nowhere is this debate sharper than in the case of combat aircraft. Everyone agrees that dramatic improvements were made in aircraft design and propulsion from the 1920s through the 1950s. Toward the end of this era, between the late 1940s and early 1950s, the US air forces transitioned from prop- to jet-powered aircraft. The improvements in speed made possible by the move to jet propulsion were enormous. For example, the P-51 Mustang, the mainstay of the US Air Force at the end of World War II, had a maximum speed of 440 miles per hour. By comparison, the F-86 Sabre used in the Korean War had a maximum speed of nearly 700 miles per hour. Great improvements in aircraft speed continued to be made throughout the 1950s. The F-104, introduced in 1959, had a maximum speed of some 1,300 miles per hour. Because such significant improvements were being made so rapidly, during this period combat aircraft quickly obsolesced. As a result of this fact, and the perception that a major war with the Soviet Union could erupt at almost any time, the Services felt compelled to introduce new generations of combat aircraft at a breakneck pace. Reflecting this trend, between the mid-1940s and 1960, the US Air Force introduced 11 new fighter designs.

Since 1960, improvements in aircraft design and propulsion have continued. Among other things, aircraft engines have become progressively more powerful, efficient and reliable. Moreover, these improvements have enabled the Services to develop and field substantially more effective aircraft. However, these improvements have not led to the kind of dramatic leaps in speed that characterized the 1940s and 1950s. The maximum cruising speed of the F-15, for example, is roughly the same as that of the F-4 introduced some 15 years earlier.[29] This maturing of fighter design and platform capabilities is one reason why the Services began to accept progressively longer service lives for aircraft from the 1950s through the 1990s. This trend is reflected in the steady increase in the average age of the US fighter inventory over this period. The average age of the Air Force's fighter inventory grew from about 2 years in 1955, to 7 years in 1975, to 11 years by 1990. Similarly, between 1955 and 1990, the average age of the Navy's fighter inventory increased from about 4 years to 11 years.

In terms of speed, the F-22 marks something of a departure from the incremental rates of change that have marked successive generations of fighters over the past several decades. It will have a "supercruise" capability, defined as the ability to cruise for sustained periods at Mach 1.5 or higher. However, this capability comes at a very high price. The unit procurement cost of the F-22 is likely to reach some $124 million, between two and three times as much as the F-15. Largely because of this high cost, the Air Force plans to procure only some 339 of these aircraft. By comparison, the Air Force plans to buy 1,763 JSF, which will *not* have a supercruise capability. Likewise, the 548 F/A-18E/F and 1,089 JSF the Navy and Marine Corps plan on purchasing will have no supercruise capability.

[29] To be sure, the F-15 is far superior to the F-4 in terms of maneuverability and several other important performance criteria.

In other words, in terms of speed at least, the Services planned next-generation fighters, for the most part, will represent only relatively modest improvements over current-generation systems. This might suggest that the longer service lives for combat aircraft projected in current plans are appropriate, or even that one or more of these next-generation fighters should be cancelled or deferred, with new-production or remanufactured current-generation systems purchased instead.

Others argue that planned next-generation combat aircraft will provide dramatic or even revolutionary improvements in design and propulsion. In addition to the supercruise capability of the F-22, both the F-22 and the JSF will be designed to be far more stealthy than current-generation fighters. The F-22, for example, is estimated to have a radar cross-section of some .01 square meter, compared to 10 square meters for a typical current-generation fighter. Such a reduction in radar cross-section could reduce the effective range of enemy surface-to-air missile (SAM) tracking radars from some 125 miles to 30 miles.[30] This might suggest that current plans to procure the F-22 and the JSF make sense or even that procurement of these new platforms should be expanded or accelerated.

A similar debate exists in terms of ships and ground vehicles. In their basic design and propulsion, major surface combatants have changed only relatively modestly in the past several decades. This is reflected, among other things, in the fact that the maximum speeds of successive generations of surface combatants have remained relatively constant over time. Nor are dramatic improvements in speed forecast for the future. On the other hand, it may be possible to reduce the radar cross-section of next-generation surface combatants by as much as 50 to 75 percent, and to improve ship propulsion and design by incorporating electric-drive propulsion.[31] In the case of ground vehicles, while dramatic improvements in speed, armor protection and lethality appear unlikely, some substantial improvements in these areas may be possible.[32]

In some cases, next-generation platforms might also be worth procuring because they may be designed in a modular fashion that makes it substantially easier to incorporate modifications and upgrades. Among other things, this might allow for much longer effective service lives. Similarly, deferring the procurement of a next-generation system unless and until it promises a dramatic advance in capabilities may conflict with changes in the way some weapon systems are now developed. This is because, increasingly, weapon systems are developed from the outset with the idea that each new system produced, or block of systems produced, will incorporate new, more advanced design features—allowing potentially revolutionary improvements to be made in an evolutionary manner.

In the end, determining whether or not the pace of technological advance projected for next-generation aircraft, ships and ground vehicles is significant enough to justify their very high cost is beyond the scope of this report. The point of this section is simply to note the likely rate of change and progress in basic design is one of the factors that needs to be taken into account when

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[30] Lane Pierrot, *A Look at Tomorrow's Tactical Air Forces* (Washington, DC: CBO, January 1997), p. 77.

[31] Michael O'Hanlon, *Technological Change and the Future of Warfare* (Washington, DC: Brookings Institution Press, 2000), p. 79.

[32] Ibid.

deciding the appropriate service lives for existing weapons platforms, and whether such platforms should be replaced by next-generation systems, or new-production or remanufactured current-generation platforms.

ADVANCES IN PRECISION-GUIDED MUNITIONS

The use of PGMs can increase the effectiveness of current-generation weapons platforms by an order of magnitude or more. Unguided "dumb" bombs delivered from aircraft often land hundreds of feet from their intended targets. By contrast, many PGMs have accuracies measured in tens of feet. Due primarily to the modification of existing aircraft, over the past decade the number of aircraft capable of delivering PGMs has increased substantially, even as the overall size of the Services' fighter and bomber inventories has declined. Moreover, under current plans the variety and number of PGMs, as well as the number of PGM-capable aircraft is projected to increase still further over the coming decade.

PGMs are by no means the only element in the US military's growing arsenal of precision-strike capabilities. Improvements in C4ISR capabilities (discussed in the next section of this chapter) may be of even greater importance. Moreover, in at least a few instances, new weapons platforms appear to have contributed significantly to those capabilities—as in the case of the F-117 fighter-bomber and the B-2 bomber. Nevertheless, PGMs have in the past, and will continue in the future, to be a critical element in the development of US precision-strike capabilities.

During the Gulf War, the Services employed some 227,000 bombs and missiles against Iraqi targets, about 17,000 (8 percent) of which were PGMs.[33] By comparison, during the war in Kosovo, NATO used some 23,000 bombs and missiles, about 8,000 (35 percent) of which were PGMs. Moreover, during the initial phase of the air campaign, when the weather was bad and concerns about Serbian air defenses were at their greatest, as much as 90 percent of the munitions expended were PGMs. [34]

The use of PGMs not only improved the effectiveness of US strikes against Iraq in 1991 and against Serbian forces in 1999, it also contributed—along with the use of special jamming, reconnaissance and other support aircraft as well as a small number of stealth aircraft—to the extremely low casualty rate suffered by US forces. During the Gulf War, the allied air forces flew some 40,000 strike sorties and suffered 38 combat losses. The loss rate was even lower in Kosovo, where NATO air forces flew some 13,000–14,000 strike sorties and lost only two aircraft to Serbian air defenses. But even the Gulf War loss rate was several times lower than that suffered by US air forces flying missions over North Vietnam during the Vietnam War.

One of the reasons PGMs comprised only a relatively modest share of the munitions used in the Gulf War is that only a limited number of aircraft were capable of employing them at that time.

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[33] Government Accounting Office (GAO), *Operation Desert Storm: Evaluation of the Air Campaign* (Washington, DC: GAO, June 1997), p. 178.

[34] Anthony H. Cordesman, *The Lessons and Non-Lessons of the Air and Missile War in Kosovo* (Center for Strategic and International Studies (CSIS), July 20, 1999), p. 14.

For example, laser-guided bombs (LGBs) were the most widely used, and perhaps the most effective, type of PGM employed by US air forces during the war. However, the ability to employ LGBs during the Gulf War was severely constrained because of the relatively small number of aircraft in the US inventory equipped with laser designators. The United States had only some 300 such aircraft at that time. By comparison, in large part because of the procurement of additional low-altitude navigation and targeting for night (LANTIRN) pods, the number of fighters equipped with laser designators has roughly doubled over the past decade. Moreover, under current plans, the number of such aircraft is projected to grow from some 600 aircraft to nearly 900 by 2010.

The United States currently possesses a vast inventory of relatively modern PGMs. Over the past several decades, DoD has procured some 122,000 air-to-surface PGMs, as well as some 4,000 sea-launched Tomahawk cruise missiles. In order to improve US PGM capabilities and ensure that US forces are capable of effectively defeating the kinds of threats that might emerge in future years, current plans also call for the Services to buy large quantities of new PGMs. Specifically, the Services are projected to buy a total of some 88,000 JDAMs, a relatively inexpensive kit that can be attached to existing dumb bombs, and 24,000 Joint Standoff Weapons (JSOWs), a more expensive unpowered glide bomb. Both weapons will rely (at least in their initial versions) on information from DoD's Global Positioning System (GPS) satellite network for guidance and, as such, will be capable of being delivered from almost any combat aircraft. Their reliance on GPS guidance gives these systems a true all-weather capability, the effectiveness of which was demonstrated during the war in Kosovo. Today, approximately 500 US combat aircraft appear to have been modified to carry the JDAM. By 2010, the number of JDAM-capable aircraft is projected to increase to nearly 2,000.

In addition to these relatively short-range systems, current plans call for acquiring at least 2,400 precision-guided Joint Air-to-Surface Standoff Missiles (JASSMs), which are projected to have a range of some 100 miles. The Navy also plans to procure 1,353 Tactical Tomahawks, a new and less costly version of the Tomahawk cruise missile, beginning in FY 2002. Taken together, these trends in PGM-capabilities suggest that, notwithstanding the projected aging of the Services' combat aircraft inventory, the effectiveness of Services' air forces may grow substantially, perhaps even dramatically, over the next decade.

ADVANCES IN COMPUTERS, SENSORS AND COMMUNICATIONS SYSTEMS

Many observers believe that the most important advances in military capabilities likely to be made over the next several decades will involve improvements in computers, sensors and communications systems.[35] These are the technologies that are most critical to the development of C4ISR systems. C4ISR systems include everything from dedicated satellites and support

[35] For an extensive discussion of the potential for developments in sensor, communications and computer technologies to improve military capabilities, see O'Hanlon, *Technological Change and the Future of Warfare*, pp. 32–67.

aircraft (e.g., JSTARS, AWACs, and EA-6Bs) to target detection and targeting pods fitted onto combat aircraft, or incorporated into other weapons platforms.

PGMs incorporate many of these same technologies. More importantly, the effectiveness of PGMs is highly dependent on the existence of an effective supporting C4ISR architecture. Even a PGM with 100 percent accuracy and lethality would be of little use if, for example, through the use of deception, terrain cover or mobility, an adversary were able to keep his most valuable military assets hidden from view.

