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MANAGEMENT PERSPECTIVES PERTAINING TO ROOT CAUSE ANALYSES OF NUNN-MCCURDY BREACHES

VOLUME 4

Program Manager Tenure, Oversight of Acquisition Category II Programs, and Framing Assumptions

RAND NATIONAL DEFENSE RESEARCH INSTITUTE

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Prepared for the Office of the Secretary of Defense

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RAND NATIONAL DEFENSE RESEARCH INSTITUTE

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Preface

Continuing concern about large cost overruns in a broad range of major defense programs led Congress to enact new statutory provisions extending the ambit of the existing Nunn-McCurdy Act, stipulating that the U.S. Department of Defense (DoD) review and report on the factors affecting program costs in both specific and general terms. In accordance with the revised Nunn-McCurdy Act, the Performance Assessments and Root Cause Analysis (PARCA) office must provide its root cause explanation as part of a 60-day program review triggered when the applicable military department secretary reports a breach.

In March 2010, in view of staffing limitations, the newly created PARCA within the Office of the Secretary of Defense (OSD) elected to rely on federally funded research and development center support in discharging its new responsibilities. Since then, PARCA engaged the RAND Corporation to conduct multiple studies on the root causes of Nunn-McCurdy breaches or other large cost increases in seven major defense acquisition programs: the Wideband Global Satellite, the Longbow Apache, the *Zumwalt*-class destroyer (DDG-1000), the Joint Strike Fighter, the Excalibur, the Joint Tactical Radio System Ground Mobile Radio, and the Navy Enterprise Resource Planning.[1]

This report derives management perspectives from analysis of Nunn-McCurdy breaches and other cost growth questions with three issues related to the acquisition of materiel by DoD. Partly in response to a finding by the U.S. Government Accountability Office that the tenure of program managers was relatively short, the head of PARCA asked RAND to analyze the tenure of program managers and to provide an alternative perspective on the data relating to this topic, along with any conclusions that could be

[1] See Irv Blickstein, Michael Boito, Jeffrey A. Drezner, James Dryden, Kenneth Horn, James G. Kallimani, Martin C. Libicki, Megan McKernan, Roger C. Molander, Charles Nemfakos, Chad J. R. Ohlandt, Caroline Reilly, Rena Rudavsky, Jerry M. Sollinger, Katharine Watkins Webb, and Carolyn Wong, *Root Cause Analyses of Nunn-McCurdy Breaches, Volume 1: Zumwalt-Class Destroyer, Joint Strike Fighter, Longbow Apache, and Wideband Global Satellite,* Santa Monica, Calif.: RAND Corporation, MG-1171/1-OSD, 2011; and Irv Blickstein, Jeffrey A. Drezner, Martin C. Libicki, Brian McInnis, Megan McKernan, Charles Nemfakos, Jerry M. Sollinger, and Carolyn Wong, *Root Cause Analyses of Nunn-McCurdy Breaches, Volume 2: Excalibur Artillery Projectile and the Navy Resource Planning Program, with an Approach to Analyzing Complexity and Risk,* Santa Monica, Calif.: RAND Corporation, MG-1171/2-OSD, 2012.

drawn about whether recent policy changes have been effective in increasing tenure. A second issue was the management of Acquisition Category II programs and whether existing decentralized systems used to track the cost growth and performance of these programs are adequate or whether additional centralized guidance is warranted. The third issue that this report deals with is an exploratory one to determine whether it is feasible in acquisition programs to identify program assumptions that are so key to the program's success that they could be used as a way to manage cost and schedule risk.

This report should interest DoD staff and military personnel who are involved in the acquisition of defense systems.

This research was sponsored by OSD PARCA and conducted within the Acquisition and Technology Policy Center of the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community.

For more information on the RAND Acquisition and Technology Policy Center, see http://www.rand.org/nsrd/ndri/centers/atp.html or contact the director (contact information is provided on the web page).

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Summary

In light of continuing program cost growth and observations by the U.S. Government Accountability Office (GAO) placing defense acquisition on the high-risk target list, Congress has become particularly concerned about the execution of major defense acquisition programs. This concern, coupled with the reality of shrinking defense budgets, led Congress to enact statutory provisions that would focus greater policymaker attention on the oversight of major defense acquisition programs (MDAPs) and other large, costly programs.[2] For example, the Weapon Systems Acquisition Reform Act of 2009 (WSARA) established a number of requirements affecting the operation of the Defense Acquisition System and the duties of the key officials who support it, including the requirement to establish a new organization in the Office of the Secretary of Defense (OSD) with the mandate to conduct and oversee performance assessments and root cause analyses for MDAPs.[3]

In March 2010, the director of the Office of Performance Assessments and Root Cause Analysis (PARCA) determined that he required support to execute his statutory responsibilities and turned to federally funded research and development centers and academia to help with the research and analysis of program execution status. RAND was among the institutions engaged to carry out root cause analyses, which it has completed for six programs to date.[4]

In addition to the root cause analysis of Nunn-McCurdy breaches in specific acquisition programs, the PARCA director posed some additional questions to RAND to determine whether they affect the management of such programs or might provide a useful perspective in managing them. One pertained to program manager (PM) tenure, which was not a featured cause in the analyses RAND had previously performed. However, PARCA asked RAND to calculate current PM tenure using easily available sources, in part to determine whether tenure periods have increased since policy guidance designed to lengthen tenure was published in 2005 and 2007. A second question posed was whether existing decentralized systems used to track the cost growth and

[2] Public Law 111-383, Ike Skelton Defense Authorization Act for Fiscal Year 2011, December 20, 2010.

[3] Public Law 111-23, Weapon Systems Acquisition Reform Act of 2009, May 22, 2009.

[4] Blickstein et al., 2011, 2012.

performance of acquisition category (ACAT) II programs are sufficient, or whether additional centralized guidance and control from OSD are warranted. Additional oversight may provide transparency of ACAT II performance and contribute to more efficient acquisition processes. However, new reporting and control requirements will place additional burden on the defense agencies and military departments as well as on the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD (AT&L) and the PARCA office, which is given the authority to issue guidance on ACAT II programs by WSARA and will bear responsibility for any additional oversight. The third question dealt with the management of cost and schedule risk and whether the identification of key assumptions, which we call framing assumptions, could be a useful risk management tool.

Program Manager Tenure

Program manager tenure is frequently mentioned in regard to improving acquisition outcomes and accountability. Policies have attempted to enforce longer program manager tenure over the past few decades, because it has been found in at least one study that longer program tenure is one of the building blocks for program success typically leading to lower cost growth.[5] GAO reported in 2007 that PM tenure was 17.2 months in the programs it reviewed.

PARCA asked RAND to calculate current PM tenure using easily available sources to provide an understanding of the length of PM tenure. Part of the motivation behind this request was to see if tenure periods have been increasing since policy guidance designed to lengthen tenure was published in 2005 and 2007.

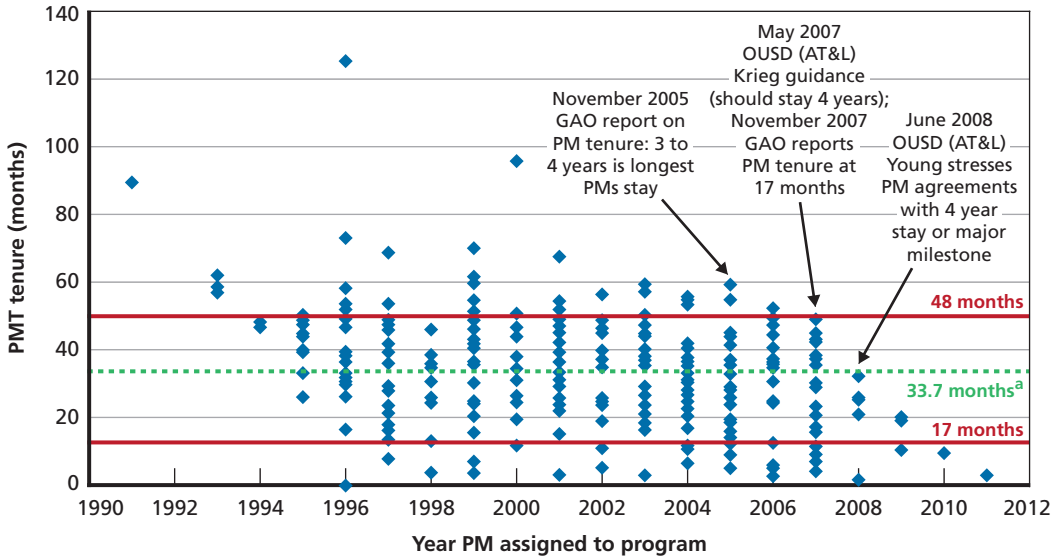
Results

To quantify PM tenure using current data, we extracted program point-of-contact data from Selected Acquisition Reports (SARs) from calendar years 1997 through 2011. Our final database, excluding incomplete tenure periods, contained 370 program manager tenure periods from 136 programs submitting SARs from 1997 to 2011 (both annual and quarterly).

Using the largest available dataset of program manager tenure periods that had been completed, we calculated that the average tenure for those program manager periods was 33.7 months, which aligns more closely to the GAO statement in 2005 regarding PM tenure (no more than three to four years) rather than the November 2007 statement of 17.2 months. The results of this set of data are presented in Figure S.1. We also calculated tenure by eliminating several outliers in terms of tenure length, and we

[5] 1st Lt Christina F. Rusnock, *Predicting Cost and Schedule Growth for Military and Civil Space Systems,* thesis, Wright-Patterson Air Force Base, Ohio: Air Force Institute of Technology, AFIT/GRD/ENC/08M-01, March 2008, p. 99.

Figure S.1
Average Number of Months PM Is Assigned to Program (full dataset)



[a]RAND calculated average of 370 program manager terms using 1997 to 2011 SAR data.
SOURCE: SARs (1997–2011).
RAND *MG1171/4-S.1*

included only tenure periods that started between 1997 and 2008. The result was an average of 33.2 months, only slightly lower than the average from the larger dataset.

This initial data analysis did not help us answer the question regarding PM tenure periods after the 2005 and 2007 PM tenure policies, however, because there were too many tenure periods that had not been completed after 2008. We therefore also conducted a statistical analysis that includes open tenure periods. One challenge in introducing open tenure periods to this analysis is that these periods cause bias in the average, because the program managers have not finished their tenure in a particular program, which makes the overall average shorter than if they had. We applied a statistical approach that calculates probable tenures for open periods. (See the discussion in Chapter Two for details).

Given this statistical treatment, the data provide some support that program managers remained in positions longer after the release of the revised guidelines in 2007. However, because of the small numbers of positions and the large number of open positions among those beginning in 2006 or later, the differences among groups are not statistically significant, and the observed differences could be chance occurrences rather than real difference among the groups of positions.

Additional years of data for these positions and new positions starting in 2011 or later could help to establish if the differences among groups demonstrate persistent changes to practice after the release of the revised guidelines. But even if the differences

proved to be persistent, they might not have been caused by the revised guidelines. We would need to rule out other potential sources of change before we could make that attribution. However, analysis of additional data would be a valuable first step to exploring fully the effects of the 2007 guideline change.

Observations

Our research leads us to the following observations:

The intent of policies to lengthen PM tenure may not have been achieved. PM tenure has been reviewed/quantified periodically during the last 40 years. It is difficult to assess whether these policies have been successful based on previous data and studies and current data.

No enforcement mechanism has been readily apparent over time. This could be because enforcement is limited because of the fundamental conflict that exists between what military officers need to do to be promoted and their tenure as program managers. Unless these two are aligned such that lengthy tenure in a program can be advantageous for promotion, then it appears unlikely that these tenure policies will consistently yield positive results.

We cannot determine whether the policies of 2005 and 2007 have helped to lengthen PM tenure. A statistical analysis using open/closed tenure periods indicated that the estimate of the mean time in position for tenure periods starting after 2007 is biased, because of the large number of tenure periods that remain open at the last data collection. This creates an average that is lower than if all PM tenure periods in a sample have both a beginning and an ending. Using these same data, we found that PMs are less likely to stay as long in their tenure periods, meaning that 75–85 percent will likely reach two years, but only 50 percent will likely reach three years. PMs that started in tenure periods after the policy change are much more likely to remain in those periods longer than PMs starting in periods between 2005 and 2007.

We also found that adjusting for a variety of data issues (outliers, open periods, etc.) will give us more confidence in the data but will only minimally change the result of PM tenure during the last 14 years for MDAPs.

By taking into account closed program manager tenure periods, we found that PM tenure is on average 33 months. This result is much higher than GAO's 2007 figure of 17.2 months for 39 programs but includes a larger sample size covering more years and does not include any open periods.

In conclusion, this analysis has been able to quantify PM tenure using current data but cannot definitely say whether recent policies regarding PM tenure have had any positive effect toward lengthening tenure over the last several years, because there are still too many open tenure periods during that time period.

Performance of ACAT II Programs

Because additional reporting and control requirements come with costs, the decision to mandate additional guidelines for ACAT II programs may be warranted only if there are problems with the existing system that result in cost growth and schedule slippage and that can be dealt with by more centralized oversight. To determine if such performance issues do plague current ACAT II programs, we conducted two sets of analyses, one on a sample of ACAT II programs and one on a comparable set of MDAPs. Both sets include programs from across military departments and procurement program categories (e.g., aircraft, weapons, shipbuilding and conversion). We evaluate program performance focusing specifically on unit cost growth over the program's life and instability in annual quantity procured over time. Then, we compared the overall performance of the ACAT II and MDAP samples. This comparison leads to some general inferences about the performance of ACAT II programs under the current system of oversight, their performance relative to MDAPs, which are subject to more centralized monitoring and requirements, and the need for additional centralized reporting and control requirements.

For our analysis, we rely on budget information provided by the military departments and included in the President's official budget justifications as well as congressional hearings and testimony to construct program narratives. The information includes summary information on cost and quantity for the past, current, and requested fiscal year. We used the information to select ten ACAT II programs and seven MDAP programs, covering all procurement program categories across all three military departments. We used the information to construct time series datasets of unit cost and annual quantity procured for each program in our sample by collecting and integrating annual data on cost and quantity provided in these budget documents.

Using the time series data on program cost and quantity, we graphed annualized unit cost against annualized quantity. We assessed these graphs looking at large revisions and sharp fluctuations in quantity and cost as well as slow growth over time. To explain cost growth or periods of apparently weak performance, we matched the narrative information on each program to the unit cost graphs.

Results

Although our sample size and composition prevent a meaningful statistical comparison of cost growth, our qualitative assessment of program performance should have some general application to acquisition programs. Furthermore, our intention was to conduct broad assessment of the performance of the two program types to determine whether ACAT II programs appear to perform, on average, better or worse than MDAPs, rather than to provide precise metrics on this performance or precise quantification unit cost growth over time. We find that, overall, both ACAT II and MDAP programs perform reasonably well once they have entered production. In both cases,

programs experience some cost growth and some instability in unit cost and annual quantity procured over the period considered. However, in neither case do we observe crippling instability, runaway cost growth, or severe production delays. Of the ACAT II programs we consider, we find that four show no reason for concern, five have some issues of minor concern, and three warrant some more significant concerns. Across the board, ACAT II programs in our sample are more significantly affected by instability in unit cost than by actual cost growth. Instability is particularly likely early in the lives of new ACAT II programs, associated with development and modernizations. There also seems to be a clear relationship between unit cost and quantity. Much of the cost growth that we do observe occurs as a result of downward revisions in procurement quantities, perhaps stemming from changes in demand associated with the contingencies in Iraq and Afghanistan.

Programs in the MDAP sample can similarly be distributed across the three performance categories: no serious concerns, minor concerns, and some concerns. Our assessment places three programs in the first category, three in the second, and only one in the third. As was true for ACAT II programs, several MDAP programs show some cost growth over their program life (including projected out-years), and some have experienced periods of instability associated with modernizations and fluctuations in demand. However, several also show a decrease in average unit cost over the period considered.

Our assessment suggests that ACAT IIs reach a level of performance currently, without rigorous centralized oversight, that is at least equal to that of MDAPs operating with centralized reporting and control requirements and oversight.

Framing Assumptions

Defense acquisition programs routinely must estimate cost, schedule, and technological performance far in advance of actual work. And they must account for differences in acquisition strategy and market conditions. As a result, programs must make assumptions about their programs and the conditions that might affect them. When these assumptions prove faulty, they can cause the program to miss important cost and schedule benchmarks, which can lead to breaches of Nunn-McCurdy thresholds. Key assumptions are called "framing" because of the influence they have on program performance. This exploratory research was done in an attempt to define framing assumptions in a way that others can use them to assess and, potentially, control program risk and to explore the possibility of identifying them for a selected set of programs.

Results

We arrived at the following definition for a framing assumption:

A framing assumption is any explicit or implicit assumption that is central in shaping cost, schedule, and/or performance expectations.

A framing assumption has the following five characteristics. First, the consequences of the assumption being wrong will significantly affect the program in a way that matters (e.g., significant cost growth or schedule slippage). In other words, the assumption is important to the success of the program. Second, the consequences of the assumption being wrong cannot be avoided. Third, the outcome or certainty with respect to the assumption is unknown (there is some risk). Fourth, the consequences of the assumption failing or holding true do not hinge on other events or chain of events. Finally, a framing assumption should typically distinguish a program from all other programs. An example of a framing assumption might be that "competitive prototyping will save 5 percent of the procurement cost." This would be opposed to an assumption that held, "the contractor will perform well," which would be common to all programs.

Researchers then examined five defense programs in various stages of maturity:

- Advanced Pilot Training (APT) System
- Joint Light Tactical Vehicle
- Joint Precision Approach and Landing System
- Littoral Combat Ship Modules
- Space Fence.

For each program, we attempted to identify framing assumptions in three categories: technological, management incentives and program structures, and mission requirements. The results appear in Table S.1.

A similar exercise using the seven programs on which RAND conducted a root cause analysis yielded similar results, i.e., researchers were able to apply the definition to the programs and identify framing assumptions. Note, however, that identifying framing assumptions is typically much easier after the fact, and the reason for the root cause analyses was that the programs had already breached the Nunn-McCurdy thresholds.

The important finding of this research is that it is possible to define framing assumptions and apply them to programs that are in their early stages, which is when program managers would want to do this to help them manage program risk. The efficacy of using framing assumptions to manage risk remains to be seen. However, this research suggests some common characteristics for such assumptions. One is that the assumption needs to focus at a high level and not on the fine-grained detail of the program. Additionally, framing assumptions should be relatively few in number; about three to five seems right. Clearly, more assumptions could be identified, but the focus must fall on the ones that can truly affect the program's outcomes. Assumptions need

Table S.1
Framing Assumptions Identified for Five Acquisition Programs

Program	Technological	Management Incentives and Program Structures	Mission Requirements
APT System	Training aircraft (both airframe and avionics) will be nondevelopmental.	Potential customers will want to buy the APT with minimal modifications.	Current training scenario is valid: Use of existing T-38 can be extended until 2020. Simulators can be used instead of actual flight time (to save money).
Joint Light Tactical Vehicle	Incremental/open architecture will reduce risk and allow for more efficient upgrades. Competitive prototyping will reduce risk and cost.	A Joint Army and Marine Corps program will save money as requirements are compatible.	The services have effectively assessed long-term and short-term needs.
Joint Precision Approach and Landing System	Incremental development will lower risk, while COTS/GOTS hardware and software will lower costs.	Navy is the best service to lead acquisition with the ordering of the increments driven by the Navy's more demanding requirements.	System is suitable for all types of air vehicles.
Littoral Combat Ship Modules	Sea frames and modules can be independently developed: Spiral/incremental development will lower risk. Can successfully test modules on other ship platforms. New capabilities can be added easily.	New, open business model approach allows for independent development of sea frames and modules: Leveraging PARMs and other programs. Benefits of open architecture/commercial practices. Government suited to act as system integrator. RDA can be program focal point (4 PMs, 3 PEOs, 2 SYSCOMs).	The Navy is willing to drop requirements (in spiral context) to keep to schedule.
Space Fence	Capability is achievable despite some immature technologies at the outset. Can scale technology to track order of magnitude greater number of objects (radar components, software interoperability). Competitive prototyping reduces risk and cost.	Block approach is a more effective acquisition strategy. The legal, diplomatic, and political issues with site decisions can be resolved easily.	Minimal manpower required to operate and support system. Two instead of three sites will be sufficient to meet operational goals.

to be revisited as the program moves through the acquisition process, because they can change or even be supplanted by other assumptions. Implicit assumptions are more difficult to identify than the explicit ones.

As mentioned, the utility of framing assumptions as a risk management technique remains to be demonstrated. A useful extension of this research would be to examine the assumptions of a broader range of programs to identify those that might be problematic.