In some instances, it may be necessary to buy new platforms to fully take advantage of advances in computers, sensors or communications systems. However, in many cases advances in these areas can be incorporated into existing platforms through modifications and upgrades.

The potential impact of such improvements is most easily measured in the case of computers. The maximum number of computer computations possible per second has increased by roughly an order of magnitude every five years for at least a decade.[36] At the same time, the cost of computing power has declined dramatically. For example, between 1985 and 1990, the cost of a given amount of computing power dropped by a factor of ten.[37] Moreover, these trends are projected to continue for the foreseeable future.

Although the greatest advances may continue to be in the area of computing power, significant advances are also likely in sensors and communications. For example, it has been estimated that as a result of improvements in their cooling elements and other advances, the range of some infrared sensors could be increased by 25–50 percent.[38] Likewise, improvements in radar technology appear likely, among other things, due to the miniaturization of electronic components. For example, while the radar onboard the Joint Surveillance, Targeting and Attack Radar System aircraft used in the Gulf War had a resolution of about 12 feet, it may soon be possible to produce radars with resolutions of only about one foot that can be placed aboard unmanned aerial vehicles (UAVs).[39] As with advances in computer technology, improved sensor capabilities can often be retrofitted onto existing platforms.

One area where it is clear that the Services' sensor capabilities will greatly improve over the coming decade, primarily through modifications made to existing aircraft, is in night-attack capabilities. Under current plans, the number of aircraft equipped with forward-looking infrared (FLIR) systems, or night vision goggles and modified cockpits, is projected to grow from roughly 1,100 today to 1,800 by 2010.

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[36] Kenneth Flamm, "Controlling the Uncontrollable," *Brookings Review*, Winter 1996, pp. 22–25.

[37] Panel on the Future Design and Implementation of US National Security Export Controls, *Finding Common Ground*, p. 254.

[38] O'Hanlon, *Technological Change and the Future of Warfare*, p. 36.

[39] "Gnat Exploits Advanced SAR," *Aviation Week & Space Technology*, August 30, 1999, p. 30; David Mulholland, "New US Radar Increases Possibilities for UAVs," *Defense News*, September 20, 1999, p. 20.

Finally, potentially dramatic improvements in communications capabilities also appear to be on the horizon. Over the past few years there has been remarkable progress in some areas of military communications. For example,

> [i]n NATO's 1999 war against Serbia, new software and procedures were used to hasten the transfer of satellite reconnaissance data and other tactical intelligence to warfighters. In some cases they received it within minutes, rather than the hours or days that had been necessary before. Navy ships in a given battle group can now exchange data between them at the rate of 128 kilobits per second or more. [40]

Moreover, future progress promises to be even more impressive. Some of the most significant advances will likely result from the digitization of communications.

> Digitized information networking on the battlefield is just beginning to come into its own, and major progress will occur as various systems are put in place. For example, experiments have recently been conducted to transfer targeting data originating at an imaging satellite via an AWACS aircraft to an F-15E Strike Eagle fighter over the [joint] tactical information distribution system (JTIDS). This type of rapid routing of information from satellite to a weapons platform has generally not been possible to date.[41]

Taken together, these trends in computers, sensors and communications systems suggests that, for some time to come, retrofitting existing platforms with new electronics will remain a very cost-effective means of improving capabilities. The potential for even very low-cost avionics modifications to yield dramatic improvements in capability was recently noted by the House Defense Appropriations Subcommittee. According the committee, for about $200,000 per aircraft, F-15s could be upgraded with a new datalink ("Link 16"), which allows aircraft to share target information and, tests suggest, could lead to a five-fold improvement in air combat kill ratios. On the other hand, as noted earlier, in at least some instances it may prove necessary to buy new platforms to take full advantage of advances in these technologies. Moreover, some new platforms are designed to be more easily upgradable in these areas. This might make them relatively cost-effective investments over the long term despite their very high, upfront procurement costs.

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[40] O'Hanlon, *Technological Change and the Future of Warfare*, pp. 52–53.

[41] Ibid., p. 52.

V. Options for Managing the Defense Capital Stock

In this chapter four different options for managing the defense capital stock are described and discussed. The first option would be essentially to implement the Clinton Administration's QDR defense plan. The second option would involve slowing the projected pace of modernization and relying more on the continued production of current-generation systems or modifications and upgrades of existing current-generation systems. The third option calls for reducing the force structure to offset some of the costs of modernizing and sustaining the defense capital stock. The fourth option is intended to suggest an appropriate capital stock management strategy that is consistent with one particular approach to transforming the US military and would be affordable within roughly currently projected defense budget levels (See Table 4).

Option 1: Current Plan

One option would be to try to fund the modernization plan formulated during the Clinton Administration. Arguably, that plan is necessary and sufficient to meet the missions and strategy laid out in the QDR. On the other hand, as discussed in the previous chapter, views can and do differ substantially on the question of whether or not the current modernization plan is necessary, sufficient or excessive. In terms of the various considerations discussed in the previous chapter, this option would be generally consistent with the view that the US military must continue to modernize its forces relatively rapidly—notwithstanding the slower approach to modernization exhibited by some potential adversaries over the past decade—among other things, because of the need to meet much higher standards of performance than during the Cold War.

This option would *not* be consistent with the view of the RMA discussed in the preceding chapter. However, as noted earlier, there are a wide variety of views on the pace, shape and implications of the RMA. The approach to the RMA discussed above (and expanded upon later in this chapter) assumes that, in most cases, it will take a decade or more of R&D and experimentation before the implications of the RMA are clear enough to support large-scale production decisions for new weapon systems, and that those new weapon systems may differ substantially from those that are called for under the current modernization plan. By contrast, the current modernization plan would be consistent with a view of the RMA which held: that the implications of the RMA are relatively clear today; that future challenges will differ in magnitude, but not essentially in kind, from those we face today; that weapons platforms, of the kinds included in the current plan—and not just PGMs and computers, sensors and communications systems—offer dramatic advances in capabilities; and that, therefore, the best option would be to begin serial production of the wide range of next-generation fighters, helicopters, aircraft carriers, and other traditional kinds of weapons platforms included in the current modernization plan.

Whether or not the current plan is desirable, it is far from clear that it is affordable. The current defense plan suffers from a substantial mismatch between its likely costs and projected funding levels. Prior to leaving office in January 2001, the Clinton Administration recommended

increasing future defense spending above the levels included in the February 2000 Clinton budget plan. The revised plan would have provided DoD with an additional $53 billion over the FY 2002–07 period, including $14 billion more in FY 2002. Under this proposal, DoD would have been provided $310 billion in FY 2002, and roughly $305 billion annually over the following five years.[42] However, over the long term, the actual costs of the current defense plan would likely substantially exceed the level of funding included even in the revised Clinton plan.

There are a number of reasons why executing the current defense plan would probably require a significant increase in funding in coming years. These reasons include:

- the projected entrance into production of a broad range of new weapon systems, including the F-22, F/A-18E/F, JSF, New Attack Submarine (NSSN), DD-21 surface combatant, and Comanche helicopter;

- the fact that many of these new weapon systems will cost twice as much or more to procure than the systems they are replacing;[43] and

- the likelihood that, as has been true historically, DoD's O&S costs—including military personnel pay, operations and maintenance (O&M) activities, military construction, and family housing—will prove to be significantly higher than currently anticipated.

The long-term costs of executing the current defense plan can be only roughly estimated. A reasonable estimate, however, is that an average of about $345 billion annually would be needed over the next 15 years for DoD to fully implement its current modernization, force structure and readiness plans—including, as noted earlier, an average of $80 billion a year for procurement alone. This suggests that the current defense plan suffers from a plans-funding mismatch of some $40 billion a year over the long run.

If, rather than the current plan, it is assumed that over the long term DoD would need to spend enough to replace all of its current weapons inventory on a steady-state basis, DoD's costs could reach some $360 billion a year, including about $95 billion a year for procurement. In this case, the plans-funding mismatch would appear to average some $55 billion a year over the long run.

For FY 2002, the Bush Administration has proposed a DoD budget of about $310 billion, essentially the same as that recommended in the January 2001 Clinton plan.[44] The Bush Administration's overall budget plan assumes that funding for defense would increase only at the

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[42] Although the Clinton Administration's revised DoD budget proposal was included in Secretary of Defense William Cohen's final *Annual Report to the President and Congress*, released in January 2001, it is unclear whether the proposal was ever approved by the Office of Management and Budget.

[43] Cost growth from one generation to the next varies considerably, depending on the type of weapon system. Historically, such cost growth has been the greater for aircraft than, for example, ships or combat vehicles.

[44] The Bush administration's request also includes some $14 billion for Department of Energy and other non-DoD defense related activities, bringing the total FY 2002 request for national defense to about $325 billion.

rate of inflation in the years beyond FY 2002—that is, that in real terms DoD's budget would stay essentially flat over the longer run. The new administration has, however, stated that it might amend its FY 2002 DoD budget request pending completion of its ongoing defense review. Likewise, the Bush Administration has emphasized that the long-term defense spending projections included in its overall budget plan are simply placeholder estimates that are expected to be revised once its defense review is completed.

Given recent, and growing, projections that the federal government will run significant budget surpluses over the next decade and beyond, the defense budget *could* be increased enough to pay for the current defense plan. However, both major political parties appear to have other, higher priorities. A consensus has emerged that the portion of the surplus generated by the Social Security trust fund should not be used to finance new spending or tax cuts and instead should be used to pay down the debt. This effectively reduces the size of the available surpluses projected by the Congressional Budget Office from about $5.6 trillion over the next ten years to less than $3.1 trillion. Against a surplus of this magnitude, a broad range of costly new initiatives have been proposed. President Bush has proposed a tax cut that would cost at least $1.6 trillion, and possibly more than $2 trillion, over the next decade.[45] The president and others have also proposed initiatives related to expanding or reforming Social Security, Medicare and other entitlement programs, and increasing spending on education, health research and some other discretionary domestic programs. Given all of these other priorities, sustaining even a relatively modest real (inflation-adjusted) increase in funding for defense might be difficult.

Table 4: Summary of Options for Managing DoD's Capital Stock

Option	Description	Average Annual Cost (FY 2002 dollars)*
1.	**Current plan**: maintain QDR modernization, force structure and readiness goals.	$345 billion**
2.	**Place greater emphasis on current-generation systems**: maintain QDR force structure and readiness goals.	$330 billion
3.	**Cut force structure**: use cuts to partially offset modernization costs, maintain planned readiness levels.	$315 billion
4.	**Focus on transforming US military**: place greater emphasis on current-generation systems, cut force structure and provide $5 billion annual transformation funding wedge.	$310 billion

* In addition, roughly $14 billion a year would be needed for Department of Energy and other non-DoD defense-related activities.

** Funding requirements would grow to some $360 billion a year, assuming the QDR force structure's steady-state procurement funding requirements must be met.

[45] The higher figure includes the additional interest payments on the federal debt that would be required due to the proposed tax cut. See, Robert Greenstein, "Cost of Bush Tax Cut Rises," Center on Budget and Policy Priorities, February 13, 2001. At press time, House and Senate negotiators had just reached agreement on a tax cut totaling $1.35 trillion over 11 years (exclusive of additional interest costs).

OPTION 2: GREATER FOCUS ON CURRENT-GENERATION SYSTEMS

Another option would be to reduce the planned procurement of next-generation weapon systems and rely more on both new production of current-generation systems, and modifications and upgrades of existing current-generation systems. Whether or not this option would leave the US military adequately prepared to meet future challenges is debatable. On the other hand, this approach would be substantially less expensive than the current plan. In terms of the various considerations discussed in the previous chapter, this option would be generally consistent with the view that the US military can afford to modernize its forces more slowly than during the Cold War in part because of the slower pace of modernization among key potential adversaries, and despite the higher standards of performance now expected of the US military (alternatively, supporters of this option might reject some or all of these higher standards).

Although differing from the approach to the RMA discussed in the preceding chapter, like the current plan this option would be consistent with an alternative view on the RMA. Similar to the current plan, this view of the RMA holds that the implications of the RMA are relatively clear today. Unlike the current plan, however, this view of the RMA would emphasize the importance for future effectiveness of PGMs and computers, sensors and communications systems, rather than new weapons platforms.

This option would involve making difficult choices concerning: first, which next-generation systems should be cancelled or deferred; second, whether, in place of those foregone next-generation weapon systems, new-production current generation systems should be procured or existing systems should have their service lives extended through modifications and upgrades; and, third, in those cases where service life extension efforts appear appropriate, how extensive those efforts should be.

Answering these questions with any degree of precision is well beyond the scope of this report. In turn, without answering these questions relatively precisely, it is impossible to provide a high confidence estimate of the cost of this option. Instead of answers, this section offers some general observations related to these questions, and provides a very rough, illustrative estimate of the costs and savings that might be associated with such an option.

Among other things, in attempting to determine whether an existing weapon system should be replaced by a next-generation system or a new-production current-generation system, or have its service life extended through modifications and upgrades, it is important to bear in mind the following:

- The latest production versions of current-generation weapon systems are often far more effective than the earlier versions of the system that makeup the bulk of the existing weapons inventory. They are likely to be especially superior to those existing systems that are approaching retirement age. Thus, replacing existing current-generation weapon systems with the latest new-production versions of the same systems represents a decision to modernize, and not simply sustain, DoD's capital stock—albeit generally at a slower pace than modernizing through the procurement of next-generation weapon systems.

- Modification and upgrade efforts can vary dramatically in terms of cost and effectiveness. Typically, efforts aimed simply at extending the lives of existing systems are relatively inexpensive, while those aimed at not only extending their service lives but also significantly improving the system's capabilities can be fairly costly. An example of what might be involved in an effort of the latter type of upgrade is provided by the Marine Corps' ongoing AV-8B remanufacturing program. Under this program 74 older AV-8B Harrier IIs are being upgraded to the most recent new-production Harrier II Plus configuration. The program involves providing each aircraft with a new fuselage, a new higher-powered engine and new avionics, including a new radar and a night-attack capability. The program is also expected to add about 6,000 hours (roughly 20–25 years) to the life of the aircraft.

- Modifications and upgrades can often provide a cost-effective means of not only extending the lives of existing systems but also lowering O&S costs.

- It is often difficult to determine whether the most cost-effective alternative to buying a next-generation system would be producing a new current-generation system, or modifying and upgrading an existing current-generation system. In the case of the AV-8B Harrier II Plus program, for example, although the Marine Corps and Boeing Corporation claim that remanufacturing old AV-8Bs costs only two-thirds to three-quarters as much as buying new-production AV-8Bs, the General Accounting Office has argued that remanufacturing is actually *more* expensive.[46]

- Age alone is seldom a useful measure of whether or not a particular system needs to be replaced. Intensity of usage (e.g., number of flight hours and stressfulness of missions flown) is generally a better measure. For example, with an average age of over 40 years, the KC-135 tanker is usually thought of as an extremely old aircraft. However, based on hours flown, the Air Force has estimated that it might be possible to keep these aircraft in operation for many more decades. Likewise, the Air Force's fleet of C-5 cargo aircraft, which are between 11 and 31 years old, is estimated to have flown only about 20 percent of the flight hours judged possible with that airframe. On the other hand, one also has to look beyond intensity of usage. Corrosion and other factors can seriously reduce the service lives of aircraft and other systems. Thus, for example, corrosion damage, rather than fatigue from over-usage, seems likely to be the main limiting factor for the KC-135 fleet.

- The best solution may vary considerably depending on the type of equipment (e.g., combat aircraft, support aircraft, surface combatants, submarines, auxiliary ships, and combat vehicles). Historically, various types of equipment have typically been kept in service for substantially different periods of time. Likewise, some types of equipment may be better suited to undergo service life extension programs than others. In other words, this is clearly not a case where one size fits all.

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[46] GAO, *Navy Aviation: AV-8B Harrier Remanufacture Strategy Is Not the Most Cost-Effective Option*, (GAO/NSIAD-96-49, February 1996), p. 2.

As noted earlier, without specifying precisely which next-generation systems would be deferred or cancelled, and whether the foregone systems would be replaced by new-production current-generation systems, or have their service lives extended through modification and upgrade efforts, it is impossible to provide a high-confidence estimate of the cost of pursuing this option. However, a reasonable, albeit very rough, estimate of the average procurement costs likely to be associated with such an option might be $70–75 billion a year over the next 15 years. This is roughly the midpoint between the cost of simply replacing the existing capital stock with the same or comparable current-generation systems and the cost of modernizing the existing force structure with next-generation systems as called for under the current plan. Thus, this option would result in procurement savings of as much as $10 billion a year, compared to the current plan. In addition, the slower pace of modernization would yield some R&D savings. If it is assumed the R&D savings would amount to $5 billion a year, total annual savings under this option could reach $15 billion.

OPTION 3: CUT FORCE STRUCTURE

Another option would be to try to eliminate the existing plans-funding mismatch by making reductions in the size of the planned force structure. Whether or not a smaller force structure could effectively carry out the missions and strategy called for in the QDR and elsewhere is debatable. In the near term, force structure cuts would clearly result in some increase in the risks associated with maintaining the two-MTW capability mandated by the QDR. Such reductions would also likely require DoD to reduce its forward presence in some regions of the world, and possibly its level of commitment to contingency operations. On the other hand, over the longer term, improvements in capabilities resulting from force modernization might allow the US military to reduce the size of its force structure and still meet all or most of the requirements specified in the QDR. Such reductions could also yield substantial budgetary savings.

In terms of the various considerations discussed in the previous chapter, like the current plan, this option would be generally consistent with the view that the US military must continue to modernize its forces relatively rapidly. This option's assumptions about the RMA would also appear to essentially mirror the assumptions of the current plan (i.e., Option 1). Among other things, like the current plan, this option would be consistent with a view of the RMA which held: that the implications of the RMA are relatively clear today; that future challenges will differ in magnitude, but not essentially in kind, from those we face today; that weapons platforms—and not just PGMs and computers, sensors and communications systems—offer dramatic advances in future capabilities; and that, therefore, buying the next-generation of traditional weapons platforms called for under the current plan makes sense.

Viewed from a long-term perspective, DoD's past modernization efforts have often been financed in part by cuts in the size of the military. Indeed, over the past 45 years DoD has consistently decided that the best way to improve the overall capability of the US military is to adopt progressively more modern, but also smaller, forces. To be sure, this decision has not always been entirely conscious. Not surprisingly, DoD planners generally wish to replace old equipment with new (and typically much more costly) equipment on a one-for-one basis and to retain existing force structure. However, when budget realities have forced them to choose, they have consistently chosen quality over quantity.

Although US defense spending experienced some fairly dramatic ups and downs during the Cold War, the overall trend was only modestly upward. Overall funding for defense increased at an average annual rate of just under 1 percent over the 1955–90 period. Conversely, over that same period, the number of active duty troops in the US military declined at an average annual rate of just over 1 percent. Illustrative of this general trend is the fact that in FY 1990, despite the fact that DoD's budget was some 30 percent higher than in FY 1955, the number of active duty troops in the US military had declined from 2.935 million to 2.070 million.

Despite the fact that the US military was about 30 percent smaller in FY 1990 than in FY 1955, few (if any) would suggest that the US military that fought in Desert Storm was not at least several (and perhaps many) times more capable than the US military that existed in 1955. There is every reason to believe that this improvement was, in large measure, due to the decision (whether entirely conscious or not) to trade-off quantity for quality—that is, the decision to adopt a progressively smaller but more modern, better-equipped (as well as better educated and trained) military.

From the industrial revolution onward, a similar trend toward increased capitalization is, of course, precisely what has occurred in the civilian economy. Given past trends and the logic favoring increased capitalization in a modern industrialized country, it is almost certainly true that the US military should continue to make this tradeoff in the future—that is, that it should continue to become progressively more capital-intensive over time, even if that means sacrificing some force structure.[47]

A simple extrapolation of the trends of the past 45 years might suggest that by FY 2015 the size of the US military would be projected to fall from today's level of about 1.38 million troops to about 1.2 million. Although smaller, if history is any guide, this force would nevertheless be substantially more modern, and thus more capable, than today's QDR force. This is not necessarily to argue that DoD should, in fact, plan to make reductions of this magnitude over the next several decades. Ultimately the decision as to whether or not to do so will depend on, among other things, the manner and extent to which the US military's missions and capabilities evolve over time (some missions, such as peacekeeping, are more labor intensive than others), the form and scale of the threats to US security, and the level of funding made available for defense. The point is simply that, based on the history of the past 45 years, DoD might be projected to make such a quantity/quality tradeoff.

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[47] Reducing the size of the military need not necessarily mean reducing force structure (e.g., the number of Army divisions, carrier battle groups or fighter wings). In some instances it might be possible and preferable to maintain the same force structure and instead reduce the number of personnel and weapon systems associated with each force structure element (e.g., maintain the same number of fighter wings, but assign fewer fighters to each wing). In other instances it might even be possible to maintain the same number of weapon systems, or even expand the number of systems, in the inventory, if those systems could be made to require significantly less labor to operate and support. In other words, in theory, increasing the capital-intensiveness of the military need not necessarily mean reducing its size as measured in terms of either number of weapon systems or force structure (vice personnel levels). An example of a development that *might*—because of much lower O&S requirements—allow for such an expansion in numbers of systems, even while personnel levels are reduced, would be the replacement of manned aircraft with UAVs.

The historical trend, and seeming logic, of trading off quantity for quality also has implications for the use of steady-state analysis as a means of estimating future procurement funding requirements. Steady-state analysis provides a very useful approach to estimating long-term procurement costs. By drawing attention to those categories of weapon systems where current plans appear to be over-funded or under-funded, relative to steady-state requirements, this kind of analysis can force more rigorous thinking among planners. It also provides a valuable baseline from which one can consider the budgetary effects of changed assumptions about weapon system service lives and inventory goals.

Like any approach to estimating long-term costs, however, steady-state analysis also has some limitations. Perhaps most importantly, this approach imposes fixed assumptions (in terms of equipment service lives and inventory requirements) on what is arguably a dynamic situation. If history is any guide, it seems unlikely that DoD will actually replace its existing inventory of weapon systems on a one-for-one basis or sustain today's force structure indefinitely into the future.

If the US military were projected to continue to make such a tradeoff of quantity for quality in the future, the implications for procurement funding requirements could be substantial. The precise impact would depend on many factors, including specifically which elements of force structure were cut and the pace at which this substitution of capital for labor took place. A simplified illustration of the potential impact, however, is instructive.