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Abbreviations

AAE	Army Acquisition Executive
ABV	assault breacher vehicle
ABP	assumption-based planning
ACAT	acquisition category
ACP	Army Cost Position
ACTD	Advanced Concept Technology Demonstration
ADM	Acquisition Decision Memorandum
AFRB	Air Force Review Board
AFSSS VHF	Air Force Space Surveillance System Very High Frequency
AME	aviation mission equipment
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
APT	Advanced Pilot Training System
APUC	average procurement unit cost
ASA (ALT)	Assistant Secretary of the Army (Acquisition, Logistics, and Technology)
ASA (FMC)	Assistant Secretary of the Army (Financial Management and Comptroller
ASA (I&E)	Assistant Secretary of the Army (Installations and Environment)
ASA (M&RA)	Assistant Secretary of the Army (Manpower and Reserve Affairs)
ASARC	Army Systems Acquisition Review Council

ASN (RDA)	Assistant Secretary of the Navy (Research, Development & Acquisition)
ASP	Acquisition Strategy Panel
ASR	Acquisition Strategy Review
ATC	Air Traffic Control
BCT	Brigade Combat Team
BY	base year
CAE	Component Acquisition Executive
CAPE	Cost Assessment and Program Evaluation
CCD	charge-coupled device
CDD	Capability Development Document
CIO	chief information officer
CMC	Commandant of the Marine Corps
CNO	Chief Naval Officer
COCOM	combatant commander
COTS	commercial off-the-shelf
CY	calendar year
DAB	Defense Acquisition Board
DAES	Defense Acquisition Executive Summary
DAMIR	Defense Acquisition Management Information Retrieval
DASA (ASM)	Deputy for Acquisition and Systems Management
DCS	Deputy Chief of Staff
DDL	digital data link
DoD	U.S. Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DDR&E	Director of Defense Research and Engineering
DSB	Defense Science Board
DT&E	developmental test and evaluation

DUSA (T&E)	Deputy Under Secretary of the Army (Test and Evaluation)
ELSG	Electronic Systems Group
ELSS	Electronic Systems Squadron
ELSW	Electronic Systems Wing
EMD	engineering, manufacturing, and development
ER	extended range
ERP	Enterprise Resource Planning
FCS	Future Combat System
FRP	full-rate production
FY	fiscal year
FYDP	Future Years Defense Program
GAO	U.S. Government Accountability Office
GOTS	government off-the-shelf
GWOT	Global War on Terror
HAC	House Appropriations Committee
HASC	House Armed Services Committee
HBCT	Heavy Brigade Combat Team
HIMARS	High Mobility Artillery Rocket System
ICD	Initial Capabilities Document
ICE	independent cost estimate
IIR	imaging infrared
ILCM	Integrated Life Cycle Management
IPT	Integrated Product Team
IR	infrared
ISP	Information Support Plan; also Initial Spares Package
JDAM	joint direct attack munition
JLTV	joint light tactical vehicle
JPALS	joint precision approach and landing system
JROC	Joint Requirements Oversight Council

JSF	Joint Strike Fighter
JSOF	Joint Special Operations Force
JTRS	Joint Tactical Radio System
KPP	key performance parameter
KSA	key system attribute
LAIRCM	large aircraft infrared countermeasure
LCAC SLEP	Landing Craft Air Cushion Service Life Extension Program
LCMP	Life Cycle Management Plan
LCRRPR	low-cost reduced-range practice rocket
LCS	littoral combat ship
LRIP	low-rate initial production
LSI	lead system integrator
LUH	light utility helicopter
MCATTD	Marine Corps Advanced Technology Transition Demonstrator
MDA	Milestone Decision Authority
MDAP	major defense acquisition program
MDR	milestone decision review
MLRS RRPR	Multiple Launch Rocket System Reduced-Range Practice Rocket
MOA	memorandum of agreement
MP	mission package
MS	milestone
MTVR	medium tactical vehicle replacement
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NDI	nondevelopmental items
OCO	Overseas Contingency Operation
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom

OIPT	overarching integrated process team
OPEVAL	operational evaluation
ORDALT	ordnance alteration
OSD	Office of the Secretary of Defense
OTS	off-the-shelf
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
PA	performance assessment
PARCA	Performance Assessments and Root Cause Analysis
PARM	participating acquisition resource manager
PAUC	program acquisition unit cost
PDR	Preliminary Design Review
PE	program element
PEO	Program Executive Office
PM	program manager
PMA	Program Management Activity
PMS	Program Manager, Ship
PR	program review
RAM	rolling airframe missile
RCA	root cause analysis
RDA	research, development, and acquisition
RDT&E	research, development, test, and evaluation
RF	radio frequency
RMP	Risk Management Plan
ROS	reduced operational status
SAC	Senate Appropriations Committee
SAE	service acquisition executive
SAR	Selected Acquisition Report
SASC	Senate Armed Services Committee

SDS	system design specification
SE	systems engineering
SEP	Systems Engineering Plan
SFAE-AV-A9	U.S. Army Program Manager for Aviation Systems
SLAMRAAM	surface-launched medium-range air-to-air missile
SLEP	Service Life Extension Program
STRC	Standards in Training Commission
SUAS	small unmanned aircraft system
SYSCOM	Systems Command
TEMP	Test and Evaluation Master Plan
TRA	technology readiness area
UAV	unmanned aerial vehicle
UAS	unmanned aerial system
UCR	Unit Cost Report
USA	U.S. Army
USAF	U.S. Air Force
USN	U.S. Navy
VCSA	Vice Chief of Staff of the Army
VTUAV	vertical takeoff and landing tactical unmanned aerial vehicle
W&TCV	weapons and tracked combat vehicles
WGS	wideband global satellite
WSARA	Weapon Systems Acquisition Reform Act
XLWB	extra-long wheel base

CHAPTER ONE

Introduction

In addition to doing root cause analyses on major defense acquisition programs (MDAPs) that incurred Nunn-McCurdy breaches, the Director of the Office of Performance Assessments and Root Cause Analyses (PARCA) asked RAND to explore some additional issues to determine whether they might affect the management of such programs. This report presents research conducted on three relevant topics: the tenure of program managers, the need for Department of Defense (DoD)–level oversight on Acquisition Category (ACAT) II programs, and the potential use of framing assumptions as a way to manage program risk. The issues raised by these topics are discussed briefly below.

Tenure Research

In November 2007, the U.S. Government Accountability Office (GAO) released a report that observed the following regarding program manager (PM) tenure:

> while DoD policy provides for program managers of major defense acquisition programs to serve as close to 4-year tenures as practicable, many serve for only 2 years. . . . our work has shown that rather than lengthy assignment periods between key milestones as suggested by best practices, many of the programs we have reviewed had multiple program managers within the same milestone. . . . analysis for this review showed that for 39 major acquisition programs started since March 2001, the average time in development was about 37 months. The average tenure for program managers on those programs during that time was about 17.2 months—less than half of what is prescribed by DoD policy.[1]

PM tenure has long been a topic of interest to DoD, which has established policies designed to increase that tenure, most recently in 2005 and 2007. The Office of the Secretary of Defense (OSD) asked RAND to conduct research on the tenure of PMs

[1] U.S. Government Accountability Office, *Defense Acquisitions: Department of Defense Actions on Program Manager Empowerment and Accountability,* GAO-08-62R, Washington, D.C., November 9, 2007a, p. 8.

in MDAPs. The policy question addressed is whether PM tenure has lengthened since the 2005 and 2007 policy guidance that attempted to extend it.[2] OSD PARCA is also interested in any historical and recent outcomes in PM tenure in MDAPs. In addition, it is seeking an alternative to GAO's 2007 analysis of PM tenure. Reviewing data after 2007 is one way to identify whether PM tenure policies have been able to increase the tenures of PMs as intended.

ACAT II Programs

Cost growth in defense acquisition and procurement programs has long been an issue of concern to policymakers. The size of these programs, their often long development time lines and significant costs, and the need for repair and modernization of equipment create significant risk for unexpected costs that exceed expectations and slips in schedule that delay the delivery of important systems. DoD also often depends on contractors to produce and supply procured equipment and technology, raising concerns about contractor incentives and competition as well as oversight and monitoring. There have been many legislative attempts to control cost growth and development delays. These have achieved some success but have failed to either fully control unexpected increases in program costs or eliminate long production delays. In addition, existing requirements cover primarily the largest acquisition programs—MDAPs—leaving smaller and non-MDAP programs without consistent oversight at the OSD level. Oversight for these smaller programs occurs only at the military department level.[3] The motivating question driving this report is whether existing decentralized systems used to track cost growth and performance of ACAT IIs are sufficient or whether additional centralized guidance is warranted.

Framing Assumptions

Defense acquisition programs routinely face the challenge of estimating cost, schedule, and technological performance far in advance of actual work. They must also account for differences in acquisition strategy and market conditions. As a result, programs must make a number of assumptions about their programs and the conditions

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[2] The guidance is presented in the following DoD documents: U.S. Department of Defense Instruction (DoDI) 5000.66, *Operation of the Defense Acquisition, Technology, and Logistics Workforce Education, Training, and Career Development Program*, December 21, 2005; and Kenneth J. Krieg, Under Secretary of Defense for Acquisition, Technology, and Logistics, "Program Management Tenure and Accountability," memorandum, Washington, D.C., May 25, 2007.

[3] Programs are designated as MDAPs based on a number of factors, including total lifetime cost.

that might affect them. Although a necessity, assumptions expose the program to cost growth and schedule delays.

When assumptions prove faulty, they can cause the program to miss important cost and schedule benchmarks. More important, they can cause programs to breach Nunn-McCurdy thresholds, which can lead to a program's termination. Key assumptions are called "framing" because they so influence the program performance expectations that, when faulty, they lead to significant cost growth, performance shortfalls, schedule slips, or any combination of these three undesirable outcomes.

This exploratory research was done for the PARCA office in an attempt to define framing assumptions in a way that others can use them to assess and, potentially, control program risk and to explore the possibility of identifying them for a selected set of programs.

Organization of This Report

This report is organized as follows. Chapter Two explores the topic of PM tenure over the past 40 years. The chapter specifically looks at policies and recommendations, along with how PM tenure has been quantified in the literature. It next provides our analysis of PM tenure using data available since 1997. The analysis initially focuses on data presented in the Selected Acquisition Reports (SARs) for PM tenure periods in which PMs have completed their tenure. It then provides a short statistical analysis that incorporates more recent data on PMs who have not completed their tenure. The goal of the latter analysis was to reach conclusions regarding PM tenure length and the 2005 and 2007 policies that attempted to lengthen tenure. The final part of the chapter presents our conclusions.

Chapter Three deals with the topic of oversight for ACAT II programs. It describes the existing oversight policies and the practices in the military services. It then compares 12 programs (when treating Hellfire as a separate program), MDAP program performance with that of ACAT II, describes the factors that contribute to success and failure, and lays out three courses of action that the PARCA office could pursue concerning the issuance of guidance.

Chapter Four explores the topic of framing assumptions and their possible use as a way to manage risk in acquisition programs. It begins by defining framing assumptions and listing their salient characteristics. It then tests the feasibility of identifying framing assumptions by examining five DoD acquisition programs. It also takes a retrospective look at the programs for which the RAND National Defense Research Institute has done root cause analyses. It concludes by providing some overarching observations.

Chapter Five briefly summarizes conclusions relating to the three issues of interest.

CHAPTER TWO

Program Manager Tenure

As outlined in Chapter One, PM tenure has long been a topic of interest to DoD, which has established policies designed to increase that tenure, most recently in 2005 and 2007.

Additional exploration of other research quantifying PM tenure since 2007 did not yield any relevant answers to the research question of whether PM tenure has lengthened as a result of these policies. However, a look back over the past 40 years revealed that PM tenure is not a new policy issue, and it has been measured several times in sample sets of programs, by individual service, and also by all services collectively.

Research Approach

PARCA requested that RAND calculate current PM tenure using easily available sources to determine the evidence base since GAO's 2007 assessment. Part of the motivation behind the request was to determine whether tenure periods have been increasing since the 2005 and 2007 guidance as a way to better understand the reasons for program success or failure. The RAND team completed a literature review to identify previously existing PM tenure policies and to track how other studies have quantified PM tenure.

To quantify PM tenure using current data, we extracted program point-of-contact data from the SARs for 1997–2011. This method was advantageous because the data were standardized in one location and were easily extracted from OSD's Defense Acquisition Management Information Retrieval (DAMIR) system. In addition, given that that the available data went back to 1997, there was sufficient information on a variety of programs. We chose to use data from MDAPs that had multiple PMs, because we could define the tenure of a particular PM as the date that the PM was assigned to the date that the subsequent PM was assigned. This approach provided distinct starting and ending points for each PM in the data set. For PMs with open tenure periods (that is, the period of service by a program's current PM), we conducted

a statistical analysis to determine the effects of open tenure periods, particularly in the most recent years.

Data Shortcomings

The data used for the analysis had several notable shortcomings. Some PM tenure periods did not have an end date, either because the PMs were still with the program or because the program was no longer submitting SARs. Finding end dates for programs when this information was not included in the data would have required a significant amount of research beyond of the scope of this study, so we excluded these data. There were also several raw data errors in which the start date for one PM was announced but the following chronological SAR listed a different PM with a start date before that of the previous PM. This caused negative numbers in tenure periods. Thus, we excluded these data also. Some PMs managed several programs, so we had to count "tenure periods" rather than PMs. In addition, the data pulled from the SARs do not differentiate between acting and permanent PMs, so very short periods may indicate changeover between PMs, in which the deputy PM is acting in the PM role temporarily. Shorter periods may also indicate pre–Milestone (MS) B programs, and longer periods could reflect data reporting issues between subprograms.

The Past 40 Years

Over the past 40 years, various policies have been implemented in an attempt to increase PM tenure in defense programs. Several studies have also attempted to quantify the tenure of PMs. For example, GAO, the Defense Science Board (DSB), the RAND Corporation, and the Institute for Defense Analyses have all done work quantifying PM tenure.

Policies and Recommendations

Recommendations and policy actions have appeared in a variety of sources since the early 1970s. Deputy Secretary of Defense David Packard addressed PM tenure in his speeches and memorandums from the early 1970s. According to Dews et al., one major policy element of Packard's initiatives was to "reduce the turnover rate of program managers so that they have longer job tenure."[1] Likewise, in 1973, a DSB report on reducing the costs of defense system acquisition addressed the role of PM tenure by pointing out that "the program manager's tenure may be abbreviated due to rotational

[1] Edmund Dews, Giles K. Smith, Allen Barbour, Elwyn Harris, and M. Hesse, *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s,* Santa Monica, Calif.: RAND Corporation, R-2516-DR&E, 1979, p. 2.

tours of duty that stress command responsibilities, rather than management achievement, for recognition and advancement."[2] As a consequence, the DSB recommended that "the tenure of key DoD program people be increased, at least to coincide with the beginning and end of major phases of a program."[3] The DSB recommendation was followed up shortly thereafter by DoD Directive (DoDD) 5000.23 in November 1974, which looked at "System Acquisition Management Careers." Though not as specific as the DSB recommendation, the policy stated that "the tenure of program manager assignments should be sufficient to ensure management continuity."[4]

About ten years after the 1973 DSB study, the board surveyed the services and contractors regarding selection, training, career patterns, and the length of assignment of PMs. It concluded that "management continuity during the start-up of production was critical and suggested that the milestone provision be modified" based on data indicating that PM turnover is much more likely during the early phases of a program.[5] The panel also concluded that "tour lengths for military program managers appear too short,"[6] adding that program management should be improved by "stabilizing the tours of military program managers. Extend tours beyond the current practice of about 30 months."[7]

The Defense Acquisition Workforce Improvement Act was enacted in November 1990. Two years later, in 1992, GAO reviewed some of the act's provisions regarding PMs. Particularly applicable to our study were the findings concerning tenure requirements for PMs:

> Effective October 1, 1991, the act required that newly appointed program managers of major and significant nonmajor defense acquisition programs . . . agree to a tenure requirement that they remain in their position until the completion of the first major milestone closest in time to the date they had served 4 years, and sign a written agreement to remain on active duty or in federal service, as applicable, during this period.[8]

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[2] Office of the Director of Defense Research and Engineering, Defense Science Board Task Force, *Reducing Costs of Defense Systems Acquisition: Design-to-Cost, Commercial Practice vs. Department of Defense Practice,* Washington, D.C.: Defense Science Board, AD-762-487, March 15, 1973, p. xvi.

[3] Office of the Director of Defense Research and Engineering, Defense Science Board Task Force, 1973, p. 29.

[4] U.S. Department of Defense Directive 5000.23, *System Acquisition Management Careers,* November 26, 1974.

[5] Quoted in U.S. General Accounting Office, *DoD Acquisition: Strengthening Capabilities of Key Personnel in Systems Acquisition,* Washington, D.C., GAO/NSIAD-86-45, May 1986a, p. 75.

[6] Defense Science Board, *Report of the Defense Science Board Task Force on Transition of Weapons Systems from Development to Production*, Washington, D.C.: Office of the Under Secretary of Defense, Research and Engineering August 1983, p. 47.

[7] Defense Science Board, 1983, p. 52.

[8] U.S. General Accounting Office, *Defense Management: Implementation of the Defense Acquisition Workforce Improvement Act,* Washington, D.C., GAO/NSIAD-92-97, January 1992, pp. 2–2.

The above tenure agreements were in place for nearly 15 years before Under Secretary of Defense for Acquisition, Technology, and Logistics Kenneth Krieg reiterated the importance of acquisition position tenure requirements for PMs working on MDAPs and major automated information systems (MAIS) in DoDI 5000.66. The new policy stated that a PM should have a tenure period around the "milestone closest to 4 years or as tailored by [Component Acquisition Executive] based on unique program requirements. [PMs should also] execute a written tenure agreement."[9]

Following this guidance was Section 853 of the John Warner National Defense Authorization Act for Fiscal Year 2007.[10] The law, which passed in September 2006, directed "the Department [of Defense] to revise guidance on qualifications, resources, responsibilities, tenure, and accountability of program managers before and after Milestone B."[11] In response to the act, Under Secretary Krieg issued a memorandum on May 25, 2007, stating that, "in accordance with 10 U.S.C. 1734, the tenure period for program managers of major defense acquisition programs shall correspond to the major milestone closest to 4 years, subject to an exceptional circumstances waiver." Tenure agreements should be used in Acquisition Category I and II programs.[12]

In 2008, Krieg's successor, John Young, again stressed the importance of PM performance and of having a strategy in place to ensure longer tenures. He testified before Congress regarding the initiatives in place as of 2008:

> I have put in place a comprehensive strategy to address improving the performance of program managers. Key to this are program manager tenure agreements for Acquisition Category (ACAT) I and II programs, which are our largest programs. My expectation is that tenure agreements should correspond to a major milestone and last approximately 4 years. Another fundamental piece I have established is Program Management Agreements—a contract between the program manager and the acquisition and requirements/resource officials—to ensure a common basis for understanding and accountability; that plans are fully resourced and realistically achievable; and that effective transparent communication takes place throughout the acquisition process.[13]

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9 U.S. Department of Defense Instruction 5000.66, 2005, p. 21.

10 Public Law 109-364, John Warner National Defense Authorization Act for Fiscal Year 2007, October 17, 2006.

11 See Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Report to Congress on Program Manager Empowerment and Accountability,* Washington, D.C.: U.S. Department of Defense, August 2007, p. 1–2.

12 Krieg, 2007, p. 1.

13 John J. Young, Under Secretary of Defense, Acquisition, Technology, and Logistics, testimony before the U.S. Senate Committee on Armed Services, Washington, D.C., June 3, 2008, pp. 3–4

These examples of policy and study recommendations illustrate the long-standing view that PM tenure should be actively monitored to ensure leadership stability in acquisition programs. The repetition of themes over the past 40 years also illustrates the difficulty of implementing and enforcing these policies. The next section presents some quantitative data from the same period to provide a better understanding of PM tenure over time.

Quantifying Program Manager Tenure over the Past 40 Years

In October 1979, RAND published a report that attempted to quantify PM tenure using data from the military services. The authors found that PM tenure averaged two and a half to three years and that there had been an increasing trend in tenure since the mid-1960s:

> By the end of the 1960s it had become apparent that acquisition programs often suffered from too rapid a turnover of program managers. Program duration sometimes exceeded 10 years, and program managers frequently served less than 2 years on the job. . . . In the period 1961–1965, for example, the average tenure for all program managers was 18 months; for Army program managers, the average was only 12 months. . . . The data on program manager tenures from 1961 to 1978 indicate a steady increase in tenure from an all-Service average of about 18 months in the 5 years centered on 1963 to about 32 months in the 5 years centered on 1976. . . . The steady upward trend in the 5-year moving averages that was already established in the 1960s has continued in the 1970s. Since 1969, the 5-year moving average has lengthened from 26 months to 32 months, an increase of nearly one-fourth. . . . But, as in so many instances, a direct causal connection between these elements of policy and practice cannot be established.[14]

The RAND research was followed by a DSB study in 1983 that surveyed the services and contractors regarding selection, training, career patterns, and length of assignment among PMs. The survey results indicated that the average tour length for military PMs had improved but still averaged less than three years. The study also pointed out the drastic difference in PM tenure between government and industry, stating that "industry program managers have tours of up to 10 years with four to six years being quite common."[15] The panel concluded that PM tenure was too short and should be extended "beyond the current practice of about 30 months."[16]

In the mid-1980s, GAO also released a report addressing PM tenure, and, as in the 1979 RAND study, tried to provide some quantitative data. GAO used case-study programs but also tried to look at tenure in the early and later phases of programs:

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[14] Dews et al., 1979, pp. 15–16.

[15] Defense Science Board, 1983, p. 46.

[16] Defense Science Board, 1983, p. 52.

> Programs experienced considerable turnover in program managers during their earliest phases, particularly in the Army and the Air Force. In our 17 case study programs, the tenure of program managers who had been replaced averaged 9 months for 3 Army programs, 16 months for 6 Air Force programs, and 39 months for 6 Navy programs. As the programs progress, tenure tends to increase. Those currently serving as program managers have been in their positions (as of August 1986) for an average of 26 months for Army programs, 31 months for Air Force programs, and 26 months for Navy programs. Tenure of program managers replaced from January 1982 to August 1984—for all programs and phases—was longest in the Navy. The average tenure of Navy program managers was 3.9 years, compared with 3.1 years for Army program managers and only 1.9 years for Air Force program managers.[17]

In July 1986, GAO released more figures on program manager tenure. At that point, GAO reported, "The program managers averaged approximately 27 months experience on their current program as either the program manager or deputy program manager. The deputies had approximately 30 months of experience on their current program as either the deputy or the program manager."[18]

Continuing the trend to quantify program manager tenure, the Institute for Defense Analyses released a study in November 1988 stating that, in the Army "the average tenure of departing program managers was 37.8 months through 1987," and, in the Navy, "about 23 months at the end of 1985." It added, "Tenure at departure is not reported. However, Navy sources say that most program managers stay for almost a full four years."[19]

In October 2007, the Commission on Army Acquisition and Program Management in Expeditionary Operations used a prior 2001 Center for Naval Analyses study to characterize PM tenure in the Army. The study rated PM tenure as "red" in both the Army and Air Force but "yellow" in the Navy and Marine Corps. The rationale for the Army rating was that "more than half of sampled PMs served less than 3 years."[20]

Some of the most recent quantifications of PM tenure were done by GAO. In 2005, GAO stated that PM tenure was longer but that most PMs still left after three

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[17] U.S. General Accounting Office, 1986a, pp. 79–80.

[18] U.S. General Accounting Office, *Acquisition: DoD's Defense Acquisition Improvement Program: A Status Report,* Washington, D.C., GAO/NSIAD-86-148, July 1986b, p. 11.

[19] David R. Graham, Barbara A. Bicksler, Robert P. Hilton, Marshall Hoyler, Herschel Kanter, Walter M. Locke, George H. Sylvester, and John R. Transue, *Defense Acquisition: Observations Two Years After the Packard Commission, Institute for Defense Analyses, Volume I: Main Report,* IDA Report R-347, Arlington, Va.: Institute for Defense Analyses, November 1988, pp. VI-4.

[20] Commission on Army Acquisition and Program Management in Expeditionary Operations, *Urgent Reform Required: Army Expeditionary Contracting,* Washington, D.C., October 31, 2007, p. 18.

or four years.[21] In November 2007, it released more data on PM tenure, finding significantly shorter averages. In this second study, GAO analyzed 39 MDAPs that started after March 2001. It calculated the average PM tenure for these programs at only 17.2 months.[22]

Table 2.1 summarizes the data that have been presented on program manager tenure in the literature over the last 40 years. These data indicate that average PM

Table 2.1
Quantifying PM Tenure over the Past 40 Years

	Average PM Tenure (months)				
Approximate Years of Data	**All Services**	**Air Force**	**Army**	**Navy**	**Data Source**
1961–1965	18		12		Dews et al., 1979, pp. 5, 15
End of 1960s	< 24				Dews et al., 1979, pp. 5, 15
Mid-1960s–1979	30–36				Dews et al. 1979, pp. 5, 15
1961–1978	1961–1965: 18 1974–1978: 32				Dews et al., 1979, pp. 5, 15
Circa 1983	< 36				Defense Science Board, 1983, p. 46
January 1982–August 1984		22.8	37.2	46.8	U.S. General Accounting Office, 1986a, pp. 79–80
Circa 1986		16	9	39	U.S. General Accounting Office, 1986a, pp. 79–80
As of August 1986		31	26	26	U.S. General Accounting Office, 1986a, pp. 79–80
Circa 1986	27				U.S. General Accounting Office, 1986b, p. 11
1985–1987			37.8	23	Graham et al., 1988, p. VI-4
Circa 2001			< 36		Commission on Army Acquisition and Program Management in Expeditionary Operations, 2007, p. 18
Circa 2005	36–48				U.S. Government Accountability Office, 2005, p. 47
2001–2007	17.2				U.S. Government Accountability Office, 2007, p. 8

[21] U.S. Government Accountability Office, *Best Practices: Better Support of Weapon System Program Managers Needed to Improve Outcomes,* Washington, D.C., GAO-06-110, November 2005, p. 47.