If it is assumed that the substitution of capital for labor would continue to allow the US military to cut force structure at an average annual rate of about one percent, as noted above, the size of the US military would be projected to decline by about 15 percent over the next 15 years. This suggests that procurement funding requirements would also decline from the steady-state baseline level by roughly 15 percent over this period. However, in theory such a reduction would not have to wait until FY 2015, but should be possible much earlier. This is because the weapons DoD buys today are not intended to equip the US military of today, but the military that will exist some years down the road. A period of 2–5 years typically separates the point at which funding is appropriated for a weapon system and its actual fielding. Moreover, under current plans, the weighted average service life for major weapon systems is projected to reach some 40 years.[48]

This suggests that today's procurement funding levels may not need to reflect the quantities required to support today's force structure, but rather the smaller force structure likely to exist a decade or more from now. This might understate future procurement requirements somewhat because the weighted average service life for minor procurement may be shorter than it is for major weapon systems. But even assuming a weighted average service life for all procurement of 30 years rather than 40 years, one might expect current procurement funding levels to reflect the quantities needed to support not today's force structure, but the force structure existing 15 years from today. If, as suggested above, the force structure in FY 2015 might well be 15 percent

[48] As noted earlier, this is the projected average age for major weapon systems weighted for cost.

smaller than today's, then today's procurement funding requirements might actually be some 15 percent below the *steady-state* cost of equipping the current force structure.

Under this option, the size of the US military would be cut by 15–20 percent over roughly the next five years and remain at that level through 2015. This would yield average annual O&S savings of some $25 billion compared to the current plan. By contrast, under this option procurement funding would be reduced by only about $5 billion, or roughly 5 percent below the level required to fully implement the current modernization plan.[49] As such, though smaller, unit for unit and troop for troop, by 2015 this force structure would be significantly more modern than the force structure projected under the current plan.[50]

OPTION 4: FOCUS ON TRANSFORMATION

As noted earlier, if we are in the early stages of an RMA that is likely to dramatically change the kinds of technologies that are available and the way wars are fought in the future, DoD will need to take a substantially different approach to capital stock management. This option attempts to describe the main elements of an alternative approach that would focus on the transformation of the US military. Furthermore, it specifies an approach that should be affordable within likely future budget levels.

Before discussing this option in detail, it is important to understand several points. First, there are a broad range of views concerning the RMA. These views differ, among other things, on the timing and the magnitude of the changes likely to be brought about the RMA. This option assumes one particular perspective on the RMA, but certainly not the only perspective. As noted earlier, each of the three other options discussed in this chapter is also, at least arguably, consistent with an alternative view of the RMA. Second, while this approach is specifically designed to be affordable within defense budgets of roughly $310 billion a year, it is not the only option that could be made affordable at this budget level. For example, as noted in the discussion of Option 3, force structure cuts alone would be sufficient to reduce costs to this level if the cuts were made deep enough. Third, while spending would not be increased substantially over the coming decade and a half under this option, it is possible that funding requirements would rise over the longer term. This is because, under this option, the next 15 years would be largely devoted to R&D and experimentation. But by 2015 or so, it would likely make sense to begin large-scale procurement of some of the systems developed over the preceding years.

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[49] This funding level would allow essentially all of the major weapon systems called for under the current modernization plan to be procured in the numbers currently projected. The modest cut reflects the fact that a smaller force structure would, however, allow a reduction in the purchase of some procurement items, such as spare parts and ground support equipment, that are more closely related to operating and supporting the force structure, than modernizing it.

[50] Assuming DoD continued to tradeoff quantity for quality over the longer term, the size of the US military would be projected to decrease still further in the years beyond 2015. If instead it were decided to refrain from any further cuts, either modernization plans would have to be slowed after 2015, or funding for procurement would have to be increased above the levels provided in this option for the next 15 years. This is because the amount provided for procurement under this option would be insufficient to replace the equipment in even this option's smaller force structure with next-generation systems on a one-for-one basis for the indefinite future (i.e., on a steady-state basis).

Indeed, depending on the pace of technological change, the success of transformation-related R&D and other factors, it may make sense to begin moving into large-scale procurement of transformation-related weapon systems by 2010, or possibly even earlier for some systems. In that case, it would likely prove necessary to increase procurement funding above the levels projected for the next 15 years under in this option.

The view of the RMA reflected in this option assumes that future breakthroughs are likely not only in computers, sensors and communications systems, and PGMs, but in some new kinds of weapons platforms as well. However, because of the need to stay within essentially flat budgets and the assumption that that we are in the early stages of an RMA, under this option transformation efforts would focus primarily on R&D and experimentation over the next 15 years. In other words, this option is consistent with a view of the RMA which holds that the RMA's implications for DoD and the Services—while they may ultimately be quite dramatic—are today still rather unclear. Reflecting this assumption, this option would require changing DoD's current approach to capital stock management in several important ways.

First, this option would place greater emphasis on R&D and procurement efforts that support "*wildcatting*": experimenting with a *limited (but operationally significant) number* of a *wide variety* of military systems, as well as operational concepts and force structures. The goal would be to identify those systems, operational concepts and force structures that are capable of solving emerging strategic and operational problems or exploiting opportunities, and of eliminating those which are not. Put simply, given the considerable uncertainty that surrounds the implications and course of the RMA, this option assumes that DoD needs to cast a broad net.

Wildcatting has been a hallmark of successful modernization transformation strategies. For example, the 19th century military transformation at sea saw wooden ships powered by sail yield to ships constructed with metal hulls and powered by turbine engines. During that transformation, among the 30 vessels of the Royal Navy fit to take a place in the line of battle in 1870, there were three types of steam engines, four screw propeller arrangements, 16 varieties of armor protection, 18 hull models, and no fewer than 20 scales of armament. Similarly, during the rapid advances in aviation technology that occurred in the 1920s and 1930s, the US military developed and flight–tested 12 medium and heavy bombers, and nearly 70 attack, fighter and trainer aircraft. None, however, were produced in large numbers.

Should this option be selected, it would be critical that the Services begin wildcatting now. Today even those military systems that are placed on a fast track for development and fielding often take ten years or more to reach forces in the field. Considerable additional time is required to determine how best to employ new military systems and to make the appropriate force structure adjustments.

Second, just as the RMA's lack of clarity at this early stage would make extensive wildcatting critical, it provides a powerful incentive to *avoid "locking in"* to new kinds forces or weapon systems. Lock-in occurs when limited resources are spent to purchase a system in large numbers. The result both narrows the range of options (as fewer types of systems are procured) for dealing with emerging challenges and locks the force into the current state of technological advancement. Resources that could have supported exploring a wider range of systems and sustaining continued

advances in technology are, instead, consumed by the existing force. This may work well if we guess right (i.e., if the fielded force serendipitously turns out to be the right force to meet post-transformation challenges), and if the rate of technological advance slows. If not, we will have committed ourselves to a single-point solution in a very uncertain world. We will have either bought the wrong systems or the right systems prematurely—before the rapidly advancing technologies that enable them have matured.

The US Navy understood this well in the 1920s and 1930s, during the transformation from a battle fleet centered around battleships to one focused on carrier battlegroups. It was unclear whether naval aviation would be optimized by spreading it throughout the fleet (e.g., having a few aircraft on every surface combatant) or concentrated on aircraft carriers. Moreover, it was also unclear what kind of carrier would be optimal. Consequently, the Navy created options for itself by wildcatting. It invested in four classes of carriers, *but only produced six carriers in all*. It also experimented with aircraft on carriers and on surface ships and even tried working with dirigibles.

On the other hand, Britain's Royal Navy, which emerged from World War I with a dominant lead in carrier aviation, chose to lock itself in to existing technology by keeping its carrier force. The result is that the Royal Navy had to absorb operations, maintenance and personnel costs, which limited funding for R&D on naval aviation (which was progressing rapidly), and on new carriers that might have optimized the potential of air power at sea. Moreover, Royal Navy carriers depreciated rapidly in effectiveness as more powerful naval aircraft (requiring bigger carriers) came on the scene. Over time, the Royal Navy saw the US Navy and Imperial Japanese Navy, who entered the competition in naval aviation at a much later date, surpass it and become dominant in this new form of warfare.

As in the past, the goal of DoD's wildcatting efforts over the next decade or two would be the creation of strategic options on a range of military capabilities. These options could be used both to dissuade prospective competitors from resuming a high level of military competition and, in the event dissuasion or deterrence failed, exercising those options to prevail in the competition itself. It is important to note that creating such options need not involve a defense budget train wreck. The US military developed the foundation for strategic aerial bombardment, the carrier navy, modern amphibious warfare, and mechanized air-land operations during the relatively lean budget years of the 1920s and 1930s. What it does imply, however, is a different set of strategic—and budgetary—priorities.

Third, this option would avoid investing enormous resources in *existing* kinds of weapon systems that may not be appropriate for the post-transformation world. DoD's current modernization plans call for the military to spend tens and, in some cases, hundreds of billions of dollars to procure costly next-generation tactical fighters and aircraft carriers, as well as upgraded tanks. But if the view of the RMA discussed earlier in this report is essentially correct, forward bases, ports and airfields are likely to be at high risk of destruction or pre-emption in a future conflict. In that case, we may not be able to forward deploy our relatively short-range tactical air forces, or our heavy digitized divisions, or be able to move our new class of carriers through choke points like the Strait of Hormuz, or even the Taiwan Strait, at an acceptable risk.

In short, this option assumes that future adversaries will present the US military with a very different set of problems than it faced a decade ago in the Persian Gulf or even more recently in

Kosovo. If that is true, then simply pursuing the current modernization strategy may lead us to buy into a defense capital stock that will depreciate rapidly in value far in advance of its expected life cycle. At the same time, the high cost of procuring these next-generation weapon systems also risks crowding out investment in wildcatting opportunities, such as going forward with the streetfighter combatant and Trident conversion, fielding a dramatically different Army division, exploring more fully the systems that could enable the Marine Hunter Warrior concept, and facilitating the Air Force's transformation to a global reach air force. That being said, this option would still entail moving ahead with a substantial number of next-generation weapon systems. As important as it is to hedge for the future by investigating new kinds of weapon systems, forces and concepts of operation, it is equally important to hedge by maintaining robust capabilities in traditional kinds of forces.

Given these considerations and goals, in budgetary terms, an effective and affordable transformation strategy would probably require the following:

- **Providing increased resources for R&D and experimentation**. Just how much should be set aside to fund wildcatting efforts is unclear. However, an average of at least $5 billion a year over the coming decade or two might be necessary. In its 1997 report, the NDP recommended a transformation wedge of some $5–10 billion a year. Most of this funding would probably be allocated to R&D, especially for prototyping and Science and Technology (S&T) programs. S&T is the earliest phase of the R&D process, where the greatest breakthroughs in technology typically occur. S&T programs also tend to be relatively inexpensive. However, some of this $5 billion would also be used for procurement—in cases where limited production runs were required to field a number of systems sufficient for meaningful operational testing.

  It is important to understand that this extra $5 billion a year would not represent the sum total of DoD's spending on transformation under this option, but only the cost of wildcatting efforts. By the end of this decade it is likely that a substantial share of the other R&D spending would also be allocated to transformation—as those efforts initially funded through this transformation wedge are moved into advanced development, in preparation for eventual production. Funding for these advanced phases of R&D would be found primarily by shifting funding away from the development of more traditional systems. It is also possible that less funding would be needed to fund wildcatting efforts by the end of this decade—reflecting the maturation of the RMA—allowing some of that funding to be used to finance advanced development of RMA systems.

- **Scaling back planned acquisition of next-generation weapon systems**. Given the existence of a substantial plans-funding mismatch in the current plan, and the need to provide additional funding for wildcatting efforts, an affordable transformation strategy would have to involve some defense bill payers. Part of this bill would be covered by scaling back or canceling a number of major next-generation weapons programs. In this respect, the RMA option would closely resemble Option 2. As discussed in the previous chapter of this report, given the potential of electronics upgrades, PGMs and other considerations, current-generation weapon systems may well remain effective for some time to come. Conversely,

some of the most costly next-generation platforms called for in current plans may prove to be ill-suited to the post-transformation world, making them poor investments.

- **Placing greater emphasis on current-generation systems**. To compensate for the cancellation of a number of next-generation weapon systems, additional resources will have to be allocated to both new production of current-generation systems and modifications and upgrades of existing current-generation systems. In this respect, too, the RMA option resembles Option 2. The level of savings that would result from this approach would depend on precisely which next-generation systems were cancelled, and whether the foregone next-generation systems were replaced with new-production or modified and upgraded current-generation systems. However, as noted earlier in the discussion of Option 2, a reasonable, albeit very rough, estimate of the procurement costs likely to be associated with such an approach might be $70–75 billion a year.

- **Cutting the size of the force structure**. To make this option affordable within long-term DoD budgets of roughly $310 billion a year, it would also be necessary to make some cuts in the size of the planned force structure. As noted earlier, a 15–20 percent cut in force structure might yield average O&S savings of some $20–25 billion a year over the long run. The $70–75 billion a year procurement funding requirement resulting from taking a slower approach to modernization (adopted in Option 2) might also be further reduced to reflect this smaller force structure, bringing annual procurement costs to some $65 billion a year.

A reasonable estimate of total O&S and procurement savings resulting from this option would be $35–40 billion a year. These savings would be partially offset by the $5 billion a year added for wildcatting efforts under this option. As such, this option might be affordable within long-term DoD budgets averaging some $310 billion a year—the budget level projected for FY 2002 under the last Clinton Administration plan and the amount actually requested for DoD in the first Bush budget submission.

As noted earlier, however, it is possible that by around 2015—or possibly earlier, depending on the pace at which new kinds of challenges emerge and the RMA develops—the cost of this option would increase substantially, as at least some of the new kinds of systems developed and experimented with are put into full-scale development and production. On the other hand, it might be possible to offset much of this cost growth by making deeper cuts in more traditional kinds of weapon systems or force structure if the new kinds of weapon systems put into production promised dramatic increases in effectiveness. In the absence of such reductions, however, the overall procurement budget would likely have to grow well above the $65 billion-a-year level assumed for the next 15 years under this option.

It is also important to understand that, although this option was intentionally designed to be affordable within roughly flat defense budget levels, the view of the RMA articulated here implies a significantly different approach to modernization than the current plan even absent budgetary pressures. Thus, even if DoD's budget were to be increased to some $345 billion a year—roughly the level needed to support the current plan—the traditional modernization programs and force structure cut under this option would not simply be bought back. Instead, given this view of the RMA, most of the additional funding would likely be used to further

accelerate R&D and experimentation and possibly the production and fielding of new kinds of weapon systems.

VI. DEFENSE INDUSTRY CONSIDERATIONS

Over the past decade, a great deal of attention has been focused on how modernization plans and force structure should be changed to reflect the end of the Cold War and budgetary realities. In recent years, increased attention has also been paid to the question of how the Services can continue to recruit and retain quality military personnel in the face of a strong economy, higher operational tempo and other factors, as well as the demands involved in maintaining high equipment readiness levels. By comparison, much less attention has been paid to the question of how the US defense industry is likely to be affected by changes in the shape and level of defense spending and what steps might need to be taken to ensure that the United States retains a healthy and innovative defense technology and industrial base.

This is unfortunate, because, over the long term, the ability of the United States to field effective military forces depends critically on having access to a healthy DTIB, one that is capable of developing and producing the right kinds of weapon systems, and doing so in a timely way. This means that DoD and the defense industry must work to ensure that, over the next several decades, the United States sustains an industrial base that includes all of the most critical capabilities it might need in the future.

This chapter provides a brief introduction to DTIB issues and some general observations about how those issues could—or should—affect future modernization and recapitalization plans. Though it would be helpful, a more detailed analysis of how current plans and alternative approaches would affect the defense industry, or how concerns about the DTIB should perhaps help shape these alternatives, is beyond the scope of this report.

RECENT HISTORY OF THE US DEFENSE TECHNOLOGY AND INDUSTRIAL BASE

The US defense technology industrial base has been marked by two major trends over the past decade. It has shrunk significantly in size and has been substantially consolidated. Between FY 1990 and FY 2000, defense outlays for non-pay purchases[51] (which includes non-pay O&M, plus procurement, R&D and military construction) declined by about 24 percent. Over that same period, defense-related industry employment fell by some 28 percent, from 3.12 million to 2.24 million workers. When a narrower definition of the defense industry is used, focusing on those companies that develop and produce weapons and other equipment, the decline in spending has been even more pronounced. Over the past decade, spending on R&D and procurement, combined, has dropped by nearly 60 percent, while funding for procurement alone has declined by just over 50 percent.

[51] Between FY 1990 and FY 2000, defense outlays for purchases for goods and services (i.e., DoD spending exclusive of pay for military personnel and civilian DoD employees).

These figures may overstate the level of decline in the defense industry to some extent, because FY 1990 represented one of the peak years for Cold War spending on weapons R&D and procurement. Compared to average spending levels of the post-Vietnam (FY 1974–90) period, DoD today spends about 23 percent less on R&D and procurement combined, and some 40 percent less on procurement—still a substantial decline, especially for procurement, where weapons manufacturers have traditionally made their profits.

There has also been a marked decline in the quantity of weapon systems produced. For example, the Services procured 458 tactical fighters in FY 1980 and 300 fighters in FY 1990. By comparison, only 63 fighters were procured in FY 2000. Similarly, the number of warships procured declined from 10 in FY 1980 and 13 in FY 1990, to only 5 in FY 2000. There has been a parallel reduction in the variety of weapon systems produced. For instance, in FY 1980, the Services had eight different types of fighters in production. By FY 1990 the number had declined to six, and only five different fighters are in production today.

The reason for the decline in production quantities is not simply a result of the drop in spending on procurement but the rise in unit procurement costs as well. As noted earlier, each new generation of weapon system typically costs much more to procure than the system it is replacing. This is certainly true with most of the latest next-generation weapon systems. For example, on a unit-cost basis, the F-22 costs two to two-and-a-half times more to procure than the F-15C/D, while the F/A-18E/F costs roughly 50 percent more than the F-18C/D. The higher R&D costs associated with the latest next-generation weapons programs has also indirectly contributed to the decline in procurement quantities. The R&D bill for the F-22 is some $25 billion, roughly three times more than was spent to develop the F-15. That is funding that might otherwise be available for procurement.

The decline in procurement funding, procurement quantities, and types of systems in production that has occurred over the past decade has had a significant impact not only on the size of the defense industry, but its structure. Most importantly, the defense cutbacks that began in the early 1990s helped spur a dramatic consolidation of the defense industry. DoD has identified 12 different industrial market sectors that produce weapon systems or other equipment that is important to US national security (e.g., fixed-wing aircraft, tactical missiles, satellites, surface ships, and tracked combat vehicles). Between 1990 and 1998, the number of prime contractors shrank in 10 of these 12 markets. In three of these sectors the number of prime contractors declined by more than 65 percent, and in six sectors the number of primes dropped by 30–40 percent.[52] Only in submarines and ammunition was there no change. More importantly, the number of prime contractors is now down to two or three companies in all but three of these 12 market sectors.

In many ways, this consolidation has been healthy for both DoD and the defense industry. The end of the Cold War left the US defense industry with substantial overcapacity in many market sectors. Such overcapacity increases design and production costs because it results in excess,

[52] GAO, *Defense Industry Consolidation: Competitive Effects of Mergers and Acquisitions*, (Washington, DC: GAO, March 4, 1998), pp. 6–7.

underutilized production facilities and excess overhead. Defense industry consolidation offered a means of reducing or eliminating this overcapacity. As a result, consolidation yielded substantial cost savings.

However, defense industry consolidation also raises serious concerns about the ability of DoD to continue to reap the benefits of competition over the long term. Through most of the 1990s, DoD believed that the efficiency benefits arising from further consolidation of the defense industry were likely to outweigh consolidation's negative impact on competition. Reflecting this view, DoD generally encouraged consolidation during these years and did little to interfere with how the defense industry restructured itself. But toward the end of the decade DoD seemed to reach the conclusion that defense industry consolidation activity had gone far enough. This was evidenced by the Justice Department's 1998 decision to block Lockheed Martin Corporation's bid to acquire Northrop Grumman Corporation.

Despite the end of the Cold War, and the significant decline in spending on defense acquisition, and especially procurement, most defense stocks have done relatively well during the past decade. Between 1990 and 1997, aerospace/defense stocks increased in value by about 300 percent, compared to about 350 percent for the Standard and Poors (S&P) 500.[53] From 1998 to early 2000, some defense stocks experienced significant declines in value. But since then they have rebounded substantially. Last year defense stocks rose more than any other sector of the S&P 500.[54]

DEFENSE INDUSTRY ISSUES

The United States obviously needs a DTIB that can meet its national security requirements. The difficulty for US defense planners is in deciding the kind and level of access the US military needs to both defense and non-defense industries to ensure that it can meet this objective, and then judging how different approaches to recapitalization and modernization will provide that access. A critical first step in planning for the future of the US DTIB is spelling out a list of desirable characteristics for that base that need to be created or preserved. At the most basic level, at least four characteristics would seem to be necessary. These four characteristics relate to the defense industry's fostering, achieving or maintaining:

- competition;
- innovation;
- production; and
- profitability.

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[53] DoD, *Annual Industrial Capabilities Report to Congress* (Washington, DC: DoD, January 2001), p. 19.

[54] Robert Little, "Clouds Lurk as Defense Shares Rise," *Baltimore Sun*, February 4, 2001.

In the next part of this chapter, these four characteristics are described and discussed in more detail, and considered in relation to three, of the four, alternative options for modernization and recapitalization described in the previous chapter.[55] Specifically, an attempt is made to evaluate how well each of these options would do measured against these four characteristics. It should be noted that these characteristics can overlap and influence each other. For example, the amount of competition in the defense industry may have an impact on both the level of innovation and the efficiency of production. It is also important to stress that these comments represent very much a preliminary, first-cut assessment of the interaction between these various options and desirable industrial base characteristics. In addition, it is worth emphasizing, as is reiterated at the end of this chapter, that an overarching goal of DoD and the defense industry should be to ensure that critical and unique weapons development, manufacturing and support capabilities are preserved over the long run. Doing so will inevitably involve and affect all four of the characteristics noted above and discussed below.