[22] U.S. Government Accountability Office, 2005, p. 8.

tenure ranges from 18 to 48 months. However, it is important to note that the methodologies vary from study to study, which reflects the difficulty in accurately capturing how long PMs have remained in their positions over time.

Analysis Using Data on Recent Program Manager Tenure

The wide range of calculated PM tenures reflects several data sources and a variety of sample sizes. PARCA requested that RAND attempt to develop a separate measurement for PM tenure using easily accessible data. As explained above, we used data from SARs issued between 1997 and 2011 to quantify PM tenure; this is a standard source with easily accessible data that captures the largest possible sample size and includes data from all the services. The remainder of this chapter presents the results of that analysis.

RAND Analysis of Data on Program Manager Tenure, CY 1997–2011

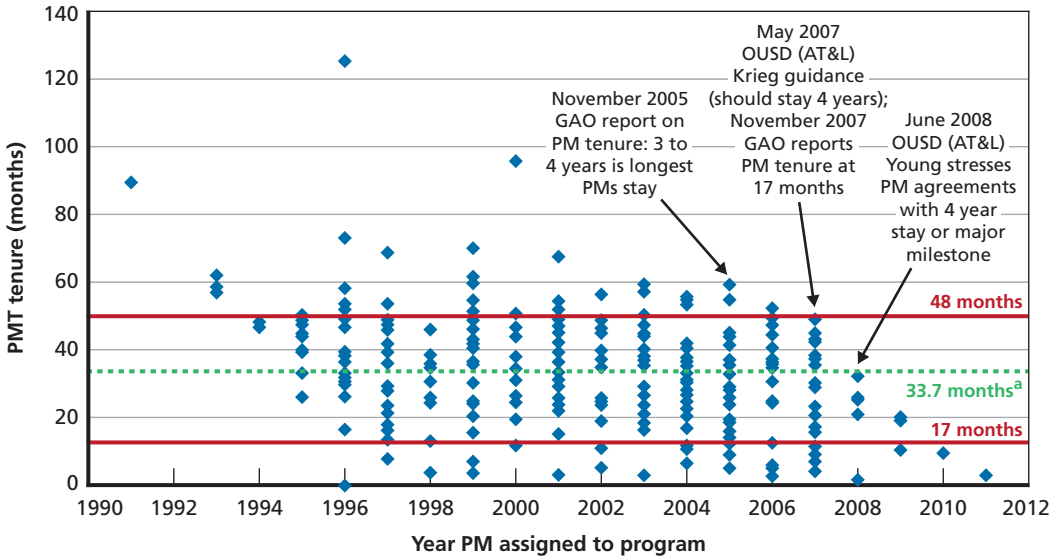
There are several ways to present the results of our analysis. The calculations are similar using the average number of months, but our sample sizes vary based on whether we decided to include open tenure periods and outliers. The calendar year (CY) 1997–2011 SARs included PMs who started their tenure as far back as 1991. Table 2.2 shows what we decided to exclude in the three ways we calculated PM tenure (see Figures 2.1, 2.2, and 2.3).

The first sample that we used to calculate PM tenure excluded open tenure periods but included PM tenure periods that started as early as 1991, along with other outliers. Our final database, excluding incomplete tenure periods, contained 370 PM tenure periods from 136 programs that had submitted SARs (both annual and quarterly) between 1997 and 2011. Average tenure for those PM periods was 33.7 months, which aligns more closely with the 2005 GAO assessment (no more than three to four years) than its 2007 estimate of 17.2 months. Figure 2.1 shows the results of this analysis.

Table 2.2
Exclusions for Quantifying PM Tenure

Method	Data Range (years)	Exclusions from Sample
Figure 2.1	1991–2011	Excludes open tenure periods but includes tenure periods that started as early as 1991 as well as other outliers
Figure 2.2	1997–2008	Excludes the outliers by eliminating PM tenure periods starting before 1997 and after 2008
Figure 2.3	1997–2008	Excludes data before 1997 and after 2008 and tenure periods greater than 60 months and less than 7 months

Figure 2.1
Average Number of Months PM Is Assigned to Program (full data set)



[a]RAND calculated average of 370 program manager terms using 1997 to 2011 SAR data.
SOURCE: SARs (1997–2011).
RAND *MG1171/4-2.1*

As the figure indicates, the spread or range of data varies considerably across years and within the same year. There are also several outliers with short terms and long terms, as well as a few data points before 1997 and after 2008. Figure 2.2 eliminates the outliers by first omitting years before 1997 and after 2008. After eliminating these outliers, 316 PM tenure periods remained. Given this sample, the total average tenure period was 32.1 months. This does not differ much from the original result of 33.7 months but is still significantly higher than GAO's 2007 estimate of 17.2 months, which had a sample size of only 39 MDAPs.

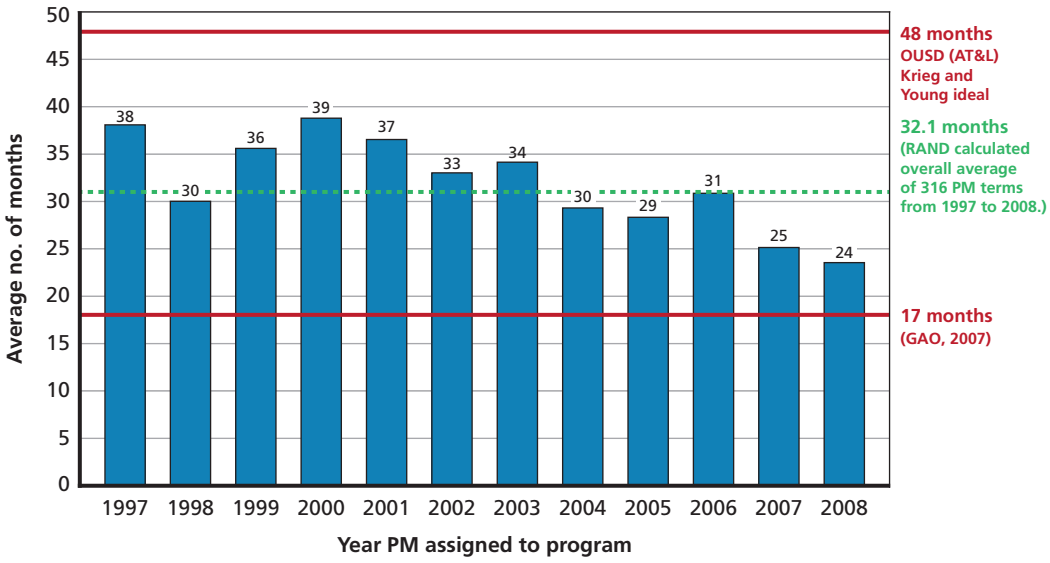
We then narrowed the data set even further by eliminating data before 1997 and after 2008 and by disregarding tenure periods greater than 60 months and less than seven months. We did this to remove data that could bias the results, such as major outliers and tenure periods that had not closed. After eliminating these data, 294 PM tenure periods remained. This third sample set yielded an average tenure period of 33.2 months. This was close to our original average using the full data set, but it was still significantly different from GAO's 2007 figure. These data are presented in Figure 2.3. [23]

[23] We began the analysis with a full data set. We initially found, though, that the data were "noisy." Accordingly, we decided to run scenarios: full data set and excluding what we thought were outliers and open periods. The point of this exercise was to see if there was any major bias in the data from some extreme outliers and open periods. A careful examination of the composition of the full sample set led us to conclude that the outliers would be

Statistical Analysis Including Open Tenure Periods

PARCA was specifically interested in a subset of our overall data set on PM tenure periods: PM tenure periods after the 2005 and 2007 DoD policy guidance that both stressed the lengthening of these periods. Given that we were interested in data near the 2005 and 2007 policy actions, we also needed to take into account open PM tenure periods. One challenge in introducing open tenure periods to this analysis was that these periods cause bias in the average or mean, because the PMs have not finished their tenure in a particular program. This makes the overall average shorter than if the PMs had finished their tenure. Understanding that this issue would complicate the analysis, we introduced the open tenure periods that we had previously eliminated and attempted a statistical analysis to determine whether the 2005 and 2007 policies were able to lengthen tenure.

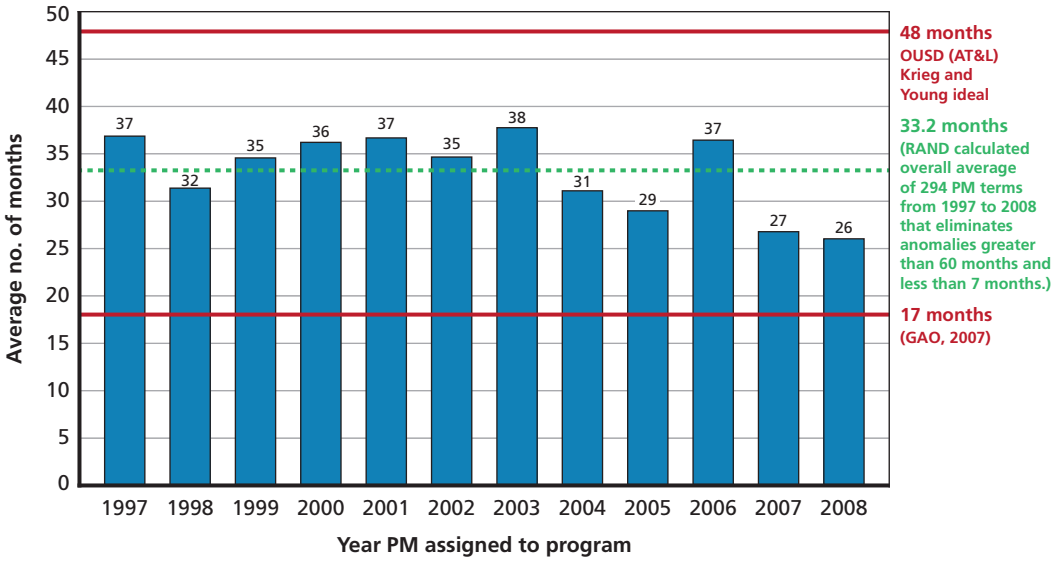
Figure 2.2
Average Number of Months PM Is Assigned to Program (1997–2008 only)



SOURCE: SARs (1997–2008).
NOTE: Each bar represents the average tenure of PMs who started their assignment in that given year.
RAND *MG1171/4-2.2*

under seven months based on the thought that these PMs were most likely acting PMs. (Note: The SARS have no data that identify acting versus permanent PMs.) The reasons for the upper outliers were less evident. Nine terms were over 60 months. We have some interrelated programs: Ballistic Missile Defense System (BMDS) and Multi-functional Information Distribution System (MIDS); Chemical Demilitarization (CHEM DEMIL) Assembled Chemical Weapon Alternatives (ACWA) and Chemical Materials Agency (CMA). The final result was that even when we took out the outliers (under seven months and over 60 months), there was very little difference in the average tenure: 33.7 months compared with 33.2.

Figure 2.3
Average Number of Months PM Is Assigned to Program (1997–2008 only, excluding tenure periods of more than 60 months and less than 7 months)



SOURCE: SARs (1997–2008).
NOTE: Each bar represents the average tenure of PMs who started their assignment in that given year.
RAND *MG1171/4-2.3*

Including open tenure periods increased our data set to 464 total tenure periods. Of these, 48 PMs started in their positions before 1997, and 416 started between 1997 and 2011. Three PMs started in 2011. Obviously, only a very small fraction of PM tenure periods that started in 2011 are included in the data. Consequently, in this data set, we excluded entries from 2011 and before 1997.

Table 2.3 shows the number of PM tenure periods beginning in each year. The table also gives the percentage of these positions that remained open at the time of the final data collection. A very large number of the PMs who started their tenure periods after the policy change were still in their positions at the end of data collection. This makes it challenging to accurately estimate the average time in position for PMs following the policy change. Any estimate of the average time in position that uses only completed tenures will be severely downwardly biased for positions opened after 2006, because it is likely that only those positions with short tenures will be available for analysis. For example, nearly 39 percent of PMs who started in their positions in 2007 were still in those positions when we collected our data. The average tenure of the closed positions was 25 months. The average tenure of open positions was 42 months at the time of data collection, which means that the final tenure must average at least this long for this group. The average tenure for all cases equals 0.61 times the average tenure for positions that had closed at the time of data collection, plus 0.39 times the average

Table 2.3
PM Tenure Periods and Percentage That Remained Open at Last Data Collection, by Year

Year	Number of PM Tenure Periods	Percentage Open
1997	26	0.0
1998	19	0.0
1999	28	0.0
2000	23	0.0
2001	38	0.0
2002	19	0.0
2003	29	0.0
2004	29	0.0
2005	40	0.0
2006	30	3.3
2007	49	38.8
2008	32	68.8
2009	23	87.0
2010	31	96.8

SOURCE: SARs (1997–2010).

tenure for positions that remained open at the time of data collection (by the time they eventually close). We multiplied the mean of closed positions by 0.61 because 61 percent of positions had closed, and we multiplied the mean of the open positions by 0.39 because 39 percent of the positions remained open at the time of data collection. The average for the open positions is unknown but must be greater than 42 months, so the average tenure when all positions close will be greater than (0.61 x 25 months) + (0.39 x 42 months) = 32 months. Consequently, using only the closed positions to estimate average tenure would bias the average by at least 17 months or more than 1.4 years. The bias would be even larger for later years, when even more positions remained open at the time we collected our data.

Time in Position

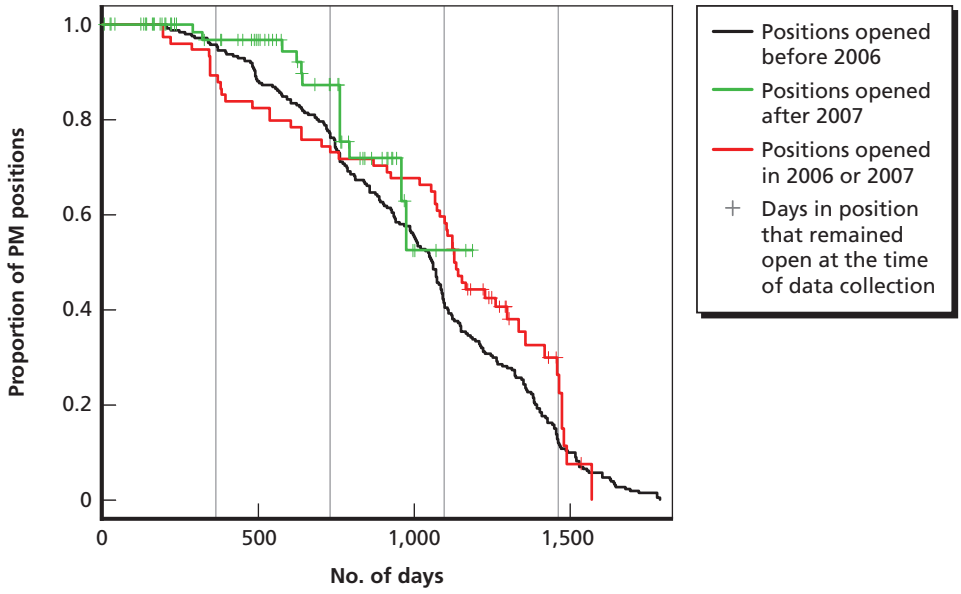
A standard solution to the problem of studying when an event will occur before it has occurred is to estimate the probability that the event will occur after a given length of

time.[24] For example, we could estimate the probability that a PM's tenure will be longer than one day, longer than two days, longer than three days, and so forth, until we have covered the full range of tenure times. The probabilities can be estimated without bias even when some PMs remain in their positions. Thus, we use this method to compare PM tenures in three distinct periods: before the first policy change (positions opened between 1997 and 2005), after the first policy but before the second guidance change and GAO report (positions opened in 2006 and 2007), and after the policy changes (positions opened in 2008 or later).

Figure 2.4 presents the results of our analysis in graphical form. For each group of programs—those beginning before 2006 (black curve), those beginning in 2006 or 2007 (red curve), and those beginning after 2007 (green curve)—the figure plots the probability that a PM's tenure was a given number of days or longer. As the figure shows, no positions beginning before 2007 remained open at the time of data collection, whereas large numbers of PMs remained in their positions among those starting in 2006 or 2007 or after 2007.

All three lines are at 1.00 for days zero to 180, because we excluded programs in which PM tenure was less than 180 days. Hence, all programs in the sample will last 180 days or longer. After 180 days, the curves turn down from 1.0 as some PMs'

Figure 2.4
Distribution of Time in Position Before and After Policy Change, All Periods (excluding those closed in less than 180 days)



RAND *MG1171/4-2.4*

[24] David W. Hosmere, Jr., and Stanley Lemeshow, *Applied Survival Analysis: Regression Modeling of Time to Event Data,* New York: Wiley Interscience, 1999.

tenure ended at these times. At one year, the black line is at 0.95, indicating that about 5 percent of PMs beginning their positions before 2006 had left those positions by one year later, so about 95 percent would remain in their positions for a year or longer. By one year, nearly 11 percent of PMs beginning in 2006 or 2007 would have left their positions, so about 89 percent would have tenures of one year or longer. Only about 3 percent of PMs starting after 2007 left their programs within a year, so 97 percent had tenures of more than one year.

For the first two years, the green curve is higher than the black curve, which, in turn, is higher than the red curve, indicating that PMs starting after 2007 had the greatest chance of remaining in their positions for two or more years, and PMs starting their positions in 2006 or 2007 had the lowest chance of remaining in their positions for two or more years. The green curve remains above the other two curves until around day 950 (about 2.6 years).

Positions beginning in 2006 or 2007 and lasting more than two years would have been closing after the revised guidelines of 2007. Combined with the general trend toward longer tenure for PMs beginning after 2007, the data provide some support for the result that PMs remained in their positions longer after the release of the revised guidelines in 2007. However, because of the small sample size and the large number of open positions among those beginning in 2006 or later, the differences among groups are not statistically significant, and the observed differences could be chance occurrences rather than real differences among the groups of positions.

Additional years of data for these positions and new positions starting in 2011 or later could help establish whether the differences among groups demonstrate persistent changes in practice after the release of the revised guidelines. Even if the differences proved to be persistent, they might not have been caused by the revised guidelines. We would need to rule out other potential sources of change before we could make that attribution. However, analysis of additional data would be a valuable first step in more fully exploring the effects of the 2007 guideline change.

Conclusions

PM tenure is a policy issue that has been reviewed and quantified periodically over the past 40 years. It is difficult to assess whether policies implemented to foster longer tenures have been successful based on previous data and studies and current data. It is possible to conclude that, since the same themes have reoccurred in policies over the past 40 years, the intent of these policies may not have been achieved. Furthermore, an enforcement mechanism has not been readily apparent over time. This could be because enforcement is limited as a result of the fundamental conflict that exists between what military officers need to do to be promoted and their tenure as PMs. Unless these two objectives are connected so that lengthy tenure in a program can be

advantageous for promotion, it is unlikely that these tenure policies will consistently yield positive results. In addition, PM tenure can be affected by a variety of issues that we have not taken into account in this study. These include, for example, the following:

- moving a PM from one program to another prematurely to fulfill a gap in a critical program
- premature termination of a program and consequent premature conclusion of a PM's tenure period
- poor performance requiring that a PM be moved out of a program
- ending a tenure period based on promotion to a position outside the program office.

Given the narrow focus of this study, we did not take into account other data sets that might have been relevant. Expanding the focus to include data on the tenure agreements between PMs and acquisition executives, along with the Precepts for the Promotion Boards in the Navy and similar processes in the other services, would provide a richer analysis of this topic.

In this study, we attempted to quantify PM tenure from 1997 through 2011 using SAR data. We then tried to determine whether the policies of 2005 and 2007 have helped lengthen PM tenure. A statistical analysis using open and closed tenure periods indicated that the estimate of the mean time in position for tenure periods starting after 2007 is biased, because of the large number of tenure periods that remained open at the last data collection. This creates an average for tenure periods starting after 2007 that is lower than will be the case when all PM tenure periods starting in 2008, 2009, and 2010 have both a beginning and an end. Using these same data, we found that PMs who started in 2006 or 2007 had about the same probability of remaining in their position for at least two years (0.75) but a greater probability of staying for three or more years (0.64 compared with 0.41) than PMs who started in 2005 or earlier. PMs starting in 2008 or later, had about an 87 percent chance of remaining in their positions for two or more years and about a 50 percent chance of remaining for three or more years, suggesting an increase in PM tenure after the second policy change. The differences are not statistically significant, because of the small number of tenure periods starting after 2007 and the large proportion of PMs from this sample who remained in their positions when we collected the data.

We also found that adjusting for a variety of data issues (e.g., outliers, open periods) gave us more confidence in the data but only minimally changed the result of our analysis of PM tenure in MDAPs over the past 14 years. By taking into account closed PM tenure periods, we found that PM tenure averages 33 months. This result is much higher than GAO's 2007 figure of 17.2 months (based on a sample size of 39 programs). However, our figure reflects a larger sample size covering more years and does not include any open periods. In conclusion, our analysis was able to quan-

tify PM tenure using current data but could not definitely say whether recent policies regarding PM tenure have had any positive effect on lengthening tenure over the past several years, because there were still too many open tenure periods at the time of data collection.

CHAPTER THREE

Oversight of ACAT II Programs

Do ACAT II Programs Need Additional Oversight?

Many legislative attempts have been made to control cost growth and to eliminate development delays. These have achieved some success but have failed to eliminate either unexpected increases in program costs or long production delays. In addition, existing requirements cover primarily the largest acquisition programs, MDAPs, leaving smaller and non-MDAP programs without consistent centralized oversight at the OSD level. Oversight for these smaller programs occurs only at the military department level.[1] The motivating question driving this report is whether existing decentralized systems used to track cost growth and performance of ACAT II programs are sufficient or whether additional centralized guidance is warranted.

Additional monitoring increases the burden on the defense agencies and military departments, which must file extra reports, and the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD [AT&L]), which will be responsible for executing new control actions. As a result, a decision to mandate additional reporting and control requirements for ACAT II programs is warranted only if problems with the existing system result in cost growth and schedule slippage and can be reduced or eliminated by centralized oversight that is cost effective.