COMPETITION

It is widely believed that some level of competition among defense contractors is important to maintaining an efficient and innovative DTIB—though, as discussed a bit later in this section, opinions differ, sometimes substantially, on the form and extent of competition required. By the simplest of measures—the number of prime contractors active in various defense market sectors—the potential for competition appears to have declined significantly over the past decade. As noted earlier, only two or three companies are now active in most key defense market sectors, including fixed-wing aircraft, submarine and tracked combat vehicle production. By this measure, under the current defense plan, the situation is likely to stay roughly the same, or get modestly worse, over the next several decades.

This may seem odd, given that fully implementing the current defense plan would require annual procurement funding to increase from roughly $60 billion to $80 billion (or $95 billion, assuming steady-state procurement over the long term). One reason such an increase is unlikely to lead to any significant growth in the number of prime contractors in the defense market—and may even lead to some further decline—is that, as noted earlier, the next-generation weapon systems to be produced are generally much more expensive, on a unit cost basis, than their predecessors. As a result, fewer systems can be produced for a given level of funding. In addition, in part reflecting an attempt to offset these higher unit costs, DoD has decided to develop and produce a smaller variety of new weapon systems.

Taken together, these trends mean that defense firms are likely to have fewer opportunities to compete for contracts in the future. Historically, a defense firm that lost one contract could look forward to competing on a new contract in the same market sector in the relatively near future. However, as the variety of systems produced has declined, and the space between the introduction of each generation of weapon system has grown, the opportunities to compete have

[55] Since a force structure cut could be made in conjunction with any of the other three modernization and recapitalization options described in the previous chapter, fully considering the industrial base implications of Option 3 would greatly complicate this discussion. To simplify the matter, force structure cuts are instead discussed only in the context of Option 4 (Note: force structure cuts are an integral part of that option).

shrunk. This is likely to lead more defense companies to leave particular defense market sectors—if not exit the defense business entirely.

Other factors that might lead some firms to exit the defense market, even if procurement funding levels were to increase, include: the perception that higher profits may be possible in the commercial market; the high administrative costs often associated with managing government contracts; the variability and unpredictability of defense spending levels; the limited potential for commercial spinoffs in certain specialized areas of defense R&D and manufacturing; and conflicts over the control of intellectual property and the passing of sensitive data to foreign business.

Holding all else constant, if the number of next-generation systems to be produced were cut, and if greater emphasis were placed on production of new current-generation systems and upgrades of existing systems, then the number of companies in the defense market would be less likely to shrink and might even be expected to grow. This is because current-generation systems generally cost much less to produce than next-generation systems, allowing for an expansion of both the number and variety of weapon systems to be produced, or modified and upgraded within an $80 billion-a-year procurement budget.

Of course, under Option 2, all else is not held constant. Instead, it is assumed that greater emphasis would be placed on the procurement of current-generation systems, at least in part precisely because it would allow the Services to live within lower procurement budgets. As such, under Option 2 it is assumed that the number and variety of systems to be procured would be essentially the same as under the current plan—the difference being that a greater number of the systems procured would be current-generation systems (either new-production or modifications and upgrades of existing systems), rather than next-generation systems. Since the same quantity and variety of systems would be produced under this option as under the current plan, the number of prime contractors in the defense market would also presumably stay essentially the same.

As in Option 2, under the "RMA Option" (i.e., Option 4) the procurement of next-generation weapon systems would be reduced and greater emphasis would be placed on the procurement of new current-generation systems, as well as on modifications and upgrades of existing systems. However, under the RMA Option it is also assumed that some force structure reductions would be made. This would substantially reduce the overall cost of the defense plan. But since it is assumed that procurement quantities would be reduced in proportion to cuts in the size of the force structure, this option might not support as many prime contractors as would Option 2 or the current plan. In other words, since the quantity of weapon systems to be procured would decline somewhat, it might not be possible to support as many prime contractors. However, since the cut in force structure would be relatively modest, the effect on procurement quantities and the variety of systems produced—and thus the number of prime contractors in the defense market—would presumably be relatively small.

More importantly, under the RMA Option, only part of the funding saved by cutting force structure would be used to lower the overall cost of the defense plan. As noted earlier, part of these savings would also be used to fund a $5 billion-a-year transformation wedge. Most of the

funding in this wedge would be used for R&D and, to a lesser extent, procurement. Specifically, as discussed earlier, it would be used to fund wildcatting efforts aimed at developing new kinds of weapon systems, and on occasion to produce small quantities of these systems to allow for operational testing and experimentation in field exercises. These wildcatting efforts would provide additional work for defense contractors, at least partially offsetting the cuts in procurement quantities that otherwise mark this option, and might open opportunities for non-defense firms to enter the market. Moreover, since much of the funding for wildcatting would be used to support contractor design teams, rather than production workers and facilities, as discussed in more detail below, dollar-for-dollar it might represent a better means of preserving competition.

In judging these options in terms of their implications for competition, it is important to note that there is substantial disagreement over the importance of competition among contractors for both efficiency and innovation, as well as the form that competition should take under various circumstances. For example, some observers believe that maintaining competition at the prime contractor level is critical, while others believe it is more important to maintain competition at the subcontractor and supplier levels. Opinions also differ on the importance of maintaining competition at the design versus manufacturing stage.

Still others point out that there are alternative means of encouraging innovation, efficient production and other qualities typically associated with competition. For example, contracts can be written in such a way as to provide even sole-source producers an incentive for reducing costs—i.e., by allowing the contractor to keep a portion of any savings generated by the implementation of new efficiencies. Moreover, under certain circumstances, attempts to maintain competition can actually undermine the goals of innovation and efficient production. An illustration of this would be where work is allocated to two different companies in order to keep them both active in the market, but where doing so means that both must be operated below their minimum efficient production rates. Arguably, this would lead to the worst of both worlds—failure to achieve the efficiency savings that would accrue from consolidation, and no real competition, since in practice the goal of keeping both companies afloat would prevent DoD from ever shifting a significant amount of work from the less-efficient to the more-efficient producer. In the case of R&D, the desire to keep a number of firms in the market to foster competition may mean that no single company receives enough business to preserve the critical mass needed to sustain an effective design team.

It is also important to note that there are ways of encouraging competition in the defense industry beyond simply adding more money and programs. In a 1998 study, the GAO suggested a number of alternative ways to maintain competitive pressures in acquisition programs despite the small number of prime contractors left in most defense market sectors. These include:

- devising strategies to compete various approaches and missions (e.g., using a missile rather than an aircraft);

- requiring major defense contractors to use open-systems architectures in designing weapon systems;

- making sub-tier competition a specific source-selection criterion and contract requirement; and

- exploring opportunities to meet military needs through greater cooperative efforts with international partners.[56]

Innovation

Judging the impact of various approaches to modernization and recapitalization on innovation in the defense industry is even more difficult than judging the impact on competition. To execute the current defense plan, over the long run it is assumed that some $40 billion a year would need to be provided for R&D. By historical standards, this is a substantial amount of money. Indeed, this is about 20 percent more than DoD spent on R&D on average during the Cold War. It is also somewhat more than is projected to be spent on R&D over the next six years, even assuming President Bush follows through on his campaign pledge to provide an additional $20 billion for defense R&D over this period. Nevertheless, there is some reason to be concerned that the current defense plan will not effectively facilitate innovation within the defense industry.

One problem is that, under the current plan, R&D funding is largely focused on the full-scale development of a relatively small number of next-generation systems. As noted earlier, the greatest breakthroughs in technology typically occur at relatively early stages of the R&D process, specifically, in the S&T phase. S&T programs and activities also tend to be relatively inexpensive. Conversely, the engineering and manufacturing development (EMD) phase of R&D, where the finishing touches are put on new designs being made ready for production, is generally very expensive. Unfortunately, under the current defense plan, so much funding may be absorbed by the EMD phase of R&D that relatively little may be left for S&T.

Moreover, because the cost of individual EMD programs has grown so high, only a relatively small number of programs can be supported through EMD, even within an overall R&D budget of $40 billion a year. This also means that, under the current plan, gaps of many years will often separate completion of EMD on one system and development of its follow-on. As such, it may be difficult for the defense industry to keep together the design teams critical to the development of successive generations of weapon systems.

Another problem is that, under the current plan, R&D at all levels is focused primarily on the development of more advanced versions of existing kinds of weapon systems. In other words, R&D efforts are overwhelmingly aimed at developing new generations of manned fighters, scout/attack helicopters, aircraft carriers, artillery systems, and other traditional weapon systems. Only a small amount of funding is focused on researching or developing new kinds of weapon systems, such as UAVs or small streetfighter surface combatants. In short, under the current defense plan, although overall funding for R&D would remain relatively high, the dollars spent might not be optimized to encourage innovation in the defense industry.

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[56] GAO, *Defense Industry Consolidation*, p. 3.

Under Option 2, less funding would be provided for R&D than under the current plan. This is because, under this option, a number of major weapon systems would be cancelled and no new R&D initiatives would pursued in place of the cancelled systems. As a result, this option would do even less to sustain innovation in the defense industry.

Under the RMA Option, more funding would be provided for R&D than under any of the other options. This is because most of the funding in the option's $5 billion transformation wedge would be allocated to R&D. Moreover, less R&D funding would be absorbed by EMD than under the current plan—since, as under Option 2, some next-generation weapon systems would be cancelled. As a result, considerably more funding would be available for S&T programs under this option than under the current plan. In addition, as discussed earlier, under the RMA Option more funding would be allocated to the development of prototypes. Prototyping is generally far less costly than full-scale development. In the case of aircraft, for example, a prototype can generally be built for 25–30 percent of the total development cost of the system.[57] Thus, in theory, by focusing investments at these earlier phases of the R&D process, DoD and the Services could explore a much broader array of new technologies and weapon systems than they could with the current EMD-centered approach to R&D.

The problem with this approach, from a defense industry standpoint, is that, historically, defense contractors have made profits in the procurement phase, not the R&D phase, of the acquisition process. Indeed, in the past, defense contractors have very often lost money on R&D. Thus, if this approach is to be pursued, steps will need to be taken to ensure that defense contractors can make a reasonable profit, even on programs that are limited to prototyping or the earlier phases of R&D. This means that somewhat more would have to be paid to cover prototyping costs than has been the case in the past (when those efforts were generally followed by EMD and, ultimately, profit-making production).

On the other hand, it may be possible to take a number of steps that would help keep prototyping costs under control, or even reduce those costs. These steps might include, for example, making greater use of unmanned, remotely operated systems (the use of human operators tends to drive up the cost of safety requirements) and sub-scale models, and in some cases to focus on the prototyping of only the most critical components of new technologies or weapon systems.

In the end, the effectiveness of this approach to innovation, compared to the current plan, would depend on a variety of factors, including: just how much making R&D profitable would increase the R&D costs associated with prototyping; the extent to which such prototyping would be sufficient to keep together the critical design capabilities of various defense contractors; and, perhaps most importantly, the degree to which emerging challenges do, in fact, turn out to require the new kinds of capabilities developed through the prototyping and S&T efforts funded under this option.

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[57] Office of Technology Assessment (OTA), *Building Future Security: Strategies for Restructuring the Defense Technology and Industrial Base* (Washington, DC: US GPO, June 1992), p. 71.