To assess if such performance issues do plague current ACAT II programs, we conduct two sets of analyses, one on a set of case studies of ACAT II programs and one on a comparable set of MDAPs. Both sets include programs from across military departments and procurement program categories (e.g., aircraft, weapons, shipbuilding, and conversions). We evaluate the performance of each program in both sets, focusing specifically on unit cost growth over program life and the amount of instability in annual quantity procured over time. Then, we compare the overall performance of the two sets of programs. This analysis and comparison suggest some general inferences about the performance of ACAT II programs under the current system of oversight, their performance relative to MDAPs, which are subject to more centralized

[1] Programs are designated as MDAPs based on a number of factors, including total lifetime cost. See Table 3.1 for details and a complete set of definitions.

monitoring and requirements, and the need for additional centralized reporting and control requirements. If sample ACAT II programs perform as well or better under the current decentralized system than sample MDAP programs under more rigorous oversight, then there may be little need for additional reporting and control requirements for ACAT II programs. If sample ACAT II programs perform worse than sample MDAPs, additional ACAT II oversight may be warranted.

A few words about the scope of our research questions and analytical approach provide some additional context for the reader. First, we adopted a very narrow research question, focused explicitly on determining whether active ACAT II programs appear to suffer from cost and schedule problems that would demand additional guidance. Although identifying the primary root causes and measuring the precise magnitude and duration of performance problems in ACAT II programs are related and important questions, they fall outside the scope of this study. Second, we used only publicly available data for the assessment of both ACAT II and MDAP programs, specifically, data from the budget justifications written by the military departments. We intentionally did not try to obtain or use other data sources, proprietary information, or personal observations or opinion held by program managers or acquisition executives within the military departments. Our reliance on objective and consistent data sources for all programs across military departments supports more meaningful comparison and limits concerns of bias introduced by personal reports. As important, the approach allows us to investigate the quality and quantity of publicly available data on ACAT II programs and to define a methodology for conducting research on and evaluations of these smaller acquisition programs in the future.

Reliance on publicly available data had advantages for this study, but it also had some drawbacks. For example, additional data or explanations directly from a program manager might have provided more nuanced assessments of program performance or better justifications for certain cost overruns or slips in schedule. It might also have highlighted areas where acquisition executives feel that additional oversight might be helpful or where ACAT II programs often struggle in performance. As noted above, we chose not to pursue these avenues, because our limited objective was to conduct a broad comparison of ACAT II and MDAP performance as a diagnostic tool to assess the need for additional guidance.

A third issue related to the scope of the study is generalizability. Since we assess only a selected set of ACAT II and MDAP programs, our analysis and observations are most relevant to these specific programs. However, because we selected our sets to include a range of different types of programs from across procurement program categories and military departments, our results should have some applicability to acquisition programs more generally.

Finally, our assessments of cost and schedule do not consider research, development, test, and evaluation (RDT&E) costs, which often account for a large portion of cost growth. The research and development phase is also often associated with sched-

ule delays. The decision not to include these particular costs was largely driven by data availability: Reliable and complete RDT&E costs are not available for most ACAT II programs. This choice means that our analysis will not capture performance issues that affect programs before their entrance into production (and so may be overly positive) and will completely miss programs that never make it out of the development stage. However, these limitations are largely outside the very narrow focus and objective of this study, which is to determine whether active ACAT II programs need additional oversight to limit cost growth. For this purpose, reliance on performance data from after the program enters production should be sufficient. Finally, to ensure comparability between our assessment of ACAT II and MDAP programs, we also focus on MDAP performance only after the program enters production.

The considerations above do not reduce the relevance or value of the analysis presented in the remainder of the report, either as a demonstration of a methodological approach to studying ACAT II program performance or as a diagnostic tool used to assess the potential need for and value of additional guidance for ACAT II programs.

Before conducting our assessment, however, it is useful to consider the oversight mechanisms and reporting and control requirements that existing statute defines for acquisition programs as well as the current procedures used by the military departments to monitor the cost growth and overall performance of these programs. The remainder of the chapter provides some detail on both levels of performance oversight.

As noted in the introduction, oversight for these smaller programs occurs only at the military department level. Although this gap in oversight may initially seem worrisome, in reality, additional centralized guidance is valuable only when it is needed or provides important transparency about program performance that improves program health over the long run. In fact, additional monitoring comes with a number of drawbacks, including extra burden on the defense agencies and military departments, which must file extra reports, and OUSD (AT&L), which will be responsible for executing new control actions. As a result, a decision to mandate additional reporting and control requirements for ACAT II programs is warranted only if there are problems with the existing system that result in cost growth and schedule slippage and that can be reduced or improved by centralized oversight.

In this chapter, we assess whether such performance issues do plague current ACAT II programs by comparing the performance of a set of ACAT II programs with that of a selected set of MDAPs, chosen to be broadly comparable and generalizable. We use this analysis and comparison to evaluate the need for additional oversight of ACAT II programs. Specifically, additional oversight may be needed only if the selected set of ACAT II programs perform worse than selected set of MDAPs. As noted above, we rely on publicly available data and keep the scope of our research narrow, explicitly considering only whether active ACAT II programs appear to suffer from cost and schedule problems that might demand additional guidance. We also consider programs only after they enter production and we exclude RDT&E costs.

Before conducting this assessment, however, it is useful to consider the oversight mechanisms and reporting and control requirements that existing statute defines for acquisition programs, particularly MDAP programs, as well as the current procedures used by the military departments to monitor cost growth and the overall performance of these programs.

Background on Existing Oversight for MDAPs

Once an acquisition program is designated an MDAP, it receives considerable oversight to ensure that it meets it cost, schedule, and technical performance requirements. Three reports are designed to provide the information necessary to carry out this oversight: Selected Acquisition Reports, Unit Cost Reports (UCRs), and Defense Acquisition Executive Summaries (DAES). The SARs and the UCRs are statutory requirements, and the DoD regulation requires the DAES. In addition to these three reports, Congress also requires that DoD establish a baseline description for each MDAP, including cost, schedule and performance goals, and anything else deemed pertinent. The Secretary of Defense must, by law, approve cost, schedule, and performance goals for these programs. Program managers must document goals for each program before it begins.[2]

Nunn-McCurdy Provisions and Breaches

One of the first legislative attempts to control cost growth in acquisition and procurement programs, the Nunn-McCurdy provisions, was initiated by Senator Sam Nunn and Representative David McCurdy as part of the 1982 National Defense Authorization Act. The Nunn-McCurdy provisions, still in use today in an updated form, created a codified way for Congress to keep pervasive cost growth in check through a system of reporting and control requirements. The provisions use unit cost growth as one metric to monitor program health. The two unit cost definitions are program acquisition unit cost (PAUC) and average procurement unit cost (APUC). PAUC is the total development, procurement, and construction cost divided by the total program quantity, and the APUC is just the total procurement amount divided by the procurement quantity. If either of these costs exceeds a threshold value, then the program is said to incur a Nunn-McCurdy breach, which triggers automatic procedures intended to mitigate cost growth. Although the provisions provided some transparency on acquisition programs and their overall health, they applied only to the largest, those qualifying as MDAPs based on their expected total cost.[3]

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[2] This description has been drawn from Gerry Land, *Oversight of Major Acquisition Programs,* Fort Belvoir, Va.: Defense Acquisition University, April 2006.

[3] 10 U.S. Code Section 2433 Unit Cost Reports, Washington, D.C.: Government Printing Office, 2010.

Modifications to the law in 2006 added some nuance by defining significant and critical breaches. A significant breach occurs when either PAUC or APUC exceeds 15 percent of the current baseline estimate or 30 percent of the original baseline estimate. A critical breach is for a 25 or 50 percent increase, respectively. The comparison to the original baseline is included to prevent cost growth being hidden by constant program re-baselining.

Changes Brought by WSARA 2009

The original Nunn-McCurdy legislation had some success in monitoring and limiting cost growth and schedule delays by illuminating important problems and program issues but was not able to eliminate either problem, and both remained significant impediments to acquisition program efficacy. More recent legislation has attempted to address cost growth and schedule slippage with other types of oversight and changes to the acquisition processes and procedures. One comprehensive effort, the Weapon Systems Acquisition Reform Act (WSARA) of 2009, sought to systematically alter the acquisition process through changes to acquisition organization, personnel structure, policy, and reporting and control requirements. Based on numerous reports and investigations into cost growth and schedule slippages that identified the lack of a solid foundation of systems engineering, cost estimation, and developmental testing early in the program as drivers of cost growth and schedule slippage, WSARA 2009 laid out specific modifications to the procurement process intended to bolster these aspects of acquisition.[4]

These changes can broadly be categorized into three areas: organizational changes, policy changes, and reporting and control requirements.[5]

Organizational Changes

WSARA 2009 dictates that DoD must evaluate its systems engineering capabilities and develop skilled employees to fill any gaps in their ability to support key acquisition decision with rigorous systems analysis and systems engineering. DoD must also do the same for developmental testing and establish a new position: Director of Developmental Test and Evaluation. The Director of Defense Research and Engineering (DDR&E), an extant position, would have new responsibilities, including periodic reviews of the critical technologies used in MDAPs. To address the common problem of unrealistic cost estimates, a Director of Independent Cost Assessment would be established to ensure that the cost estimates for MDAPs are reasonable and dependable. In addition, to better solicit feedback from the end user of MDAPs (the warfighter), the Joint Requirements Oversight Council (JROC) would be required to

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4 Public Law 111–23, 2009.

5 Sen. Carl Levin, *Summary of the Weapon Systems Acquisition Reform Act of 2009*, press release, February 24, 2009.

seek and consider input from the combatant commanders (COCOMs) when identifying joint military requirements. Finally, two new positions were created to evaluate MDAPs: the Director of Cost Assessment and Program Evaluation (CAPE) and the senior official for PARCA.

Policy Changes

WSARA 2009 requires increased interaction between the traditionally stovepiped requirements, budget, and acquisition aspects of procurement. Because cost, schedule, and performance are highly intertwined, this increased coordination can mitigate the spread of problems in one area of a program to others. To ensure a solid knowledge base in each MDAP, a Preliminary Design Review (PDR) and formal post-PDR assessment must be completed before a MS B decision can be made, sending the program into the engineering, manufacturing, and development (EMD) phase. This change is consistent with the additional responsibilities of the DDR&E. To counteract the effects of the consolidation of the defense industry, a number of new measures promoting competitions, as well as periodic program reviews, and additional competition at the subcontract level were introduced. These measures include competitive prototyping, dual-sourcing, funding of a second source for next-generation technology, use of open architectures to ensure competition for upgrades, periodic competitions for subsystem upgrades, licensing of additional suppliers, and government oversight of make-or-buy decisions. Additional oversight was also added to keep organizational conflict of interest in check.

WSARA also changed reporting and control requirements and review processes. First, both MS A and MS B certification processes were modified. Under new guidelines, before MS A certification, each program must undergo a Nunn-McCurdy–like review. In addition, any program with MS B certification waived must undergo an annual review by the Milestone Decision Authority (MDA). These amendments are applied retroactively, such that programs with MS A certification and no MS B certification and programs with MS B certification and no MS C certification must be retroactively recertified using the new requirements. Second, a program experiencing a critical Nunn-McCurdy breach must have a root cause analysis (RCA) performed, and the program may be terminated unless the Secretary of Defense certifies to Congress that the program is essential to national security and can be modified to continue in a financially sensible manner. The program's most recent milestone will be rescinded and a new milestone approval must be obtained before any new contracts or contract modifications can be signed. These revisions were intended to make oversight processes more rigorous and direct and to prevent programs with significant problems from eluding management oversight. Once again, however, their reach was limited: WSARA requirements apply only the largest defense acquisition programs, MDAPs, and not to smaller acquisition programs.

Congressional Reporting and Control Requirements

WSARA 2009 also adds reporting and control requirements that communicate progress on acquisition performance to Congress.

- The director of CAPE is required to provide an annual report evaluating the previous year's cost estimates. The CAPE office also must produce a one-time report on findings and recommendations for establishing MDAP operating and support cost baselines.
- The directors of developmental test and evaluation (DT&E) and systems engineering (SE) must produce an annual joint report on specific MDAP-related activities.
- The senior official for PARCA must produce an annual activities report.
- The director of research and engineering (R&E) must provide annual assessments on the technological maturity of technologies critical to MDAPs.
- Finally, more earned value management information was required in its congressional report.

Implications of WSARA for Acquisition Programs

WSARA is intended to improve the acquisition of MDAPs, but many of the provisions carry additional costs for the defense agencies, military departments, and offices within OUSD (AT&L). For the defense agencies and military departments, the most significant burden will be the increase in workload necessary to meet all new reporting and control requirements. More independent cost estimates are necessary, as well as the ability to monitor costs continuously. Annual reports must be presented to Congress, all requiring additional staffing and manpower to complete. For offices within OUSD (AT&L), including PARCA, additional centralized oversight will also increase the staffing burden to support the review of new data and the implementation of new control mechanisms.

WSARA also introduces the requirement for an RCA to take place for every MDAP that undergoes a Nunn-McCurdy breach. These analyses are not trivial pursuits and require considerable resources and expertise. The short turnaround time required to present the analysis to Congress adds another layer of burden. In addition, the retroactive recertifications of programs between Milestones A and B and Milestones B and C are an additional strain on DoD. To fill these new requirements, existing workforces must be retooled, new talent recruited and hired, and organizations restructured, all in a period of constrained resources.[6]

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[6] Mona Lush, *Implementation of Weapon Systems Acquisition Reform Act (WSARA) of 2009,* October 22, 2009.

Oversight of Non-MDAPS

As noted above, existing reporting and control requirements apply only to MDAPs, the largest acquisition programs based on expected lifetime cost. Many other classes of acquisition programs are defined based on the size of the program and its total lifetime cost. Table 3.1 summarizes acquisition program types and definitions.

Table 3.1
Program Types

MDAP	Designated as an MDAP by the MDA or its dollar value is estimated by OUSD (AT&L) to require an eventual total expenditure for RDT&E of more than $365 million in fiscal year (FY) 2000 constant dollars or, for procurement, of more than $2.190 billion in FY2000 constant dollars. All MDAPs are in ACAT I. MDAP Decision Authority. ACAT ID:OUSD(AT&L). ACAT IC: head of the DoD component or, if delegated, the Component Acquisition Executive (CAE) (not further delegable).
MAIS	Designated by the MDA as a MAIS or its dollar value is estimated to exceed $32 million in FY2000 constant dollars for all expenditures, for all increments incurred in any single fiscal year, or $126 million in FY2000 constant dollars for all expenditures, for all increments incurred from the beginning of the materiel solution analysis phase through deployment at all sites, or$378 million in FY2000 constant dollars for all expenditures, for all increments incurred from the beginning of the materiel solution analysis phase through sustainment for the estimated useful life of the system. All MAIS are in ACAT IA.MAIS Decision Authority. ACAT IAM: OUSD (AT&L) or designee. ACAT IAC: head of the DoD component or, if delegated, the CAE (not further delegable).
Special interest programs	OUSD (AT&L) shall designate programs as special interest based on one or more of the following factors: technological complexity congressional interest large commitment of resources program is critical to achievement of a capability or set of capabilities program is a joint program. MDAPs and MAIS cannot be considered special interest programs. Special interest programs can be categorized as any ACAT. ACAT ID or IAM:MDA is OUSD (AT&L) or designee. ACAT IC or IAC:MDA is head of DoD component or, if designated, CAE ACAT II or III. MDA is head of DoD component or, if designated, CAE.
Pre-MDAP, MAIS	A Pre-major defense acquisition program (or pre-MAIS) is one that is in the materiel solution analysis or technology development phases preceding MS B of the defense acquisition system and has been identified to have the potential to become an MDAP.
ACAT II	Does not meet criteria for MDAP. Major system. Dollar value: estimated by the DoD component head to require an eventual total expenditure for RDT&E of more than $140 million in FY2000 constant dollars, for procurement of more than $660 million in FY2000 constant dollars, or MDA designation as special interest. Decision authority CAE or individual designated by CAE Automated Information Systems (AIS) cannot be categorized as ACAT II.
ACAT III	Does not meet criteria for ACAT II. AIS that is not MAIS. Decision authority designated by CAE.

Although most of the WSARA legislation and the codified reporting and control requirements apply only to the MDAPs, WSARA did not entirely ignore the performance of smaller programs. Instead, it gave the newly created PARCA office the authority to issue additional guidance on reporting and control requirements for other types of programs, including the smallest ACAT II and III programs, as necessary and appropriate. Specifically, it states that PARCA is responsible for "Issuing policies, procedures, and guidance governing the conduct of performance assessments and root cause analyses by the military departments and the Defense Agencies." This gives PARCA the option to extend more rigorous, MDAP-like guidance to smaller acquisition programs, but it also allows PARCA the option of keeping the status quo. This responsibility suggests two related questions that PARCA leaders must answer and that motivate this report: First, is additional guidance needed? Second, if so, what should this guidance look like?

Determining the appropriate guidance and the right level of oversight to apply to ACAT IIs is important because, although the MDAPs are the largest programs in terms of size, non-MDAP programs make up a much larger share of the total active acquisition programs. Table 3.2 shows that about 92 percent of all programs are non-MDAPs not subject to centralized OSD oversight or existing Nunn-McCurdy reporting and control requirements. Instead, these non-MDAP programs are currently managed by the military departments and the defense agencies themselves, each of which

Table 3.2
Program Type: By the Numbers

		ACAT							
Program Type	**IAC**	**IAM**	**IC**	**ID**	**II**	**III**	**N/A**	**(Blank)**	**Total**
MAIS	11	14							25
Pre-MAIS	2	17							19
MDAP			34	56					90
Pre-MDAP				4				34	38
Special interest		1		1	50			3	55
Other					2				2
(Blank)					110	850	1	2	963
Total	13	32	34	61	162	850	1	39	1,192

SOURCES: Derived from DAMIR, "Active Programs," November 28, 2011; Assistant Secretary of the Navy (Research, Development & Acquisition) (ASN [RDA]) "Active Program List," August 10, 2011; and Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA [ALT]), "Active ACAT II and ACAT III Program List," January 4, 2012.

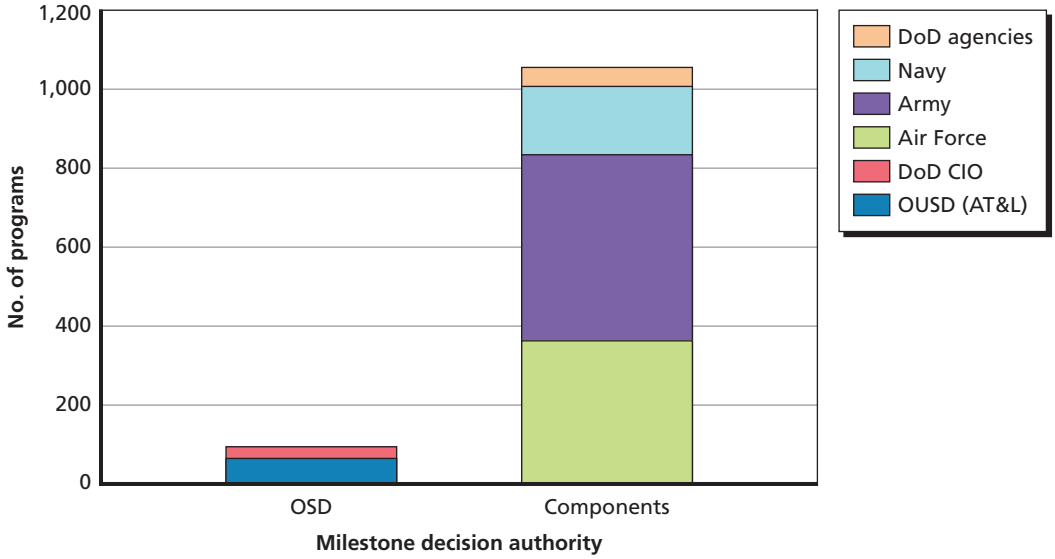
NOTE: Blank cells indicate no program in category.

has its own procedures for monitoring program health and dealing with cost overruns and schedule slips. As shown in Figure 3.1, the military departments and defense agencies currently oversee and hold milestone decision authorities for about 97 percent of non-MDAPs, or 89 percent of active programs.

Military Department Oversight of ACAT II Programs

The military departments have formal and defined systems in place to oversee and monitor their non-MDAP programs. These systems are similar to those used to monitor MDAPs and may include the use of RCA and performance assessment (PA). However, whereas all MDAP programs are subject to these guidelines, only certain non-MDAPs are formally reviewed. In each case, only "selected non-MDAP programs" are subject to formal, rigorous review processes. Each military department's specific methods for selecting non-MDAPs to follow the more stringent oversight and reporting and control requirements of MDAPs do not appear to be formally written down in a central location. As a result, it is still not clear how often reviews are applied to ACAT IIs, how effective they are in identifying or stopping cost overruns and sched-

Figure 3.1
Program Management Responsibility



SOURCES: Derived from DAMIR, 2011; ASN (RDA), 2011; ASA (ALT), 2012; Department of the Navy, "Implementation and Operation of the Defense Acquisition System and the Joint Capabilities and Development System," SNI 5000.2E, September 1, 2011; and ACQpedia, "Acquisition Category," May 23, 2013.
NOTE: Each bar represents the average tenure of PMs who started their assignment in that given year.
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ule slippage, and how frequently ACAT II programs experience severe cost overruns and schedule slippage that might be prevented by more effective centralized or rigorous oversight. These questions must be answered before we can say for certain whether additional reporting and control requirements might improve the overall performance of ACAT II programs.

However, each military department has a set of documented procedures to assess and monitor acquisition programs—one that is applied to MDAPs and at least some ACAT IIs. Each military department also handles oversight of acquisition programs slightly differently. The following sections will describe some of the frameworks in place that are designed to assess program health, inform senior leaders, and correct deviations in programs that experience cost growth and schedule slippage.

Army

The Army has a number of unique structures and methods for monitoring program health. The Army Systems Acquisition Review Council (ASARC) is central to the Army's oversight of its acquisition programs.[7]

ASARC provides senior-level acquisition managers and functional principals a forum to formally review a program's progress and health and determine if it is ready to move on to the next acquisition phase. ASARC is the Army's review board for MDAPs and selected ACAT II programs where the Army Acquisition Executive (AAE) is the MDA. Case by case, the AAE may delegate MDA responsibility to the Program Executive Office (PEO) level, in which case an ASARC is unnecessary for that ACAT II program. ASARC membership consists of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA [ALT]), who chairs the council, Vice Chief of Staff of the Army (VCSA), Deputy Under Secretary of the Army (Test and Evaluation) (DUSA [T&E]), Assistant Secretary of the Army (Financial Management and Comptroller) (ASA [FMC]), Assistant Secretary of the Army (Installations and Environment) (ASA [I&E]), Assistant Secretary of the Army (Manpower and Reserve Affairs) (ASA [M&RA]), as well as the Deputy Chief of Staff (DCS) from all Army staff. The ASARC is supported by Integrated Product Teams (IPTs), which engage in the day-to-day oversight. The overarching IPT (OIPT), which is chaired by the ASA (ALT) Deputy Assistant Secretary of the Army for Acquisition and Systems Management (ASM) DASA (ASM), conducts program reviews before ASARC and works to resolve programmatic issues that cannot be resolved at lower levels.

ASARC gets data on program health from documentation produced by program managers. Some of this documentation is statutory and cannot be tailored for a specific program. Other pieces of documentation allow for alterations that facilitate the inclusion of program-specific information. The PM can engage the OIPT to determine the

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[7] Department of the Army, *Army Acquisition Procedures,* Headquarters, Pamphlet 70-3, Washington, D.C., January 28, 2008.

optimal way to report program information via documentation. Oversight documents include the Acquisition Program Baseline (APB), Acquisition Decision Memorandum (ADM), Army Cost Position (ACP), Acquisition Strategy Report (ASR), and dozens of others. These are supplemented by supporting documents, documents specific to congressional and Defense Acquisition Board (DAB) oversight reporting, as well as program-specific documents.

ASARC conducts two types of reviews: program reviews (PRs) and milestone decision reviews (MDRs). ASARC IPTs support the program office in preparing for these reviews, including assisting with the production of documentation. MDRs are typically more extensive than PRs. The outcomes of a MDR are typically an ADM or approved APB.

Once an APB has been established, cost, schedule, and performance parameters are set. A breach occurs when the program breaks the thresholds set by these parameters. There are two types of breaches. A programmatic breach occurs when factors outside the control of the program office cause a threshold to be broken. These include guidance from above the program office level, requirement revisions, program restructuring, and doctrinal changes. A fact-of-life breach is due to internal factors, such as technical or managerial problems leading to a breach of the program's cost, schedule, or performance.

A breach sets several processes in motion. A PM review is automatically triggered. The PM must notify the MDA in a timely manner of the breach. The notification should be concise and contain courses of action necessary to correct and reset the thresholds that were breached.

Air Force

Air Force oversight is part of a larger acquisition and sustainment concept known as Integrated Life Cycle Management (ILCM). ILCM is a collection of processes designed to seamlessly integrate all portions of a life cycle from inception, development, acquisition, fielding, and sustainment.[8]

Within the ILCM construct, the Air Force uses Air Force Review Boards (AFRBs) and Acquisition Strategy Panels (ASPs) to monitor program health and assist the MDA in milestone decisions. AFRBs are forums chaired by the service acquisition executive (SAE) for conducting reviews before milestone decisions. They are required for nondelegated ACAT II programs. ASPs are forums to assist the SAE and other MDAs. They ensure that the best recommendation is made to these bodies.

The PM is responsible for supplying all statutory documentation. These documents include the Life Cycle Management Plan (LCMP), Information Support Plan (ISP), Systems Engineering Plan (SEP), Test and Evaluation Master Plan (TEMP), and Risk Management Plan (RMP), among others. The LCMP contains the acquisition

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8 Air Force Instruction 63-101, *Acquisition and Sustainment Life Cycle Management*, April 8, 2009.

and sustainment strategy for the entire life cycle of the system. Although these documents are required by law, the format and level of detail are unspecified, allowing the PM latitude in the creation of documentation.

The Air Force does not have specific requirements to handle breaches in place beyond those laid out in DoDD 5000. They do house responsibility for APB breach reporting with the Deputy Assistant Secretary for Acquisition Integration and require that PMs immediately notify the PEO of any breach.

Navy

Just as the Army and Air Force have unique oversight processes to determine program health and make milestone decisions, the Navy uses its own two-pass and six-gate review processes for acquisition programs. The goal of these processes is to ensure that acquisition aligns with Navy requirements.[9] However, not all programs are subject to the review. A brief overview of this process follows.

The process is divided into two passes, with three gates per pass. The first pass encompasses the materiel development decision and materiel solution analysis phase. It is led by the Chief Naval Officer (CNO) or the Commandant of the Marine Corps (CMC), and the three gates during this pass all deal with requirements. The first gate review grants authority for the submission of an Initial Capabilities Document (ICD) for joint review. This gate also confirms the plan for an Analysis of Alternatives (AoA). The second gate occurs after the AoA completion but before documentation necessary at MS A is submitted to the MDA. The AoA is reviewed at this gate, and the initial key performance parameters (KPPs) and key system attributes (KSAs) are confirmed for use in the Capability Development Document (CDD). The third gate review permits the CDD to be service-approved and provides full funding certification for MS A.

The second pass covers the MS A and technology development phase and the MS B and EMD phase. This pass, which also includes three gate reviews, is led by the CAE. Instead of requirements gates as in pass one, these gate reviews are acquisition-focused. The fourth of the six gates approves the formal system design specification (SDS) and allows the program to move to MS B. The fifth gate review ensures that the Navy has heeded all recommendations from the MDA and provides full funding certification for MS B. This gate review can occur before, during, or after the MS B decision, depending on the program's acquisition strategy. The final gate review assesses overall program health after the award of the EMD contract.

Should a Navy program breach the cost, schedule, or performance thresholds set in the APB, the MDA must be notified. The program office has 30 days to supply a report outlining the cause of the breach and planned action to rectify the situation.

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[9] SECNAVINST 5000.2E, *Department of the Navy Implementation and Operation of the Defense Acquisition Systems and the Joint Capabilities Integration and Development Systems,* September 1, 2011.

Summary

The mechanisms established by the military departments to monitor cost growth and other problems acquisition face are fairly extensive and include centralized and decentralized oversight processes as well as reporting and control requirements designed to identify poor performers and the root causes of their problems. However, these requirements apply primarily to MDAPs, leaving smaller ACAT II programs with less guidance. The military departments monitor ACAT II programs largely on their own, and they have systems in place to evaluate and track program performance. However, although non-MDAPs make up the majority of acquisition programs in terms of total number, only some of these programs are subject to formal review. Furthermore, it is not entirely clear how the military departments choose which programs are subject to these reviews. These observations combined with continued attention to issues of cost growth in acquisition programs among policymakers raise the question of whether additional guidance and requirements should be applied to the ACAT II programs.

Assessing ACAT II Programs

With this background, we now turn to our program assessment. The section begins with a discussion of our methodology, followed by a brief narrative and program assessment of the ACAT II programs that we selected from across military departments and procurement categories. It concludes with an overall assessment of ACAT II program performance, including a discussion of common problems and the scope of these problems.

Approach

Assessing the performance of non-MDAPs is not straightforward, because data are not easy to find or to use. There is no comprehensive list of non-MDAPs in common acquisition databases, such as DAMIR. Instead, we rely on budget Exhibit P-1s and P-40s provided by the military departments and included in the President's official budget justifications, as well as on congressional hearings and testimony to construct program narratives.

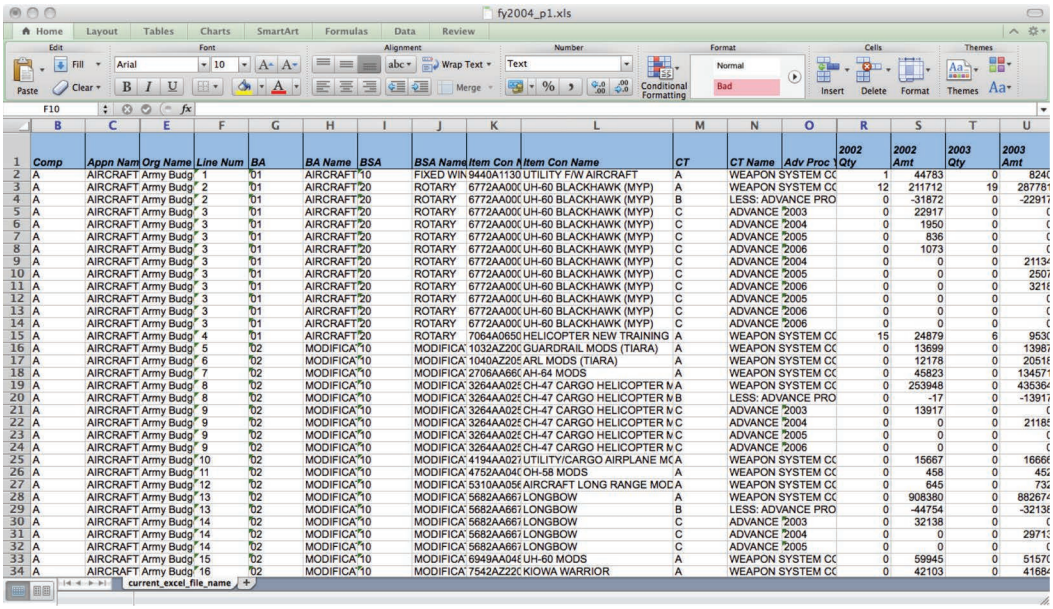
Exhibit P-1s and P-40s include information on program size and budget activity (procurement program category). Exhibit P-1 includes top-level summary information on cost and quantity for the past, current, and requested fiscal year. We used Exhibit P-1 to select ten ACAT II programs from each procurement program category across all three military departments. In each case, we selected from among the largest ACAT II programs that had been active within the last five years, but we excluded any programs that had been MDAPs.

Exhibit P-40 provides more detailed data on cost and quantity, including procurement of non–end items, such as initial spares and engineering services. Exhibit

P-40 also provides a basic program history that summarizes the program's development and sometimes identifies performance or program health issues, as well as explanations for revisions to past year estimates or future projections. We used Exhibit P-40s provided by the military departments to collect available data on cost and quantity for all programs. Exhibit P-40s contain at least three and sometimes as many as seven years of data. Values two years before the budget request are actual values; values from the year before the budget request are being executed and subject to change; and values from the year of the budget request are subject to change. These values are available for every program. Estimates for future year requests/funding often appear for the next four years, which constitute the Future Years Defense Program (FYDP). The exhibits include information on cost and quantity and details on what the money for each program specifically procures (e.g., hardware, peripherals, service contracts, training) in a given year. In addition, Exhibit P-40 includes a description of the program itself, its history, and sometimes description of problems or the rationale for revisions in cost or quantity. By collecting and merging data from Exhibit P-40 for each budget year, we can construct time series data of unit cost and quantity over a program's life span. Figures 3.2 and 3.3 show examples of what Exhibit P-1 and Exhibit P-40 tables look like when published.

To supplement the information included in Exhibit P-40, we used congressional hearings, testimony, and markups by the House Armed Services Committee (HASC), the Senate Armed Services Committee (SASC), the House Appropriations Committee

Figure 3.2
Sample Exhibit P-1



	B	C	E	F	G	H	I	J	K	L	M	N	O	R	S	T	U
1	Comp	Appn Nam	Org Name	Line Num	BA	BA Name	BSA	BSA Name	Item Con N	Item Con Name	CT	CT Name	Adv Proc Y	2002 Qty	2002 Amt	2003 Qty	2003 Amt
2	A	AIRCRAFT	Army Budg	1	01	AIRCRAFT	10	FIXED WIN	9440A1130	UTILITY F/W AIRCRAFT	A	WEAPON SYSTEM CC		1	44783	0	8240
3	A	AIRCRAFT	Army Budg	2	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	A	WEAPON SYSTEM CC		12	211712	19	287781
4	A	AIRCRAFT	Army Budg	2	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	B	LESS: ADVANCE PRO		0	-31872	0	-22917
5	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2003	0	22917	0	0
6	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2004	0	1950	0	0
7	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2005	0	836	0	0
8	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2006	0	1073	0	0
9	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2004	0	0	0	21134
10	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2005	0	0	0	2507
11	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2006	0	0	0	3218
12	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2005	0	0	0	0
13	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2006	0	0	0	0
14	A	AIRCRAFT	Army Budg	3	01	AIRCRAFT	20	ROTARY	6772AA000	UH-60 BLACKHAWK (MYP)	C	ADVANCE	2006	0	0	0	0
15	A	AIRCRAFT	Army Budg	4	01	AIRCRAFT	20	ROTARY	7064A0650	HELICOPTER NEW TRAINING	A	WEAPON SYSTEM CC		15	24879	6	9530
16	A	AIRCRAFT	Army Budg	5	02	MODIFICA	10	MODIFICA	1032AZ220	GUARDRAIL MODS (TIARA)	A	WEAPON SYSTEM CC		0	13699	0	13987
17	A	AIRCRAFT	Army Budg	6	02	MODIFICA	10	MODIFICA	1040AZ205	ARL MODS (TIARA)	A	WEAPON SYSTEM CC		0	12178	0	20518
18	A	AIRCRAFT	Army Budg	7	02	MODIFICA	10	MODIFICA	2706AA660	AH-64 MODS	A	WEAPON SYSTEM CC		0	45823	0	134571
19	A	AIRCRAFT	Army Budg	8	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	A	WEAPON SYSTEM CC		0	253948	0	435364
20	A	AIRCRAFT	Army Budg	8	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	B	LESS: ADVANCE PRO		0	-17	0	-13917
21	A	AIRCRAFT	Army Budg	9	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	C	ADVANCE	2003	0	13917	0	0
22	A	AIRCRAFT	Army Budg	9	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	C	ADVANCE	2004	0	0	0	21185
23	A	AIRCRAFT	Army Budg	9	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	C	ADVANCE	2005	0	0	0	0
24	A	AIRCRAFT	Army Budg	9	02	MODIFICA	10	MODIFICA	3264AA025	CH-47 CARGO HELICOPTER M	C	ADVANCE	2006	0	0	0	0
25	A	AIRCRAFT	Army Budg	10	02	MODIFICA	10	MODIFICA	4194AA027	UTILITY/CARGO AIRPLANE MC	A	WEAPON SYSTEM CC		0	15667	0	16666
26	A	AIRCRAFT	Army Budg	11	02	MODIFICA	10	MODIFICA	4752AA040	OH-58 MODS	A	WEAPON SYSTEM CC		0	458	0	452
27	A	AIRCRAFT	Army Budg	12	02	MODIFICA	10	MODIFICA	5310AA056	AIRCRAFT LONG RANGE MOD	A	WEAPON SYSTEM CC		0	645	0	732
28	A	AIRCRAFT	Army Budg	13	02	MODIFICA	10	MODIFICA	5682AA667	LONGBOW	A	WEAPON SYSTEM CC		0	908380	0	882674
29	A	AIRCRAFT	Army Budg	13	02	MODIFICA	10	MODIFICA	5682AA667	LONGBOW	B	LESS: ADVANCE PRO		0	-44754	0	-32138
30	A	AIRCRAFT	Army Budg	14	02	MODIFICA	10	MODIFICA	5682AA667	LONGBOW	C	ADVANCE	2003	0	32138	0	0
31	A	AIRCRAFT	Army Budg	14	02	MODIFICA	10	MODIFICA	5682AA667	LONGBOW	C	ADVANCE	2004	0	0	0	29713
32	A	AIRCRAFT	Army Budg	14	02	MODIFICA	10	MODIFICA	5682AA667	LONGBOW	C	ADVANCE	2005	0	0	0	0
33	A	AIRCRAFT	Army Budg	15	02	MODIFICA	10	MODIFICA	6949AA048	UH-60 MODS	A	WEAPON SYSTEM CC		0	59945	0	51570
34	A	AIRCRAFT	Army Budg	16	02	MODIFICA	10	MODIFICA	7542AZ220	KIOWA WARRIOR	A	WEAPON SYSTEM CC		0	42103	0	41684

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Figure 3.3
Sample Exhibit P-40

wtcv.pdf

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Exhibit P-40, Budget Item Justification Sheet

Date: February 2006

Appropriation / Budget Activity / Serial No: Procurement of W&TCV, Army / 1 / Tracked combat vehicles

P-1 Item Nomenclature: STRYKER VEHICLE (G85100)

Program Elements for Code B Items: 0603653A/C03

Code: B

Other Related Program Elements:

	Prior Years	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	To Complete	Total Prog
Proc Qty	1446	575	340	100	129	10	10	10		2620
Gross Cost	3268.7	1434.0	1049.4	796.0	804.1	289.1	390.6	327.0	938.7	9297.6
Less PY Adv Proc										
Plus CY Adv Proc										
Net Proc P1	3268.7	1434.0	1049.4	796.0	804.1	289.1	390.6	327.0	938.7	9297.6
Initial Spares										
Total Proc Cost	3268.7	1434.0	1049.4	796.0	804.1	289.1	390.6	327.0	938.7	9297.6
Flyaway U/C										
Weapon System Proc U/C	2.3	2.5	3.1	8.0	6.2	28.9	39.1	32.7		3.5

Description:
A dynamic asymmetric threat and operational environment demands full spectrum, strategically responsive, agile and dominant land forces. Immediate response by a lethal, versatile, tactically agile joint force capable of operational maneuver is essential to fulfilling the Army's Warfighting needs. The Stryker-equipped BCT is this force. The use of a common platform/common chassis design reduces requirements for repair parts and logistics support in the area of operations.
The Brigade Combat Team (BCT), equipped with Stryker Vehicles can be used across the full spectrum of military operations. The Stryker Brigade Combat Team deploys rapidly and conducts effective combat operations immediately on arrival to prevent, contain, stabilize, or resolve a conflict through shaping and decisive operations. Configurations of Stryker Vehicles are:
Infantry Carrier: The Infantry Carrier Vehicle (ICV) carries an infantry squad with individual equipment. The ICV also provides protected transport and supporting fires for the infantry squad during dismounted assault.
Reconnaissance Vehicle: The Reconnaissance Vehicle (RV) provides force situational awareness, gathering and transmitting real time intelligence while moving throughout the battlefield in close, complex, and urban terrain.
Mobile Gun System: The Mobile Gun System (MGS) supports dismounted infantry and engages the enemy in close combat in order to clear opposition and permit rapid movement allowing the force to maintain the initiative, occupy and/or secure key objectives, and defeat strong points.
Mortar Carrier: The Mortar Carrier (MC) will support infantry units with screening obscurants, suppressive forces and on-call supporting fires. 120mm,81mm, and 60mm mortars provide complimentary capabilities with responsive, accurate and lethal indirect fire support to the dismounted infantry assault.
Commander's Vehicle: The Commander's Vehicle (CV) provides the brigade commanders and infantry battalion commanders with the means to receive information and data, analyze, prepare and transmit data, and control the forces/functions carrying out combat missions.
Fire Support Vehicle: The Fire Support Vehicle (FSV) provides automated enhanced surveillance, target acquisition, target identification, target tracking, target designation, position location, and communications functionality. Targets will be transmitted instantly to the fire support system and shooter.
Engineer Squad Vehicle: The Engineer Squad Vehicle (ESV) provides maneuver/mobility support capabilities which include obstacle clearing, in-stride breaching of surface mines, proofing of subsurface mines, and smoke generation for local protection.

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(HAC), and the Senate Appropriations Committee (SAC). These documents provide insight into congressional support for each program and, sometimes, congressional concerns about cost, schedule, or performance. Instances where the HASC or SASC or another congressional committee recommends more or less than the requested amount of funding are also valuable and provide insight into the health of the program.

Data on RDT&E costs are located in Exhibit R-1s. For ACAT II and smaller programs, these reports often provide data aggregated to a level that makes it difficult to attach specific research costs to specific programs.

Graphs and Program Assessments

Using the time series data on program cost and quantity, we graphed annualized unit cost against annualized quantity. We considered using graphs to compare average unit cost and cumulative quantity procured, but we found these metrics less useful for the purposes of this research effort, because they smooth over and average out the variation in unit cost and quantity procured over time that we are most interested in assessing as an indicator of program health. In contrast, graphs using annualized quantity and unit cost provide more valuable insight into changes in program health and performance over time and also capture the overall stability of the program over time. We use the same approach in our assessment of selected set of MDAPs, making our evaluations of the two sets of programs generally comparable. Although the graphs use actual values,

we also collected projected cost and quantity for each available year and program, so that we could assess the frequency and size of revisions.

We assessed these graphs looking at two primary criteria. First, we looked for large revisions and sharp fluctuations in quantity and cost, since these indicate weak program performance. Second, we looked for slow growth over time. The rationale for caring about this second type of growth is the same as that behind the Nunn-McCurdy breach. Even programs with small year-to-year increases in unit cost may show significant and problematic cost growth over a full program life span. To explain discrepancies and potential problems, we matched the narrative information on each program to the unit cost graphs. In some cases Congress or the relevant military department provided an explanation for cost growth, but in many cases, no explanation was provided.

In addition to looking at cost growth, we also considered whether there was a clear relationship between unit cost and quantity and whether specific contract, development, or other program characteristics appeared to explain the overall success or failure of the program.

Challenges

We faced some challenges in the assessment of ACAT II programs. First, data on ACAT II cost and quantity are provided in budget requests that are published as annual volumes, which means that the time series must be constructed manually. Inconsistencies and gaps are common, and programs sometimes change names as they pass key milestones, which makes tracking their development over time somewhat challenging. Some programs are also funded jointly by several components, which creates additional challenges and the potential for discrepancies. Finally, program funds may purchase not only the hardware but also peripherals and service contracts. These costs are relevant to the total program cost but must be factored out to generate comparable unit cost estimates over time. We were able to conduct these cost adjustments where necessary, using supplemental information in Exhibit P-40s. However, one result of these many challenges is that our calculated unit costs should be considered estimates rather than precise values. We are confident these estimates are sufficient to support our assessment of program health.

Assessing ACAT II Programs: Program Narratives and Results

Overview and Summary

Table 3.3 lists the ACAT II programs included in our selected set of along with the service and the procurement type. Although we considered ten programs, we have 12 program results because we consider the Hellfire missile program separately for the Army, Navy, and Air Force. We selected our ten programs carefully from among the set of available ACAT II programs, specifically choosing those with the largest funding

Table 3.3
ACAT II Programs Selected

Program	Service	Procurement Type
C-37A	Air Force	Aircraft
Hellfire missile	Air Force, Army, Navy	Air Force and Army: missiles Navy: weapons
MQ-8	Navy	Aircraft
RQ-11 Raven	Army	Aircraft
Assault Breacher Vehicle	Army, Marine Corps	Weapons and tracked combat vehicles
MTVR	Marine Corps	Weapons and tracked combat vehicles
RAM	Navy	Weapons
LCAC SLEP	Navy	Shipbuilding and conversion
M2 .50 caliber roll	Army	Weapons and tracked combat vehicles
MLRS RRPR	Army	Missiles

allocations in official budget documents over the past five years. This assured that they would be more like MDAPs than like smaller programs. Second, we aimed to choose at least one program from each service and procurement category to build a representative set of systems.

Despite our efforts, our selection will still present some limitations. Because we assess only a select set of programs, our assessments and observations apply primarily to the specific programs that we have included. However, our sampling approach should produce a selected set that is representative, allowing us to generalize carefully to other ACAT II programs. In addition, because we select the largest ACAT II programs from across procurement types, our selected set of programs should also be reasonably comparable to most MDAPs on such dimensions as technological complexity. This is a point we refer to again in our assessment of MDAPs.