PRODUCTION

From a DTIB perspective, there are at least three different measures by which production capabilities might be judged. First, there is the question of how efficiently—in terms of cost and quality—the DTIB can produce the weapons and other hardware needed to keep the military fully equipped in peacetime. Second, there is the question of how much production can be surged in a crisis or time of war. Third, there is the question of how quickly and effectively the commercial industrial base can be mobilized to support military production in the event a new peer or near-peer competitor were to emerge.[58]

Before considering how each of the various modernization and recapitalization options described in this report might fair judged by these criteria, it is important to understand that, to some extent, these characteristics may conflict with each other. For example, the efficiency of peacetime production is obviously reduced—and thus unit procurement costs increased—where the workforce and production facility used are larger than necessary to support the desired production rate. On the other hand, by definition, this excess workforce and plant capacity provides a more significant surge capability than would a more streamlined workforce and plant.

In terms of peacetime production, the current defense plan might be relatively efficient, at least assuming the plan is fully funded and the funding is provided on a stable profile.[59] Although fewer varieties of new weapon systems would enter production under the current defense plan than during past modernization efforts, most of those that are scheduled to enter production would be pursued in essentially the same way. As in the past, most of the next-generation aircraft, ships, helicopters, and other systems projected to go into production in the current plan would be procured in relatively large numbers and at relatively high production rates—and presumably the workforces assembled and plants constructed would be sized to economically produce in those numbers and at those rates.

By contrast, surge production capabilities under the current plan would likely be more limited than has been the case historically, for several reasons. Perhaps most importantly, there are some weapon systems for which, under the current plan, no new production is projected for many years. At the extreme, under the current plan, no new bomber would be put into production for about 20 years. In these cases, there would be little or no surge capability. Instead, the production capability would essentially have to be reconstituted. How long this would take would depend on a variety of factors, including how closely the system resembled other weapon systems currently in production, or similar systems being produced for the commercial market. The greater the overlap, the more easily and rapidly it might be possible to reconstitute the production base.

But even in the best of circumstances, it may be that the surge capabilities of the defense industry will be relatively limited in the future—at least compared to the surge capabilities displayed by

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[58] Ibid., p. 79.

[59] It is possible that, in some instances, currently planned production rates are substantially below minimum economic rates. However, as discussed later in this section, even very low production rates may be relatively efficient if that rate is assumed at the time the production facilities and workforce needed to execute the program are established.

the defense industry during World War II, Korea and even later wars. This is not simply a reflection of likely budget constraints. It also reflects the complexity of many new weapon systems, and the highly specialized skills and components needed to produce them. As such, the US defense industry is likely to experience a decline in its ability to surge production of major weapon systems in coming years. In other words, absent a warning period measured in years or as much as a decade, more so than in the past, future wars are likely to be fought primarily with the weapon systems and other equipment on hand when the conflict breaks out.

The potential for mobilizing the civilian economy is perhaps the most difficult measure by which to judge the different modernization and recapitalization options described in this report. On the one hand, it could be argued that, given the reduction in the variety and number of weapon systems in production, under the current plan greater emphasis needs to be placed on preparing for possible mobilization of the civilian economy for military production in the future. On the other hand, if it is assumed that a peer or near-peer competitor will not emerge for at least a decade or two, and that its emergence will be recognized early on, there may be little need to take any special steps now to prepare for mobilization.

As discussed earlier, Option 2 would involve moving ahead with the procurement of some new next-generation systems, and scaling back some others. It would likely make sense to cancel outright at least several of these systems. Cancellations tend to be the most efficient in narrow economic terms, because they may allow R&D costs to be avoided and do not result in the higher unit procurement costs that often result from decisions to scale back, but not cancel, programs. On the other hand, in some cases it may be possible to minimize these penalties or be worth paying them, and the best decision would be to scale back, rather than cancel, production.

The outright cancellation of a handful of planned next-generation systems, and the scaling back of some others, would free up funding that could be used to support the continued production of some current-generation weapon systems, or upgrades of existing systems. Moreover, some production of current-generation systems or upgrades would be needed to offset the reduction in planned purchases of next-generation systems. Because next-generation weapon systems tend to be much more expensive than current-generation systems, the reductions in planned purchases of next-generation systems assumed in Option 2 would more than offset the cost of additional production of current-generation systems. To simplify matters, under this option it is assumed that in place of foregone next-generation systems, new-production current-generation systems, or upgrades, would be procured on essentially the same schedule originally planned for the cancelled or scaled-back system. As such, the production rates and profiles would be essentially the same. In turn, this suggests that, overall, peacetime production would be equally efficient under this option as under the current plan.

On the other hand, the surge capability would arguably be even less under this option than under the current plan, for several reasons. First, greater emphasis would be placed on modifications and upgrades. From an industrial base perspective, this approach offers a means of preserving the core elements of a weapon system's production base at a lower cost than actual production. However, modification and upgrade efforts are unlikely to involve *all* of the core personnel, skills and facilities that would be needed for production. Second, while under Option 2 any surge capability would involve, at least initially, the production of a mix of additional current- and

next-generation systems, under the current plan the surge capability would primarily involve the production of—presumably substantially more effective—next-generation systems. Third, because next-generation systems are both more costly and complex, the workforce needed for peacetime production, and thus available for surging, would be larger under the current plan than under this option.

However, in cases where an extended period of warning were available within which to respond to the emergence of a peer or near-peer competitor, this option might be relatively cost effective. While under Option 2 that portion of the DTIB engaged in the production of current-generation systems would initially only be capable of surging the production of those same systems, over the longer term, it might be possible to convert much of the workforce and physical plant used to produce current-generation systems to the production of next-generation systems.

In terms of the impact on the defense production base, the RMA option closely resembles Option 2 in some key respects. Like Option 2, it would involve moving ahead with the procurement of some new next-generation systems, scaling back some others, and using part of the savings generated by these cuts to procure additional current-generation weapon systems, or modifications and upgrades of existing systems. However, under this option greater attention would be paid to preserving the defense production base.

One way of doing so would be to rely on low-rate production more often than in the past. During the Cold War, when the US military needed to equip a larger force structure, and the production of one generation of a weapon system was typically followed relatively rapidly by the production of a follow-on generation, the most cost-effective approach to procurement generally involved high-volume purchases and high production rates. In today's environment, where the force structure to be equipped is much smaller, and the years between successive generations of hardware are often much longer, low-rate production will often make more sense. Absent such a change, production gaps would occur in which critical workers, skills and manufacturing facilities might well be lost. Conversely, low-rate production would ensure the preservation of core production workers, skills and facilities.

One downside of this approach is that it might lead to higher unit procurement costs. This has often been the result of past decisions to cut production rates. However, in many cases the impact might be minimal. In the past, the adoption of lower production rates has often resulted in higher unit procurement costs, not so much because the new rate was necessarily too low to allow for efficient production, but because it was lower than the planned production rate—the rate for which the workforce was assembled and the facility built. In other words, while *unplanned* cuts in production rates (i.e., "stretchouts") usually result in inefficiencies (i.e., higher unit procurement costs), *planned* low production rates are not necessarily inefficient.

Under this option, the minimum production rates necessary to preserve core manufacturing capabilities in various industrial sectors would have to be determined, taking into account the entire manufacturing base—prime contractors, subcontractors and suppliers. A premium would be placed on ensuring that, once it is set, this minimum production rate is maintained so that producers can make major organizational and capital-investment decisions with confidence.

In sum, the greater use of low-rate production would tend to modestly decrease the efficiency of peacetime production (i.e., lead to higher unit procurement costs). But it would ensure that a wider variety of systems were in production at any given time than would be the case under the current plan or Option 2. As such, it would allow for the surge production of a broader range of weapon systems during time of crisis or war—though, as noted earlier, in any case surge capabilities may be quite limited. Likewise, it would preserve the industrial base in a broader range of market sectors, which might be important for efforts to mobilize production capabilities over the longer term, in response to the rise of a peer or near-peer competitor.

Although greater emphasis would be placed on low-rate production under this option than during the Cold War, or under the current plan or Option 2, low-rate production would not be appropriate for all weapon systems. In the case of both some next-generation systems and some current-generation systems, a better approach might be to produce the weapon system at high production rates and then close down the production line. In this event, some steps might be taken to make it easier and less costly to eventually restart production of the system or a follow-on system. At the extreme, these steps might involve laying away and preserving the physical portions of the relevant industrial base—including not only the production facility itself, but important subcontractor and supplier facilities. It might also include stockpiling some parts and other long-lead items.

Whichever approach to modernization and recapitalization is selected, a number of other steps should also be considered which would facilitate maintaining a DTIB that is effective in terms of peacetime efficiency, surge capability and mobilization potential. These steps include the following:

- **Funding/program stability:** making frequent changes in planned procurement quantities or funding levels often results in inefficient production rates and higher unit costs.

- **Multiyear procurement:** by adding greater predictability to production plans, multiyear procurement contracts can lower unit procurement costs.

- **Funding international collaborative production programs:** allows access to a broader international DTIB.

- **Increased foreign sales**: by increasing procurement quantities, foreign sales can lower unit costs for DoD, and allow for the preservation of segments of the US DTIB from which DoD is not currently making purchases.

- **Innovations in manufacturing technology:** can lead to improved production efficiencies resulting in both cost and quality improvements.

- **Designing more commonality in systems:** increased commonality could make the DTIB more efficient, among other things, by allowing DoD to reduce redundant procurement programs.

- **Greater use of commercial off-the-shelf (COTS) technology:** COTS technology tends to be less expensive than military-unique technology. Perhaps more importantly, increased use of COTS technology would result in a DTIB that is more thoroughly integrated into the civilian economy, improving both surge and mobilization capabilities.

There are tradeoffs involved in these different approaches and some of them, if pursued too far, could harm US national security. For example, extensive use of multiyear procurement contracts could substantially reduce flexibility in DoD budgeting, something that might be especially important for allowing the rapid exploitation of RMA technologies that show great promise at the R&D stage. Likewise, given the inherent uncertainty surrounding international affairs, it is always possible that weapon systems sold abroad could be used against US forces. Alternatively, such sales may fuel regional arms races. Finally, greater collaboration with foreign defense contractors could result in the intentional or inadvertent leaking of sensitive data. Thus, some of these steps will only make sense if pursued in a balanced and limited way, while others should perhaps be pursued more broadly.

PROFITABILITY

As noted earlier, at least judged by stock valuations, the US defense industry performed relatively well over the past decade. Nevertheless, there is some concern about the defense industries' long-term profitability and its ability to raise the capital it needs maintain a healthy design and production base. This concern stems in part from the significant decline in stock value experienced by the defense industry in general, and several of the largest defense firms in particular, during 1999 and early 2000. The rebound in stock valuation since then appears to have been spurred by, among other things, a belief that procurement spending is likely to rise in the future, perhaps substantially, and by declines in the performance of some other sectors of the economy, especially certain high-tech stocks, which have made defense stocks appear more attractive.

If there is a change in either of these assumptions (i.e., little or no increase in procurement funding materializes, or the currently falling technology market improves), it is possible that defense stocks will again experience a decline in value. At the beginning of 2000, in response to the drop in defense stock prices, a panel of experts was convened by DoD's Defense Science Board (DSB) to recommend changes that would help improve the health of the US defense industry. Given the recent rebound in defense stocks, it is unclear whether all of the changes recommended by this panel need to be implemented. But serious attention should be given to each of the recommendations. The overall goal should be to ensure the defense firms face reasonable risks and enjoy the prospect of reasonable rewards. The DSB panel's recommendations include the following:

- revise policies to enhance access to technical capabilities and talent by removing barriers between defense and commercial technology and industrial bases.