To preview the results of our assessment, we found that, overall, the ACAT II programs perform reasonably well, without significant evidence of runaway cost growth or schedule slippage. Table 3.4 summarizes program performance and gives a short explanation of concerns where they exist. Of the programs we consider, we find that four show no reason for concern, five have some issues of minor concern, and three warrant some more significant concerns. Across the board, instability in unit cost and quantity appears more problematic than cost growth or massive schedule delays. Instability is particularly likely early in the lives of new ACAT II programs, but this instability is not crippling, and programs are often able to stabilize over time. There also seems to be a

Table 3.4
ACAT II Performance Assessments

No Serious Concerns	Minor Concern	Some Concerns
MLRS RRPR	C37A: Small quantity purchased contributes to large fluctuations in unit cost; details on leasing program limited	MTVR: steadily growing unit costs, perhaps as a result of multiple variants
LCAC SLEP	ABV: cross-service discrepancies and projected cost growth out to FY2016	RAM: some instability and significant projected cost growth
M2 .50 caliber	Army Hellfire: fluctuation in unit costs, costs higher than in the Navy	
Navy Hellfire	Air Force Hellfire: Instability in unit cost despite off-the-shelf purchase	
	MQ8: initial unit cost growth and schedule delays resulting from development problems	
	RQ11:Instabilty in unit cost and quantity procured, projected cost growth in the long run	

NOTE: We characterize the Navy Hellfire program as one with no serious problems; however, we discuss it with the Army and Air Force programs for purposes of comparison.

clear relationship between unit cost and quantity. Much of the cost growth that we do observe occurs because of downward revisions in procurement quantities—revisions that likely reflect changes in demand associated with the contingencies in Iraq and Afghanistan. It is important to note that although we consider fluctuation in quantity as a measure of program health, it may also reflect factors outside the control of program managers. Finally, although there are instances where delays and development issues affect ACAT II program performance early in a program's life span and during modernization, there is little evidence of major schedule slippage once the program enters production. Observed delays are often linked to modernizations and technological advances. However, there are also many instances of rapidly accelerated time lines. In other cases, cost growth exists only in the projected out-years. This means that it is not certain that this cost growth will materialize. Finally, differences across military departments in terms of program performance may warrant additional investigation.

Program Narratives and Assessments

In this section, we present the results of our ACAT II program assessment. We include a brief history of the program, its major milestones, development process, and any significant problems, as well as a graph showing unit cost and annualized quantity over the life of the program.

No Serious Concerns

Multiple Launch Rocket System, Army, Weapons Procurement

The Multiple Launch Rocket System (MLRS) Reduced-Range Practice Rocket (RRPR) is a training rocket allocated to Army Active Duty and Reserve MLRS units. It is the only live fire training rocket or missile used by all U.S. Army Field Artillery rocket and missile units/crews and ensures that these units achieve and maintain combat readiness in the Global War on Terror (GWOT). The RRPR supports Army modularity, since the High Mobility Artillery Rocket System (HIMARS) and M270A1 battalions, which use the rocket for training purposes, are organic and attached to modular fires brigades supporting Brigade Combat Teams (BCTs), Joint Expeditionary Force, and Joint Special Operations Force (JSOF) combatant commands.[10]

The MLRS RRPR has been in inventory since 1993 with the last U.S. procurement in FY1995, when the Army decided to terminate funding for MLRS production. This decision resulted because the Army had sufficient tactical rockets to meet any anticipated military contingency and enough RRPRs to meet the training requirements for Active and Reserve component forces for the next ten years. However, the Senate Appropriations Committee expressed some concern about the need to maintain the MLRS production base until the extended-range (ER) rocket was to begin production in FY1997.[11] The House expressed a similar concern and recommended that the Army continue to procure the RRPR at a rate of no more than 500 per month while production transitioned to the ER version of the rocket, and production level was sustained to cost-effectively retain key elements of the industrial base.[12] No additional procurement was made after FY1995.

By FY2003, the existing stock of these training rockets had been reduced as a result of training consumption, and additional procurement was needed to preclude stockpile depletion and sustain adequate stockpile margins. Reprocurement was especially important, as the wars in Iraq and Afghanistan intensified and live fire training became increasingly important. Reprocurement to maintain the practice rocket inventory for Standards in Training Commission (STRC) requirements began in FY2003. The annual requirement for these missiles in FY2006, according to STRC, was approximately 4,800 per year. Starting in FY 2010, the system was known as the MLRS low-cost reduced-range practice rocket (LCRRPR).

The graph comparing unit cost and quantity for the MLRS RRPR (Figure 3.4) program shows no real cause for concern. The program has not experienced significant instability or long-term unit cost growth. There has been a relatively consistent rela-

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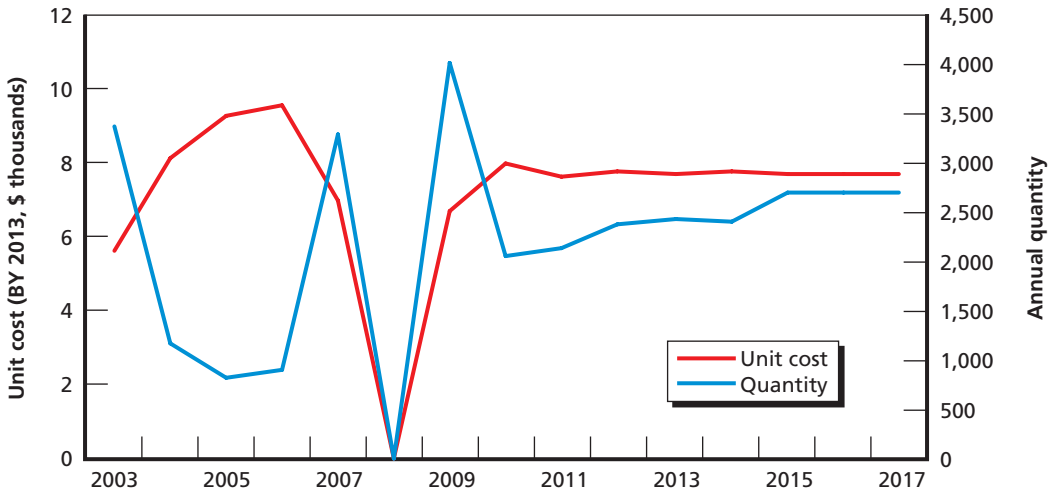
[10] Department of the Army, *FY2013 Budget Estimates Justification Book, Missile Procurement,* February 2012b.

[11] U.S. Senate, *Department of Defense Appropriations Bill 1995 Report,* Washington, D.C., U.S. Government Printing Office, 1994.

[12] U.S. House of Representatives, *Department of Defense Appropriations Bill 1995 Report,* Washington, D.C., U.S. Government Printing Office, 1994b.

Figure 3.4
Unit Cost and Quantity, MRLS RRPR



RAND *MG1171/4-3.4*

tionship between unit cost and quantity, but even large changes in quantity procured have little effect on unit cost. After the first year of reprocurement, quantity procured fell and unit cost rose slightly. Unit cost was lowest in 2003 but rose with significantly reduced quantities purchased in 2004, 2005, and 2006. It is worth noting that the FY2004 budget request projected significantly larger purchases in both FY2004 and FY2005 (of 2,934 and 3,054, respectively). These numbers were revised downward in FY2005. The Army did not provide a reason for the lower quantity procured in these years. The program has been largely stable since FY2007 and is projected to remain stable in the near future.

The lack of significant problems associated with this program may reflect the fact that the MLRS RRPR was not a new item but a fully mature item that the Army had already developed. The FY2003 procurement was a "restart" rather than a new program, so there were no initial development costs, production line restarts were clearly insignificant, and the program could enter quickly into full-rate production. Also important is that projected stability in the future depends on continued demand for the training rockets. If demand falls with the end of the wars in Afghanistan and Iraq, then unit cost may rise.

LCAC SLEP, Navy, Shipbuilding and Conversion

LCAC is a Navy air-cushion vehicle for use in amphibious operations. Ninety craft were constructed by Textron Marine and Land Systems and Avondale Gulfport and delivered from 1984 to 1987. Seventy-three vehicles have received or are set to receive the Service Life Extension Program (SLEP). Conversions should be completed

by 2018.According to the FY2013 Navy Shipbuilding and Conversion Justification Book, the SLEP "extends the craft service life from twenty years to thirty years. The new hull incorporates four modifications: additional internal compartmentation to increase cargo carrying capacity; a modified fuel system to increase range; improved skirt attachments to reduce maintenance and deep skirt to improve performance and maximize safety. The SLEP will also include the C4N electronic suite replacement as well as a modified set of TF40B engines, designated ETF40B."[13]

Congress consistently supported the program, even admonishing the Navy for being slow to address the corrosion issues that would reduce the life cycle of the LCAC below its projected 20 years. Congress was also critical of the Navy for how it considered the best way to maintain the LCAC and its production line over the service life of the vehicles. Although the Navy did not request any funding for the program until FY1999 (in a mandated report on SLEP submitted in October 1996),[14] Congress interjected and added $2.9 million in FY1997 and $19.5 million in FY1998. After an initial delay, the Navy added funding for advance procurement in FY1999 to initiate the LCAC SLEP in FY2000. Developing the program and receiving additional funding from Congress was vital, because of the Navy and Marine Corps heavy reliance on the LCAC. In fact, the LCAC was responsible for transporting 95 percent of weapons and tracked combat vehicles in a Marine Air-Ground Task Force during an amphibious landing.[15]

The SLEP construction contract option exercise for the FY 2000 and FY2001 LCACs occurred in May 2001. This allowed for the construction start of two LCAC SLEPs in FY2001. An FY2002 contract provided for SLEP construction to two additional FY2002 craft. The two additional units covered by the FY2002 contract was the minimum number of construction starts needed to preclude a significant line break.[16] The contract was awarded in December 2002 (and approved on April 10, 2002). During the early 2000s, the Marine Corps indicated that the LCAC SLEP would be a high priority should additional funds become available. Both the House and Senate responded, demonstrating the high priority of the program and confidence in its performance. During the FY2003 National Defense Authorization Act (NDAA) markup, HASC recommended the addition of $11 million to LCAC SLEP funding. This was to allow the production of an additional buoyancy box, which fixes corrosion problems and adds other improvements to the hull. Adding one box to production would

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[13] Department of the Navy, *FY2013 Budget Estimates Justification Book, Shipbuilding and Conversion,* February 2012b.

[14] U.S. House of Representatives, *Military Procurement Ship Acquisition and Offshore Based Warfare: Hearing Before the Armed Services Committee,* Washington, D.C., U.S. Government Printing Office, 1999a.

[15] U.S. House of Representatives, 1999a.

[16] Department of the Navy, *FY2003 Budget Estimates Justification Book, Shipbuilding and Conversion,* February 2002b.

prevent the production line shutdown for the buoyancy box, which had a minimum production rate of four per year. SASC went one step further by recommending the addition of $22 million to fund one additional complete conversion during FY2003, which would include the construction of a buoyancy box. Around this time, the first converted LCAC SLEP vehicle was delivered on schedule and on time. One year later, during the FY2004 NDAA markup, HASC recommended adding $21.0 million to boost LCAC SLEP funding from $73.1 million to $94.1 million.

Starting in FY2004, some modifications to SLEP improved the program's efficiency and resulted in cost savings. Specifically, rather than replacing the buoyancy box, the existing box was to be refurbished with some modifications. According to the budget justification "this change allowed construction to be accomplished near the operating units, saving transportation as well as disassembly and buoyancy box construction costs, while still achieving the same operational capabilities and service life extension."[17] The FY2005 appropriation request covered the full rehabilitation of six reduced operational status (ROS) craft: one craft each in FY2005 through FY2009, but two craft in FY2007. This also improved the efficiency of the program as "rehabilitating the ROS craft for use in SLEP will avoid taking active mission capable craft out of the inventories at the operating units." In FY2006, SLEP appropriations covered additional rehabilitation of LCAC craft through FY2011, along with "full mission trainer upgrades" in each year. Appropriations requests and budget projections suggest that SLEP will remain active in the coming fiscal years. Although total and unit cost may be revised, no significant problems or line breaks are expected.

The LCAC SLEP has very little cause for concern. Figure 3.5 shows that, despite some fluctuation in quantity procured over the life of the program, the unit cost remains fairly stable over time and even decreases over the life of the program. This overall decrease suggests learning by program managers and the discovery and exploitation of more cost- and time-effective processes. In fact, there are many examples of adept program management, including conversions completed ahead of schedule and cost savings from revised acquisition and procurement costs, saving over $100 million, which led to a DoD Value Engineering Award. Congressional support for the program is another sign of program health.

Once again, there is a relationship between unit cost and quantity, with unit cost rising when quantity falls for the LCAC SLEP. Program information suggests that four conversions are the minimum required to sustain existing industrial capacity. The graph here appears to confirm this, and unit cost rises more significantly when quantity falls below four. In a few places, cost increases may warrant additional attention: A 12 percent increase from FY2004 to FY2005 and a projected unit cost increase from FY2012 to FY2013 are worth noting (although this has yet to materialize).

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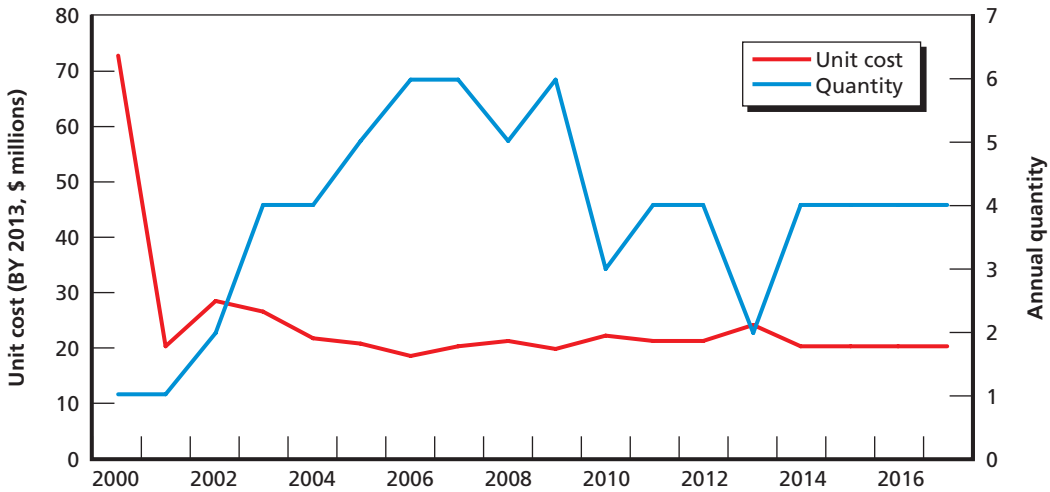
[17] Department of the Navy, *FY2005 Budget Estimates Justification Book, Shipbuilding and Conversion,* February 2004.

Figure 3.5
Unit Cost and Quantity, LCAC SLEP



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M2 .50 Caliber, Army, Ammunition Procurement

The M2 .50 caliber automatic rifle has been a mainstay of the U.S. armed forces since the 1920s. It is

> an automatic, belt-fed, recoil-operated, and air-cooled crew-served weapon. It mounts on the M3 and XM205 tripods and on most vehicles, and serves as an anti-personnel and anti-aircraft weapon. It is highly effective against light armored vehicles, low- and slow-flying aircraft, and small boats. The M2 provides automatic weapon suppressive fire for offensive and defensive purposes. It is capable of single-shot and automatic fire.[18]

The U.S. military is but one of the many buyers of the M2, which is manufactured by General Dynamics Armament and Technical Products. Other recent purchasers include Egypt, the Saudi National Guard, Colombia, Greece, Djibouti, Bahrain, Romania, Jordan, Chile, and 15 U.S. agencies, including the Army.

Army procurement of the M2 began again as a new start in the FY2008 budget to replenish low supplies resulting from demands in Iraq and Afghanistan. Reports from November 2005 claimed that, because of increased use, ammunition for the M2 produced in 1945 was being pulled out of the stockpile despite ammunition production increasing five times in size from 2001 to 2005. The 2008 budget request asked

[18] Department of the Army, *FY2013 Budget Estimates Justification Book, Procurement of W&TCV,* February 2012c.

for a restart to the program citing a "critical shortage of serviceable machine guns for our Soldiers who are participating in Operation Enduring Freedom," and noted "this request is based on deficiencies identified from on-going combat operations in Afghanistan and Iraq."[19]

The fact that the "new start" of the Army procurement could build off continued production for non-U.S. Army consumers of the weapon provided some cost savings, because it meant that the Army did not have to invest in rebuilding, repairing, or modernizing production technology or the industrial base. However, the program has still faced some design and safety issues since procurement resumed in 2007. Specifically, in the FY2012 NDAA, the Army revised its initial budget request, allocating money from the purchase of new M2 .50 caliber machine guns to the modification of existing weapons to enhance and fix safety issues associated with the weapon. In the request submitted to Congress, the Army stated that the modification and repair was a higher priority than the purchase of new weapons and SASC agreed.[20] The resulting drop in quantity procured does not appear to have affected projected unit cost. Funding was requested in 2013, likely because wars in Afghanistan and Iraq have slowed, resulting in reduced demand.

On the whole, the performance of the program since 2008 has shown no serious problems. Figure 3.6 provides little evidence to suggest that there was a significant cost to the Army associated with restarting the program in 2008 or that the program's unit cost benefited from learning or from new production efficiencies over the past five years. Congressional testimony on the program similarly reveals no serious cause for concern, with the exception of the safety issue raised in the FY2012 NDAA. These trends are not surprising, given the fact that M2 has been in production for approximately 90 years with the same basic design. The M2 is a fully mature weapon line. With countries and organizations all over the world using the weapon, it is consistently in high demand. Technical issues and production concerns should not be an issue for the M2. The unit cost of the weapon should remain constant and steady, which the recent Army procurement corroborates. However, the age of the program may also pose some risks. It is possible that additional or more serious safety and design issues may arise in the near term (similar to those reported in the FY2012 NDAA) that may affect the unit cost and viability of the program going forward.

Although the M2 program performs fairly well, there is a clear and strong relationship between the quantity procured and unit cost for this program as was true for others—the more M2s procured, the lower the unit cost. In most years, substantial changes in quantity result in large changes in unit cost. For instance, between 2008

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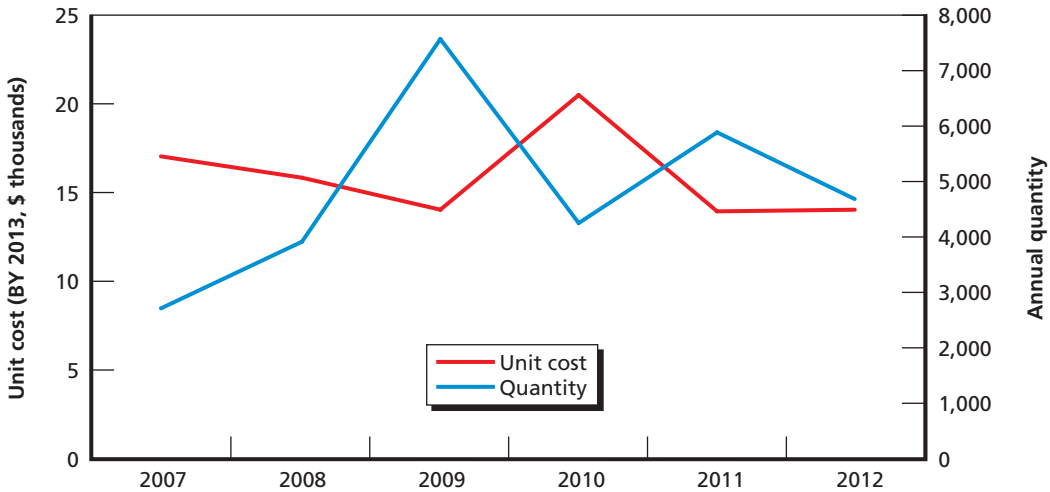
[19] Department of the Army, *FY2008 Budget Estimates Justification Book, Procurement of W&TCV,* February 2007.

[20] U.S. Senate, *National Defense Authorization Act for Fiscal Year 2012: Hearing Before the Armed Services Committee,* Washington, D.C., U.S. Government Printing Office, 2011a.

Figure 3.6
Unit Cost and Quantity, M2 .50 Cal



RAND *MG1171/4-3.6*

and 2009, quantity purchased almost doubled and unit cost fell by about 11 percent. Quantity procured increased by 56 percent between 2009 and 2010 and unit cost rose 45 percent. The maturity of this program suggests that unit cost is driven largely by production quantity, as other aspects of production have long since been refined.

Given the ease with which the program was resumed in 2008, the decision to cease funding for the program in FY2013 may not have any serious implications. However, the ease of the restart and lack of serious changes in unit cost may be based on international demand for the M2 .50. If demand falls internationally, then the implications of stopping/restarting the program may be more severe.

Minor Concerns

C-37A, Air Force, Aircraft Procurement

The C-37A is a long-range executive passenger jet that provides worldwide air transportation for the vice president, cabinet members, congressional delegations, presidential emissaries, and other high-ranking dignitaries of the United States. When first acquired, the C-37A jets replaced the aging C-137 fleet, which had grown costly and unsafe to operate. The C-37A is produced by the Gulfstream Aerospace Corporation and was originally constructed for the commercial market.

The first Air Force purchase of C-37A aircraft occurred using FY1997 funds. The initial contract covered the purchase of commercial off-the-shelf (COTS), long-range aircraft as well as necessary special modifications. It also included an option for up to four additional units before 2003. The first two aircraft were delivered by September

1998. The contracting process used for these first two aircraft provided significant savings to the Air Force. According to testimony delivered in 1998:

> With few exceptions, commercially available designs, options, practices, and processes were used throughout the acquisition. Acquisition practices were simplified to mirror those employed in the airline industry with no significant unique requirements to accommodate the needs of the Air Force. . . . The marketplace and the economic benefits gained from high volume production of similar items drove the price. The supportability package was designed to take full advantage of the worldwide Boeing, Gulfstream, and airline product support capability. No unique support structure was created to accommodate the Air Force's requirement.[21]

Although the Air Force did not ask for additional funds in FY1998 for the purchase of C-37A aircraft, HASC recommended using savings from the Air Force's favorable competitive negotiations for the C-37A in the previous year ($27.1 million from the FY1997 appropriation) plus an additional $6 million to purchase one additional aircraft for the U.S. Army. The Army completed this purchase by trading in an older C-20 aircraft, already under lease from Gulfstream Aerospace, to facilitate the purchase and equipping of this new C-37A.[22]

FY1999 funds procured four additional C-37A aircraft, but the Air Force did not allocate additional funds to the C-37A program between FY2000 and FY2005. However, it did execute a ten-year lease contract for 20 C-37A aircraft under Section 8133 of the FY2000 NDAA. The lease contract was officially awarded to Gulfstream in March 2002 as a ten-year indefinite delivery/indefinite quantity contract, with the option of purchase at the end of the 10 years.

In FY2006 and FY2009, the Air Force purchased one additional C-37. The FY2010 funding request purchased one C-37A for operational support. FY2011 funded the purchase of two additional aircraft, and FY2012 will fund the purchase of another three. FY2010 funding purchased a new aircraft, but FY2011 and 2012 funds purchased leased aircrafts whose terms of lease (Section 8133 of the FY2000 NDAA) were coming to an end. No additional funds were allocated for the FY2013 budget.

Figure 3.7 shows unit cost and quantity over the life of the C-37A program. Overall, the program performs fairly effectively, although there are some minor concerns, including an increase in unit cost through 2009 and uncertainty about the future of leased aircraft. Unit costs did decline in FY2011 and FY2012, and no additional funds were allocated in 2013.

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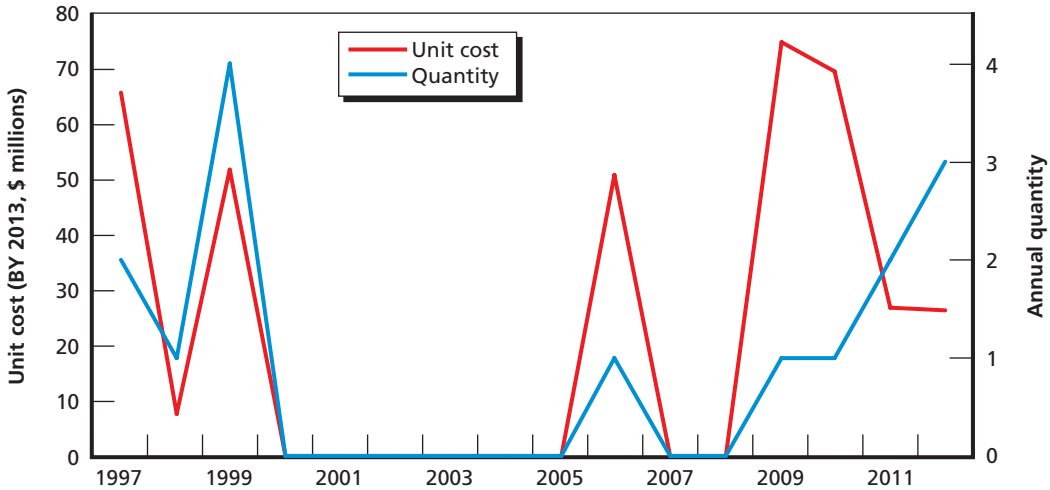
[21] U.S. Senate, *Acquisition and Technology Changes in Acquisition Procedures: Hearing Before the Armed Services Committee,* Washington, D.C., U.S. Government Printing Office, 1998.

[22] U.S. Senate, *Appropriations Committee Report on the Department of Defense Appropriation Bill 1998,* Washington, D.C., U.S. Government Printing Office, 1997.

Figure 3.7
Unit Cost and Quantity, C-37A



RAND *MG1171/4-3.7*

Sharp changes in unit cost reflect a close link between cost and quantity. Because each individual aircraft is costly, even small changes in quantity have large cost implications. Unit cost is significantly higher in FY2009 and FY2010 than in previous and later years in which quantity acquired was significantly higher. Lower unit costs in FY2011 and FY2012 may reflect the fact that the purchased aircraft were not new but were already under lease. The leasing strategy was intended to significantly reduce upfront procurement costs, both during the lease period and afterward, when the option for purchase arose.[23] The use of commercial technology also contributed to lower unit costs in the program's early years, but its benefits in later years were few. Finally, it is worth noting that the unit costs of the C-37A are likely affected throughout its program life by commercial purchases of the aircraft.

Assault Breacher Vehicle, Army/Marine Corps, Tracked Combat Vehicles

The Assault Breacher Vehicle (ABV) is a joint Marine Corps and Army tracked vehicle used for mine clearing. Although both services procure these vehicles, the Marine Corps was the developmental lead. The program has changed names several times, known as the Combat Breacher Vehicle until FY2005 but as the Assault Breacher Vehicle since then. The ABV largely uses COTS and nondevelopmental items (NDI), such as an M1A1 Abrams tank chassis. The Army describes the ABV as "a tracked combat engineer vehicle for the Marine Air Ground Task Force and the Army Heavy

[23] General Dynamics, *U.S. Government Leases Five General Dynamics Gulfstream C-37A Aircraft in $477 Million Lease and Maintenance Agreement,* press release, Falls Church, Va., October 26, 2000.

Brigade Combat Team (HBCT). It is designed to breach minefields and barrier obstacles to enable the tanks and infantry of the HBCT to maintain pace in offensive combat operations. The ABV provides crew protection and vehicle survivability equal to the M1A1 Abrams tank hull and has the speed and mobility to keep pace with the heavy maneuver force."[24]

The ABV was designed to support other Marine Corps armored vehicles. Six prototype vehicles were built for testing and evaluation from 2002 to 2006, after which the ABV received a MS III decision, leading to full-rate production (FRP). The first new vehicle was procured by the Marine Corps in FY2005, along with three refurbished prototypes. The use of refurbished prototypes was intended to accelerate ABV deliveries to operating forces in support of Operation Iraqi Freedom (OIF) mission requirements. In FY2006, the program was consolidated under the Explosive Ordnance Disposal Systems program. In FY2006, funding procured 18 additional vehicles for the Marine Corps. From FY2008 through FY2011, the Marine Corps procured a total of 23 additional ABV. Starting in FY2011, Marine Corps appropriations for the ABV program have gone to modernization as a result of lessons learned in Operation Enduring Freedom (OEF) but not to the purchase of new vehicles. These modernizations include ancillary equipment including plows, blades, and front-end equipment required to support operational units in dwell and upgrades that will increase survivability, including locating and engaging targets at night and increased accuracy during fire and maneuver. Reports by the Marine Corps suggest that these upgrades were a high priority.[25]

Despite some hiccups in the development stages, the Marine Corps experienced relatively stable unit costs right from the start of the ABV program, even as its procurement quantities varied somewhat over the period from FY2005 to FY2011, shown in Figure 3.8. Variation in procurement quantities is associated largely with demand from contingency operations in Iraq and Afghanistan. As noted above, appropriations for FY 2011 and the next fiscal year are being used to upgrade existing vehicles rather than to procure new ones.

The Army chose the ABV to support the armored vehicle needs of the Active, Reserve, and National Guard components, procuring its first vehicles in FY2008. In its budget justifications, the Army noted that the ABV would be used in HBCTs and that "the Army currently does not have the capabilities provided by the ABV."[26] FY2008 and FY2009 funds acquired a total of 21 ABVs. FY2010 funds procured 13 new vehicles. The Army procured 19 in FY2011 and plans to procure 18 in FY2012 and an additional 61 over the period FY2013 to FY2017. The vehicle has been so successful that the Seapower and Expeditionary Forces Subcommittee FY2011 National

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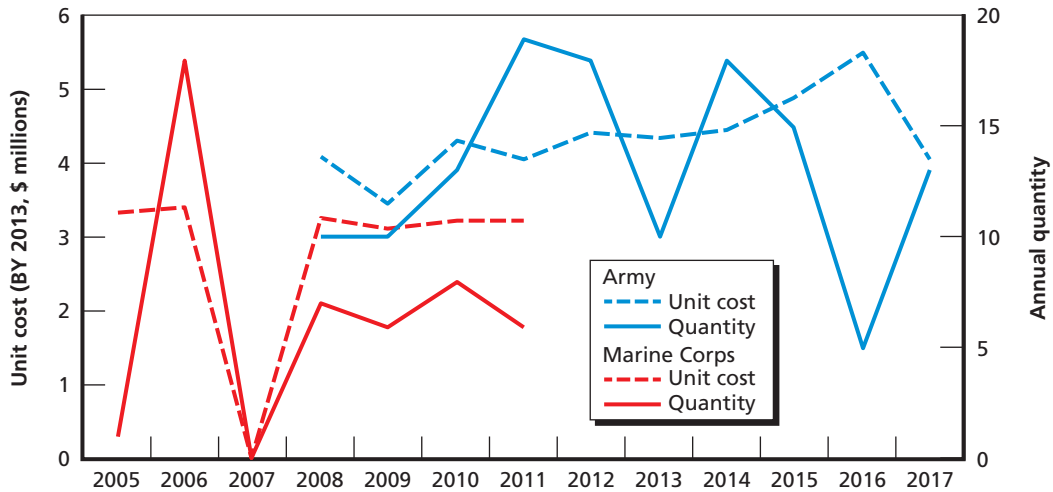
[24] Department of the Army, 2012c.

[25] Despite being described as modernization, these funding requests are included in the P-1, not the P-1M.

[26] Department of the Army, *FY2010 Budget Estimates Justification Book, W&TCV Procurement,* February 2009.

Figure 3.8
Unit Cost and Quantity, Assault Breacher Vehicle



RAND *MG1171/4-3.8*

Defense Authorization Act Markup in HASC recommended an increase in funding to procure the additional vehicles noting that "Specifically, the mark would authorize an additional 33 million for seven Assault Breacher Vehicles, which are instrumental in mine field clearance."[27]

The Army's ABV program has manifested somewhat more instability and cost growth than the Marine Corps program, especially in recent years. For example, unit costs increased almost 30 percent between FY2009 and FY2010 despite an increase in quantity procured. Cost projections after FY2013 also suggest some initial cost growth, including an increase of almost 25 percent between FY2014 and FY2016. This increase can be explained by falling procurement quantities and demand as operations in Iraq and Afghanistan draw to an end. The decision by the Marine Corps to delay the purchase of additional vehicles may also contribute to recent and projected units cost increases observed in the Army's ABV program. There is some indication of congressional concern about the health of the Army program during this period as well, specifically in the FY2012 Senate Appropriations Committee Defense Bill markup. In its report, the Senate recommended a small decrease in funding to the program of $2.9 million, noting that the Army's request included "Unjustified growth in matrix support and engineering change proposals."[28] No further details were provided.

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[27] U.S. House of Representatives, *Markup of H.R. 5136: Hearing Before the Subcommittee on Seapower and Expeditionary Forces,* Washington, D.C.: U.S. Government Printing Office, 2010.

[28] U.S. Senate, *Report on the Department of Defense Appropriations Bill 2012,* Washington, D.C., U.S. Government Printing Office, 2011b.

Unit cost is expected to fall again in 2017, when procurement quantities rise, although this projection, like others, is subject to future demand and revision. Because the Army plans to procure a large number of additional vehicles, projected increases in unit cost may be cause for some additional investigation.

In comparing the Army and Marine Corps programs, it is worth noting that the Marine Corps has consistently had lower unit costs for the ABV than has been the case for the Army, despite purchasing smaller quantities. This may be an accounting issue, as each service reports program cost slightly differently. (We calculate unit costs for the ABV using only acquired hardware, not associated peripheral and support or other services, to minimize cross-service differences). However, the difference in unit cost between the two services may also warrant additional investigation to determine if the discrepancy reflects differences in program management, acquisition processes, or equipment use. Congressional testimony and the reports of HASC, SASC, HAC, and SAC have not identified major issues or slippage in development or delivery time lines.

Hellfire Missile, Army, Navy, and Air Force, Weapons/Missile Procurement

According to the Air Force's program justification, the Predator Hellfire "is an air-to-ground missile system that provides heavy armor, precision-kill and anti-personnel capability. Laser Hellfire uses semi-active laser terminal guidance. The latest variant provides for point target precision strike, defeats future advanced armor threat and is effective against countermeasures."[29] The Air Force uses Predator Hellfire missiles for test, training, and operations, particularly aerial drone strikes by aircraft such as those conducted by the MQ-1.

The original Hellfire missile system began in 1974 as an Army program. Each variant of the Hellfire missile is best suited for specific types of environments and types of attacks. The most common are the AGM-114K and AGM-114M.[30]

The Air Force Hellfire missiles are procured off-the-shelf from the Army's Redstone Arsenal or the Navy, with contractor and location determined by lead service contract. In each fiscal year, quantities are based on current estimated price for purchase through the Army or Navy. This means that unit cost varies depending on lead service or foreign military sales procurement quantities. In most years, the purchase occurred through the Army. Funding requests after FY2008 included Overseas Contingency Operation (OCO) funding requests. It is also worth noting that many different types of Hellfire missiles are all included in the potential purchases.

The Army and the Navy also use the Hellfire missile. Procurement by both departments over the 1990s and early 2000s was limited to inventory maintenance. The Army purchased 1,800 in 1997 and 368 in 1998, and the Navy procured 248 in

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[29] Department of the Air Force, *FY2006 Budget Estimates Justification Book, Missile Procurement,* February 2005.

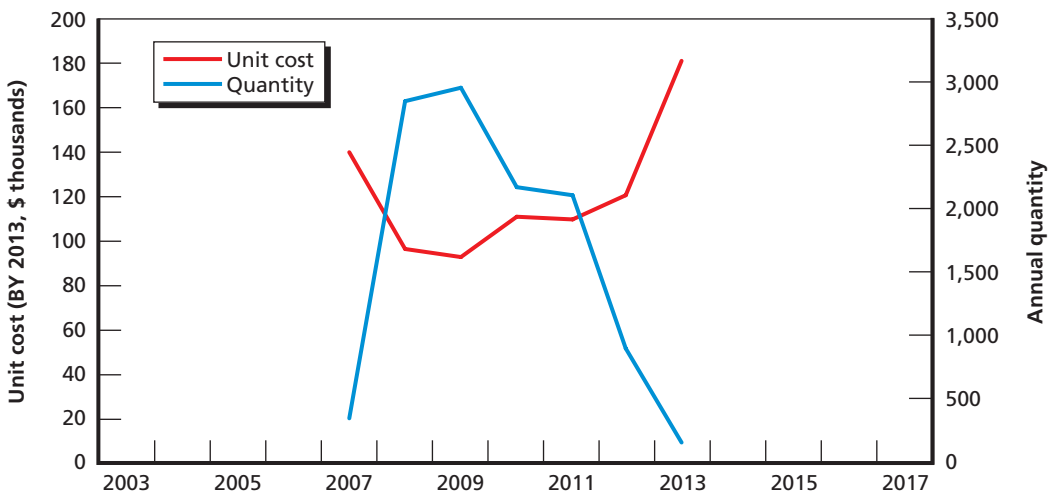
[30] Jane's Electro-Optic Systems, *Hellfire Systems AGM-114 Hellfire/Hellfire II,* January 19, 2011.

2001. The Navy budget justification noted that this purchase was intended to maintain inventory levels. Starting in 2007, however, the Air Force's use of the missile and operations in OEF and OIF significantly depleted inventories of the Hellfire missile. Both departments began new procurement at this point. Army appropriations have primarily purchased the Longbow Hellfire and the new P+ variant, both with higher unit costs. Navy procurement has purchased more of the 114K and 114M models, similar to those procured by the Air Force.

Figures 3.9 and 3.10 show the performance of the Army and Navy Hellfire programs. In general, both programs appear stable over the period under consideration. Unit cost is associated with quantity in both cases. The Navy program has been the more stable (and we categorize it as a program with no serious problems). The graph shows stability in unit cost despite some significant changes in quantity procured. This stability likely reflects the maturity of the program. Navy unit costs have also been more stable than those of the Army (Figure 3.10) or the Air Force (Figure 3.11, described below). This may reflect slightly higher procurement quantities or different missile variants. However, it is also worth noting the drop in quantity procured projected in the out-years for this system. This may reflect the effect of weakening demand for new missiles as the wars in Iraq and Afghanistan come to an end. As will be noted below, this drop in procurement of the Hellfire is consistent across services.

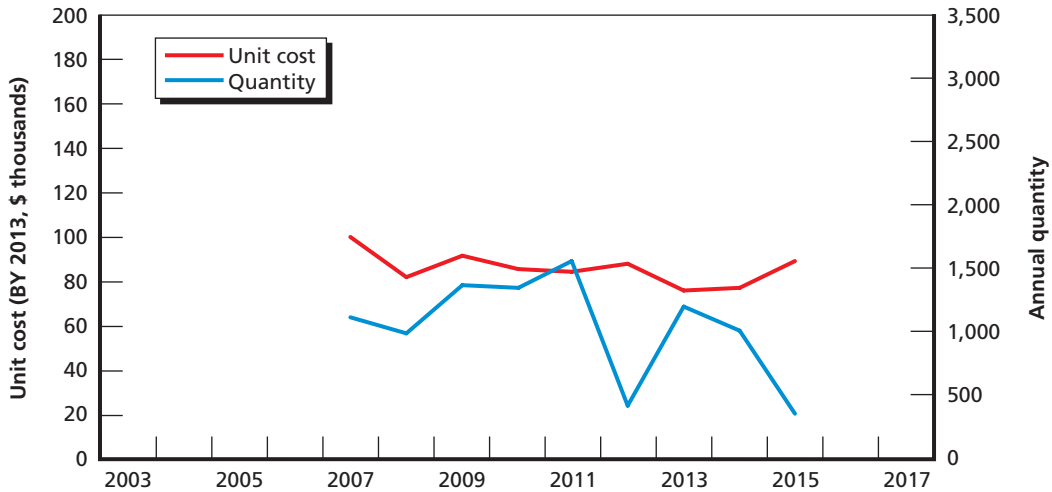
The Army's unit costs have been somewhat higher and show more significant evidence of cost growth after 2008 than either the Navy's or the Air Force's. The Army also experienced more dramatic changes in quantities procured over the time period considered. Initially, unit cost fell sharply with rising procurement quantities.

Figure 3.9
Unit Cost and Quantity, Hellfire, Army



RAND *MG1171/4-3.9*

Figure 3.10
Unit Cost and Quantity, Hellfire, Navy

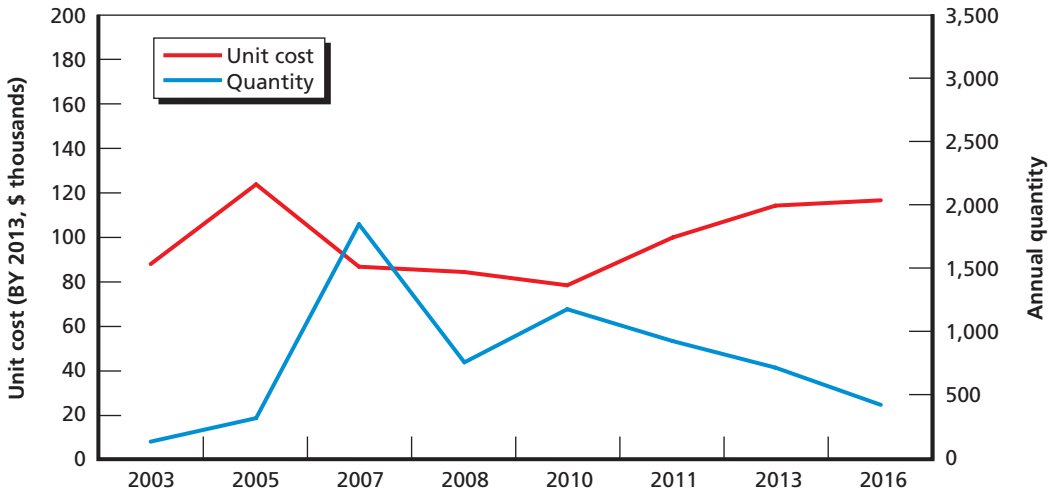


RAND *MG1171/4-3.10*

Between FY2009 and FY2010, however, quantity purchased fell by about 26 percent, and unit cost rose about 20 percent. Although a sharp drop in quantity procured between FY2011 and FY2012 did not result in a large change in unit cost, a further reduction in quantity procured projected in FY2013 does lead to a 51 percent increase in unit cost. Some increase in unit cost in recent years may reflect the procurement of new, more advanced Hellfire variants. Still, the rapid cost growth in the Army's Hellfire program since 2009 and projected in the out-years is some cause for concern. Finally, the significant differences in unit costs across military departments may warrant additional investigation. Differences may reflect nothing more than accounting differences or different missile variants, but they may also be evidence of differences in acquisition process, contracting, or efficiency.

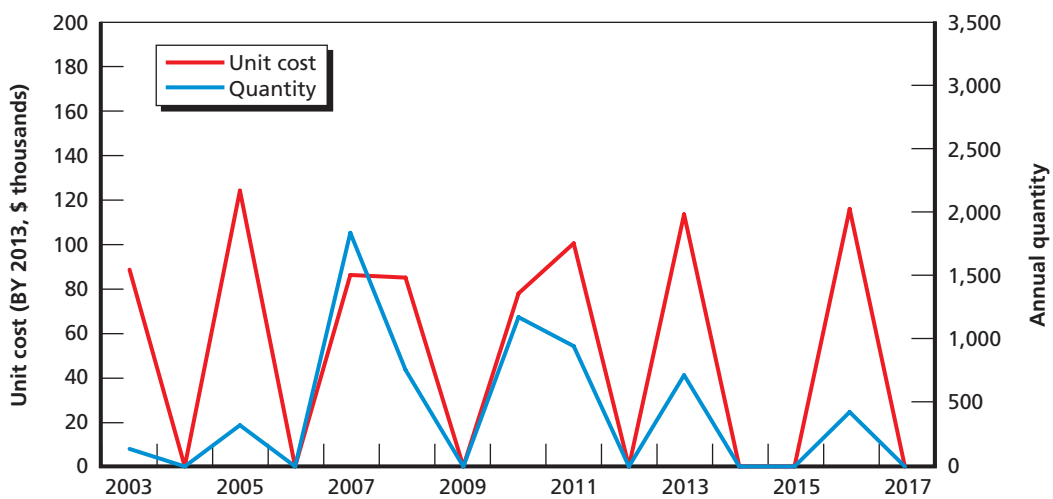
Figures 3.11 and 3.12 show that Air Force procurement of the Predator Hellfire has been affected by a significant amount of instability, which is somewhat surprising, since it has been procuring these missiles from the Army and Navy. In the initial years of the Air Force program, unit costs rose despite rising procurement quantities. Since the missiles are procured off-the-shelf from the Army, it is unclear what drove this unit cost increase. However, the increase was fairly short-lived. Costs returned to their original level by FY2007 and remained steady or declined through 2010. Some of the decline in cost between FY2007 and FY2010 may reflect the effect of new procurement by the Navy and the Army. However, costs began to rise again in FY2011. This increase in unit cost can be attributed almost entirely to changes in quantities purchased. Unit costs calculated for years after FY2010 using the FY2010 quantity (1,175) show constant or falling unit costs over the entire period.

Figure 3.11
Unit Cost and Quantity, Hellfire, Air Force, Years with Purchase



RAND *MG1171/4-3.11*

Figure 3.12
Unit Cost and Quantity, Hellfire, Air Force, All Years



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Although the recent increase in unit cost reflects a drop in quantity purchased, rather than production or design problems, both trends may still be problematic. This is especially true if they reflect waning interest in the Hellfire missile (or waning demand now that operations in Iraq and Afghanistan are winding down), which leaves

excess supply later on or elevated unit costs for an extended period. Because the majority of the observed unit cost increase is in the out-years, it is always possible that it will not materialize. Since the program history does not reveal significant or consistent increases in unit cost or schedule overruns and in fact shows the program as able to overcome instability (as it experienced in early years), there is reason to be optimistic.

The Air Force program has had higher unit costs and greater instability than the Navy's program but lower unit costs and more stability than the Army's program (since the Army restarted its procurement of the system in 2007). Although outside the scope of this effort, these cross-service discrepancies are worth additional investigation, since they may yield program management insights.

MQ-8, Navy, Aircraft Procurement

The MQ-8 (also known as the vertical takeoff and landing tactical unmanned aerial vehicle [VTUAV] or Fire Scout) was developed and manufactured by Northrop Grumman to provide reconnaissance and targeting support for ground, air, and sea forces. The MQ-8 is effectively a redesign of an earlier VTUAV program, known as the RQ-8A, which the Navy terminated in December 2001. The program continued under Army leadership, however, and the RQ-8B entered low rate initial production (LRIP) and passed MS III in 2003.