- increase the amount contractors receive in progress payments for work completed on a program from 75 percent to 85 percent.

- increase funding for R&D in areas intended to stimulate innovation, such as S&T.

- encourage aggressive cost reduction programs by sharing the savings with industry and revising profit guidelines.

- approve more multiyear contracts to reduce the uncertainty that defense contractors face and allow for more predictable (and thus efficient) production runs.

- reduce the barriers faced by US companies attempting to export weapon systems and other equipment.

Some of these recommendations may make more sense in relation to some of the modernization and recapitalization options described in this report than others. For example, restructuring contracts to improve the profitability of R&D may be more important for the RMA option than for the other options. But for the most part, whether or not these recommendations should be adopted will depend on questions that transcend the specifics of any particular approach to modernization and recapitalization.

PRESERVING THE CROWN JEWELS OF THE US DEFENSE INDUSTRY

As noted earlier, an overarching goal of DoD's efforts related to the DTIB should be to ensure that over the next several decades the United States is able to sustain a base that includes all of the most critical capabilities it might need in the future. Defining these core capabilities is far beyond the scope of this report. But doing so should not be beyond the abilities of DoD and the defense industry. Building on past efforts, DoD and the defense industry need to make a thorough review of the Services' programmatic requirements and the defense industry's financial and other requirements, with the goal of identifying and preserving those unique research, development, production, maintenance, and repair capabilities which, if lost, would be difficult or impossible to replace in a timely manner in the future. The fact that we may be entering a period of dramatic change in technology and the way wars are fought and the prospect that defense acquisition budgets may remain relatively tight, despite improved federal budget surplus projections, makes such an effort all the more critical.

Preserving these core capabilities will not be cost-free. For example, in some cases it may mean continuing the production of systems or components that might otherwise be deemed low priority. Similarly, in some cases, efforts to preserve certain capabilities may run counter to fostering one or more of the desirable characteristics discussed above. But given the importance of sustaining a robust and responsive DTIB, selective investment in critical core areas is likely to prove worthwhile. Moreover, the costs are likely to be more modest if the effort to identify critical core areas, and solutions to the loss of these areas, is begun sooner rather than later, and done explicitly and in a structured way, rather than on an ad hoc basis. Given the contraction in the defense industry that has taken place over the past decade, the days when market forces alone could be trusted to ensure the protection of such critical capabilities are probably over.

VII. CONCLUSION

As this report makes clear, there is no simple way of deciding how much money the United States needs to spend recapitalizing and modernizing its military over the next several decades. The cost of various approaches to recapitalization and modernization depends in large part on the extent to which one believes: the Services' existing inventory of weapon systems should be replaced by next-generation systems, new-production current-generation systems, or modifications and upgrades of existing current-generation systems; DoD should continue to tradeoff quantity for quality; and the RMA is likely to change the kinds of challenges confronting the US military and the way wars are fought in the future. Depending on one's views on these questions, annual procurement budgets of as little as $65 billion or as much as $95 billion might be needed to keep the US military adequately equipped over the long run.

In turn, one's answers to these questions are likely to be influenced by views concerning a broad range of other factors, including: the effect of increasing equipment age on O&S costs; the pace of modernization among potential adversaries; changes in expected standards of performance for US forces; and the nature and pace of advances in weapons platform design and propulsion, PGMs and computers, sensors and communications technologies.

In the end, the question that has to be asked is: which approach to recapitalization and modernization will best minimize the overall risks to US security, over both the short term and long term? Defense planning and strategy is to a large extent about making tradeoffs between different desirable goals and objectives, and doing so within realistic resource constraints. As a result, there is no way to simultaneously minimize *all* of the security challenges confronting the United States. In the real world, minimizing one kind of threat is, by definition, likely to mean accepting a somewhat greater risk from some other kind of threat. Perhaps most importantly, an attempt to minimize near-term threats and challenges may require the acceptance of somewhat greater risks to long-term security. Among other things, this is because the kinds of investments most critical to maintaining near-term capabilities are not the same as those needed to sustain capabilities over the longer term.

For example, a country expecting a major war within the next couple years would likely want to focus its spending on O&S activities, so that it could maintain a large and highly ready military. By contrast, under such circumstances major investments in procurement, and especially R&D, might be foolish, since it would be several years—to a decade or more—before those investments would result in the fielding of new, more capable, weapon systems. Conversely, a country facing little prospect of war in the near term, but fearing for its long-term security, might be expected to invest relatively more in procurement and R&D, and accept some reduction in force structure or readiness in order to maximize its future capabilities.

Today, of course, the United States faces a mixture of threats and challenges, some near-term, some medium-term and some long-term. The question is what approach strikes the best balance between minimizing near-term and long-term challenges to US security? That is, which best minimizes the *overall* risks to US security?

If fully funded, the current defense plan would provide potent capabilities against relatively near-term challenges. Under the current plan, the force structure would be kept at roughly 1.37 million active duty troops. According to the 1997 QDR, such a force structure would be sufficient both to carry out a wide variety of forward presence and contingency operations in peacetime, and to wage two nearly simultaneous MTWs, if called upon to do so, in wartime. There is some debate over whether the QDR force structure is indeed sufficient to carry out these tasks. But of the four options considered in this report it would clearly have the greatest near-term capabilities.

Option 2 would provide similar capabilities over the next several years, but would become progressively less capable, compared to the current plan, over the next decade or so. Its capabilities would be essentially the same as the current plan over the next few years. This is because the force structure would be kept the same size and it would be at least several years before the slower pace of modernization taken under Option 2 would affect the capabilities of the fielded forces. However, by 2010 or 2015, the differences between the current plan and Option 2 would become more noticeable.

Option 3 would result in a near-term reduction in capabilities compared to the current plan, due to the reduction in the size of the force structure. It might therefore prove necessary to change the strategy spelled out in the 1997 QDR. In particular, it might be necessary to reduce the US military's engagement in forward presence and contingency operations and to accept greater risk in terms of the current two-MTW requirement. Alternatively, the United States could replace the current two-MTW requirement with a win-hold-win approach. In this latter case, the US military would seek to maintain the capability to win quickly and decisively in one theater, while temporarily maintaining a defensive posture in the second theater. However, since modernization plans would remain relatively robust—being cut only to the extent needed to reflect the smaller force structure to be equipped in this option—the difference between capabilities under the current plan and under Option 3 would not grow appreciably in coming decades.

Option 4 would lead to the greatest reduction in near-term capabilities, compared to the current plan, as it combines the slower approach to modernization embraced in Option 2 with the force structure cut of Option 3. It would still provide a significant hedge against near-term challenges. However, as in Option 3, under this option it might be necessary to reduce the US military's engagement in forward presence and contingency operations, and to accept greater risk in terms of the current two-MTW requirement, or adopt a win-hold-win approach. Moreover, since Option 4 would also scale back purchases of next-generation weapon systems, as in Option 2, the difference in capabilities under this option and the current plan would grow in the coming decades.

However, in this case, the growth of this difference in capabilities might well favor Option 4. That is, as time goes on, the US military might become relatively more effective under this option than under the current plan. This is because, compared to the current plan, under Option 4 more funding would be invested in the development of new kinds of weapon systems, forces and concepts of operations. Whether or not this eventually proves true will depend on the extent to which the RMA actually changes the way wars are fought in the future, and the kinds of challenges the US military faces. If progress in these areas is essentially linear, then the current plan may be appropriate. On the other hand, if significant or even dramatic changes are in the

offing, then the current plan may prove highly problematic in the long run. In other words, if we really are in the midst of an RMA, the US military of 2015 and beyond is likely to be more capable under Option 4 than under the current plan, despite the fact that it would be somewhat smaller.

Whatever the merits of the current defense plan, it is clearly not affordable within currently projected defense budget levels. As noted earlier, the last Clinton Future Years Defense Program (FYDP) included about $310 billion for DoD in FY 2002, and an average of roughly $305 billion a year over the following five years. By contrast, fully funding the DoD's current plan would likely cost at least $345 billion a year over the long run. Given the size of future federal budget surpluses forecast by CBO and OMB, it is possible that funding for defense could be substantially increased over the next several decades. However, both Democrats and Republicans appear to place higher priority on other competing policy initiatives, such as tax cuts and the expansion of some entitlement benefits.

Thus, absent a significant shift in the priorities of the public and policymakers, the current defense plan would not be affordable over the long term. The other three options would all be less costly, but only the last of these, the RMA option, would likely be affordable within long-term budgets of roughly $310 billion a year. On the other hand, both Options 2 and 3 could be made affordable within budget levels of this magnitude if the cuts in, respectively, modernization and force structure, already included in those options were further expanded. Moreover, while it seems improbable that an increase in defense spending large enough to *fully* pay for the current plan will be approved by the new administration and Congress, some rise in funding for defense may be likely, at least over the next several years. As such, making the current plan affordable might not require cuts as deep as those discussed in the other options.

Whichever approach to recapitalization and modernization is pursued, it will also be important for policymakers to play closer attention than they have in the past to the impact of those decisions on the US defense industry. Among other things, it will have to work to ensure that those plans are structured so as to adequately maintain:

- **Competition:** Some level of competition among defense contractors is important to maintaining an efficient and innovative DTIB. Unfortunately, only two or three companies are now active in most key defense market sectors. Fortunately, there are alternative means of encouraging innovation, efficient production and other qualities typically associated with competition. For example, contracts can be written in such a way as to provide even sole-source producers an incentive for cutting costs. Nevertheless, it would be prudent to take steps in at least some market sectors to encourage greater competition.

- **Innovation:** To execute the current defense plan, over the long run some $40 billion a year would need to be provided for R&D. By historical standards, this is a lot of money. Still, the current defense plan may not effectively facilitate innovation within the defense industry. Among other things, it may focus too much funding on full-scale development of systems being readied for production rather than on the earlier stages of R&D, where major technological breakthroughs are generally made. If this problem is to be corrected, steps will

need to be taken to ensure that defense contractors can make a reasonable profit, even on programs that are limited to prototyping or earlier phases of R&D.

- **Production:** Whichever approach to modernization and recapitalization is selected, a number of steps should be considered which would facilitate maintaining a DTIB that is effective in terms of peacetime efficiency, surge capability and mobilization potential. These steps include encouraging funding/program stability, increasing the use of multiyear procurement, and designing more commonality in systems.

- **Profitability:** Judged by stock valuations, the US defense industry performed extremely well over the past decade. Nevertheless, there is some concern about its long-term prospects, in part because of a decline in stock value experienced between 1998 and early 2000. The rebound since then appears to have been spurred in part by a belief that procurement spending is likely to rise in the future, and by declines in the performance of some other sectors of the economy. If there is a change in either of these assumptions, defense stocks may again experience a decline. In that case, consideration should be given to a variety of steps such as allowing contractors a greater profit margin or accelerating progress payments.

Lastly, DoD and the US defense industry need to thoroughly review the Services' programmatic requirements and the defense industry's financial and other requirements, with the goal of identifying and preserving those unique research, development, production, maintenance, and repair capabilities which, if lost, would be difficult or impossible to replace in a timely manner in the future. Some of the recapitalization options discussed in this report may be more compatible with the goal of maintaining a robust and responsive DTIB than others, but whichever approach is pursued, a review of these critical capabilities needs to be initiated soon.