The Navy made the decision to resume funding for the VTUAV to meet littoral combat ship (LCS) mission requirements in FY2004, after it was determined that the LCS would be the first platform for the VTUAV.[31] The Navy signed a contract with Northrop Grumman for the development of the nine MQ-8B Fire Scout (known as the RQ-8B, until redesignated in June 2005) vehicles to be completed by 2009. According to the Navy's budget justification, the program "was designed to provide real-time intelligence, surveillance and reconnaissance data to tactical users without the use of manned aircraft or reliance on limited joint theater or national assets."[32] The Navy program received significant support from Congress. In 2003, Congress also recommended allocating additional funds to the MQ-8 program to develop an operational testing system and acquire eight aircraft for use with the LCS.[33] In 2005, the House Committee recommended additional funding for the program in the markup for the FY2006 NDAA.[34]

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[31] Jane's Unmanned Aerial Vehicles and Targets, *Northrop Grumman MQ-8 Fire Scout,* June 21, 2011.

[32] Department of the Navy, *FY2008 Budget Estimates Justification Book, Aircraft Procurement,* February 2007.

[33] U.S. Senate, *Appropriations Committee Report on the Department of Defense Appropriations Bill 2004,* Washington, D.C., U.S. Government Printing Office, 2003.

[34] U.S. Senate, *National Defense Authorization Act 2006 Report,* Washington, D.C., U.S. Government Printing Office, 2005. FY2004–FY2006 program funds are referenced in testimony but do not appear in the Navy budget or the P-1. The first record of spending is in FY2007. However, the total aircraft acquired by FY2009 matches that reported in earlier congressional reports (8–10).

The MQ-8B entered LRIP in May 2007. In January 2008, Northrop Grumman initiated a new phase of development with the first flight test using a test and training control segment. This is a shelterized version of the exact consoles and other equipment being integrated into LCSs for operational use of the MQ-8B Fire Scout. The Navy awarded an LRIP 2 contract in September 2008. The LRIP 3 contract procured three additional MQ-8B aircraft. This delivery was completed in 2011. The technical and operational evaluation (OPEVAL) started in 2009. Because of delays in the LCS development schedule, the Navy conducted sea trials, OPEVAL, and initial deployment on board the USS *McInerney*, an *Oliver Hazard Perry*–class frigate.

Starting in FY2012, MQ-8 funds began to procure the longer range MQ-8C vehicles. This upgrade addressed congressional concerns about the MQ-8B's limited range and reluctance to purchase additional MQ-8B vehicles so close to the completion of the upgraded platform.[35] A minimum of 28 MQ-8C endurance upgrade aircraft are being procured between FY2012 and FY2015 to support an Africa Command Joint Urgent Operational Needs Statement Rapid Deployment Capability. Finally, the U.S. Army had selected the Fire Scout MQ-8 as their Class IV unmanned aerial vehicle (UAV) for the Future Combat System (FCS). Coordination with the U. S. Army FCS program intended to investigate the potential cost savings for both programs where system commonalities and common logistics support can be identified. However, the FCS program was cancelled.

Figure 3.13 shows that, as with other programs, there is a clear link between unit cost and quantity for the MQ-8 program and evidence of instability. During early years, unit cost rose with quantity produced. This rising costs suggests some inefficiencies and delays associated with the development stages of the system. Unit cost will hit a high point in 2013 but should decline steadily afterward, suggesting potential stabilization with program maturity able to cope with the rapid production fluctuations. The Army, following the FCS cancellation, has expressed renewed interest in the program. This potential partnership with the Army and the large purchase for Africa Command should keep unit costs low.

Although the program does not seem to have faced any severe obstacles or permanent or runaway cost increases, it did face initial slippage in delivery schedule and struggled with program starts and stops along the way, often because of weak service commitment and a slow development time line.[36] This instability in demand and development issues associated with the move to the more advanced MQ-8C may explain the gradual increase in unit cost over the 2010 to 2013 period. A review of this program also highlights again the potential value of cross-service partnerships and the challenge of building sufficient inventories of a given system while more advanced models are

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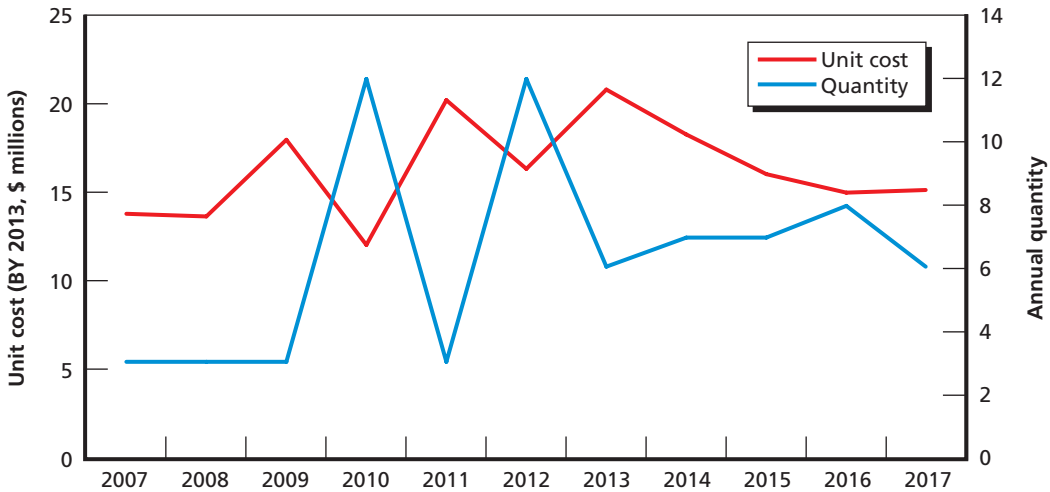
[35] U.S. House of Representatives, *Conference Report on Military Construction and Veterans Affairs and Related Agencies Appropriations Act 2012*, Washington, D.C., U.S. Government Printing Office, 2011.

[36] Jane's Unmanned Aerial Vehicles and Targets, 2011.

Figure 3.13
Unit Cost and Quantity, MQ-8



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being developed. Although purchase quantities must be kept high enough to maintain operational sufficiency and to keep the unit costs of the program from rising too high, it also does not make sense to invest in aging systems when the release of new ones is right around the corner.

RQ-11, Army, Aircraft Procurement

The RQ-11 Raven is a small, unmanned aircraft system that can handle a wide variety of intelligence, surveillance, and reconnaissance tasks at battalion level and below. The small unmanned aircraft system (SUAS) is hand-launched and provides aerial observation, day or night, at line-of-sight ranges up to 10 kilometers. Also, the aircraft has an endurance rate of 90 minutes and can deliver color or infrared imagery in real time to the ground control and remote viewing stations. The current RQ-11 Raven program originated as the FQM-151 Pointer UAV, developed by AeroVironment for the Army's Military Operations in Urban Terrain Advanced Concept Technology Demonstration (ACTD) program. As a result of lessons learned during this program, the Army asked AeroVironment to develop a smaller system that would be more man-portable. A proof-of-concept vehicle of this smaller system, named the "Flashlight" small unmanned aerial vehicle, first flew in October 2001. The Flashlight was further developed into the Raven in 2002 under the Army's Pathfinder ACTD program. However, the Raven prototype was hand-built and not suitable for mass production.

The first LRIP version was the modified Block 1 Raven SUAS, first delivered in May 2003. Testing of the Block 1 UAVs revealed some drawbacks, including a difficult launch procedure and insufficient flight stability. The program was accelerated

in 2003 to meet the needs of forces deployed to OIF and OEF. The initial SUAS purchases were made by the Army under the Rapid Equipping Soldier Support Equipment program in FY2003/04 under an urgent wartime requirement to support forces deployed in OIF/OEF. The Army initially procured 185 SUAS systems in FY2003/04 (under supplemental funding approved in FY2004). In FY2005, the Army procured 270 additional systems to support fielding to modular units. Each "system" contains three Raven aircraft.

In testimony to Congress in 2004, Army leaders described the initial procurement contracts as an "acquisition success" in which the Army responded flexibly to the demands of new contingencies. General Thurman, Director of the Army Aviation task force noted, "in a little more than one year, the Army UAV project manager, in concert with the rapid equipping force and Natick labs, put together a proposal for an initial buy of five small fixed wing, battery powered UAV systems.[37] As a result, the Raven has become the small UAV of choice for the U.S. Air Force and the Special Operations Command. The Army has the lead for a joint Service small UAV working group that has already realized benefits in payload compatibility and communications."

The SUAS program completed MS C on October 6, 2005, and successfully completed initial operational test and evaluation in June 2006. The program obtained FRP authority on October 5, 2006. FY2007 funding (total includes $5.4 million received in GWOT supplemental) procured 20 small systems hardware, contractor logistics support, and new equipment training each year. FY2008 and FY2009 funds procured 100 and 168 SUAS (officially called Raven only in 2010), respectively, program management support, contractor logistics support, and new equipment training.

The Raven system was further improved in FY2009 with the addition of a digital data link (DDL). According to the Army's budget justification, the "DDL enhancement improved operational capability for the Warfighter by: Increasing the number of channels that can be selected allowing for more air vehicles to be flown in a smaller area; Improvement in operational range through relay capability; Incorporating encryption capability; and Integration of advanced digital payloads."[38] The first DDL systems were fielded in December 2009. Program budgets for FY2010 and later include DDL in the production baseline. Additionally, retrofit kits were procured to bring all non-DDL–equipped systems to the DDL configuration.[39] Starting in FY2010, the program was renamed, from SUAS, covered under "other procurement," to "RQ-11 Raven" (its unofficial title before this), covered under Army aircraft procurement.

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[37] U.S. House of Representatives, *Fiscal Year 2005 Budget: Hearing Before the Subcommittee on Tactical Air and Land Forces,* Washington, D.C., U.S. Government Printing Office, 2004.

[38] Department of the Army, *FY2012 Budget Estimates Justification Book, Aircraft Procurement,* February, 2011.

[39] Retrofit kits are included in the P-1 appropriations but are not included in the unit cost calculations for the RQ-1, discussed below.

FY2010 base funding of $35 million procured 206 systems, which equates to 618 air vehicles.[40] FY2010 OCO funding of $45 million procured 258 SUASs, and 472 DDL retrofit kits. Also in that year, HAC recommended a reduction in funding with the rationale that these funds had been requested ahead of need. FY2011 base funding of $20.2 million procured 312 air vehicles, and FY2011 OCO funding of $17.4 million procured 248 DDL retrofit kits. FY2012 base funding of $70.8 million procured 424 systems (1,272 air vehicles) and covered the hardware costs of ground control stations, remote video terminal, initial spares package, and Vampire license and Vampire installation trainers. FY2012 contract award date was moved from December 2011 to April 2012 to incorporate additional OCO funding appropriated.[41] This funding was requested by the Army for "war replacement vehicles." Because of the short production runs, this change does not affect the schedule for future awards. FY2013 base funding of $25.8 million will procure 78 SUAS (234 air vehicles with gimbal payload engineering change proposal) as well as spares and other peripheral equipment.

The Marine Corps also adopted the Raven B as the primary UAV in its Force Protection Airborne Surveillance System program. It procured somewhat fewer Raven aircraft than the Army and only in 2008, 2010, and 2013. In other years, it purchased support systems and DDL links for its existing systems. The Marine Corps uses the Raven "to provide the company/detachment level with airborne reconnaissance to aid in detecting, identifying, and engaging or avoiding enemy units. The UAS air vehicle autonomously gathers and transmits imagery of the tactical situation in near-real time at a range of up to ten kilometers."[42]

There are some minor concerns about the RQ-11 program, stemming from its unit cost/quantity, as shown in Figure 3.14. The graph shows instability early in the program and significant fluctuation in quantity procured. Unit cost is projected to increase slowly but steadily between FY2012 and FY2016, totaling an increase of 61 percent over this time period. There is also evidence of a link between unit cost and quantity. Changes in procurement quantity during FY2005, FY2008, and FY2010–2012 all have a clear corresponding effect on unit cost. Some of the change in unit cost may be associated with technological upgrades that made the system more expensive, starting with the FY2010 or FY2012 acquisition. However, this does not explain the continuing increases in cost after FY2010 or FY2012. After FY2013, quantity procured is expected to stabilize while unit cost will slowly grow. However, these projections do not provide information on specific costs per aircraft (only for the total program)

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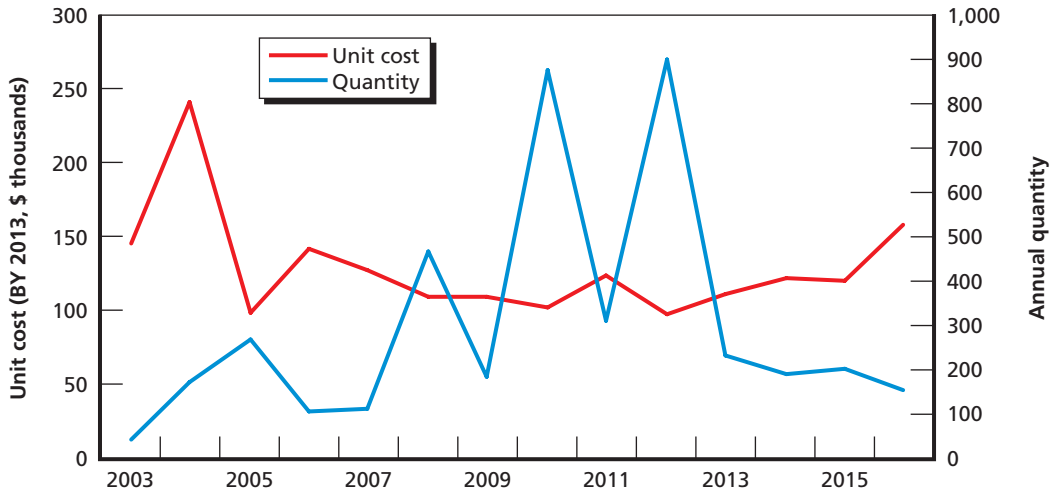
[40] In early years, the purchase of aircraft is provided by air vehicle, but in later years, budget requests list unmanned aerial systems (UAS) of varying types, each with different numbers of air vehicles. The unit cost calculations continue to reflect per vehicle cost.

[41] Department of the Army, *FY2013 Budget Estimates Justification Book, Aircraft Procurement,* February, 2012a.

[42] Department of the Navy, *FY2013 Budget Estimates Justification Book, Marine Corps Procurement,* February 2012a.

Figure 3.14
Unit Cost and Quantity, RQ-11



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and may be revised. The observed cost increase since 2010 and the general instability in procurement quantities are areas where additional investigation may be warranted. Possible explanations for the observed instability include the accelerated development time line resulting from operations in Iraq and Afghanistan, ongoing technological improvements to the system, challenges associated with integrating the new technology into military operations, and the newness of the program itself.

Marine Corps procurement of the RQ-11 has been similarly inconsistent and has also demonstrated gradually rising unit costs. However, since there are only three data points (2008, 2010, and projected 2013), it is difficult to draw any real conclusions and we do not include a graph of this program.

Congressional testimony does not raise any specific concerns about the program. Testimony in FY2005 and FY2006 praised the program for the speed of development and the flexibility the Army demonstrated in accelerating the program to meet the urgent stated needs of warfighters.

Some Concern

MTVR, Weapons and Tracked Vehicles, Marine Corps

According to the budget justification, "the MTVR is a joint U.S. Army/U.S. Marine Corps program to replace the existing medium tactical motor transport fleet of M809/M939 series trucks with cost-effective, state-of-the-art technology improvements." "Major improvements include a new electronically controlled engine/transmission, independent suspension, central tire inflation, antilock brakes, traction control, cor-

rosion control, and safety/ergonomic features." Prototype and development contracts were awarded in 1996. At the time, the Marine Corps justification stated that the remanufacture was mandatory, because of the aging of existing vehicles.[43]

The program faced some hurdles in getting initial RDT&E funds. In FY1995, HASC denied the Marine Corps request for $1.5 million to begin RDT&E for its replacement program.[44] This reflected the committee's disagreement with the Marine Corps efforts to involve the Army National Guard and Army Reserve in a joint program because this would "tend to undercut the Army's plans for replacing its fleet. The committee does not concur with the Marine Corps request of $1.545 million." At the same time, the committee also directed that the Secretary of Defense report to the congressional defense committee by March 31, 1995, on measures that will be taken to harmonize the services requirements and replacement plans.

The program successfully received RDT&E funding in FY1996, as a joint Army and Marine Corps program, although the Marine Corps took the development lead during the program's early years. In that year, $3.5 million was allocated for initiation of a MTVR. Additional RDT&E funding in FY1998 ($9 million) was spent to procure prototypes from two contractors, and $13.1 million was budgeted in FY1999 and FY2000 for a special bodies program, which will be an option item on the production contract to build and test the wrecker, dump, and tractor variants of the MTVR. Outyear funding was also allocated to source selection board, testing, management, etc. Procurement funding in FY1999 began the LRIP for production ramp-up and first article testing. Funding was also provided for various integrated logistics support functions, such as factory training, documentation, and support.

The production contract used was an Army multiyear fixed price contract with an economic price adjustment. The multiyear contract provided significant costs savings, estimated in FY1999 to save approximately 6.5 percent of total funding. According to the Marine Corps program justification, the reasons for the cost savings include "fixed contractor facilitization costs can be amortized over a large base; the work force is stabilized over a longer period; subcontractor purchases result in much larger volume discounts; 'hard tooling' commitments are made in lieu of 'soft tooling' expediencies; and line changeover/setup costs are reduced or eliminated, to name but a few."[45] Although anticipated contract costs and anticipated cost avoidance were only estimates, the estimates used by Marine Corps were based on substantiated data and industry participa-

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[43] Department of the Navy, *FY1998 Budget Estimates Justification Book, Marine Corps Procurement,* February 1997. Although this was a joint program with the Army, Army procurement of medium tactical vehicles is not considered in this summary because it qualified as an MDAP.

[44] U.S. House of Representatives, *Armed Services Committee Report on the National Defense Authorization Act for Fiscal Year 1995,* Washington, D.C.: U.S. Government Printing Office, 1994a.

[45] Department of the Navy, *FY1999 Budget Estimates Justification Book, Marine Corps Procurement,* February 1998.

tion and had been approved by MDA and corroborated by independent cost estimates by FY2000.

The program justification also emphasized the relatively low risk associated with the program, since the MTVR program was a replacement effort that used COTS and NDI. The justification states that "performance specification is stable and based upon proven performance and design parameters demonstrated in the Marine Corps Advanced Technology Transition Demonstrators (MCATTDs)." The program was considered high priority by both Congress and Marine Corps Combat Development Command and stable funding throughout the period was expected.

New vehicles were procured in each year between FY1999 and FY2003. These included lower-cost basic and long-bed cargo variants, as well as more expensive dump, wrecker, and extra-long wheel base (XLWB) variants.[46] The higher cost was driven by technology development and the fact that the dump, wrecker, and XLWB variants were also behind the basic and long-bed cargo variants in the development process. Whereas the basic and long-bed cargo variants entered FRP in FY2001, LRIP quantities for dump and wrecker span FY2002 through FY2003 (dump LRIP total is 47 and wrecker LRIP total is 308). In addition, "pre-production for the more expensive vehicles will be bay-built models to facilitize the contractor's assembly line and prepare work instructions for those specific variants. This process is time consuming as denoted in delivery schedule, but must be done prior to incorporating them into the multi-year production line. Eventually these vehicles will be brought up to full production configuration and fielded."[47]

FY2004 to FY2010 funds continued to purchase a mix of MTVR vehicles along with the support systems needed to operate the vehicles. The dump, wrecker, and XLWB MTVR variants entered FRP in FY2006. Also starting in FY2006, funds were allocated to purchase armor kits to protect the MTVRs from attacks by improvised explosive devices. Starting in FY2008, new vehicles came equipped with this armor. By FY2010, all MTVR vehicles were armored. Funds in FY2011, FY2012, and FY2013 were allocated to both baseline and OCO procurement, although in each case, the majority of funding came from OCO procurement. The MTVR was an important vehicle during operations in Iraq and Afghanistan, and additional vehicles had to be acquired to replace those that were worn out during these two contingencies.

The Marine Corps significantly revised its request in FY2012, from $392.4 million to $98 million, following a significant reduction in the acquisition target for the program. Although there is no clear explanation for the reduction, it may have been driven by the Marine Corps' own identification of other, more pressing operational

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[46] In some years, service budget requests include the data necessary to break the unit cost out into program-specific pieces. We could do this if helpful and valuable, but for now, we have simply calculated average unit cost.

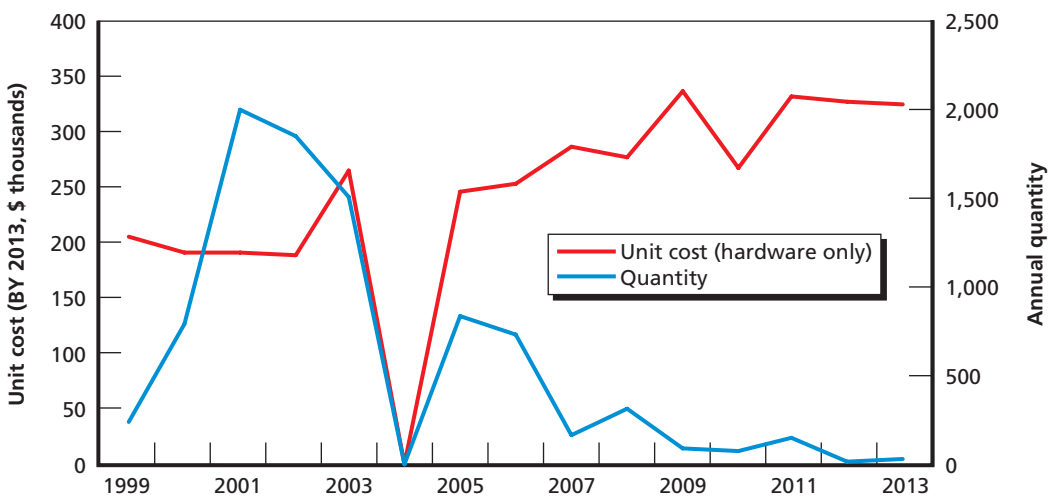
[47] Department of the Navy, *FY2003 Budget Estimates Justification Book, Marine Corps Procurement,* February 2002a.

needs. It requested that the savings from the MTVR reduction be reallocated to other Marine Corps priorities, a request the Senate granted.[48]

Figure 3.15 suggests some cause for concern with the MTVR program. Specifically, the graph suggests gradual but steady growth in unit cost and an apparent decline in Marine Corps interest in the program, as procurement falls to zero. In early years, unit cost fell with increasing quantity procured. After 2002, however, costs began to rise as procurement quantities fell. Some instability in quantities procured can be explained by the start of military operations in Afghanistan and then Iraq. However, even after procurement quantities stabilized (in about 2008), unit cost continued to rise. Marine Corps budget justifications and congressional testimony do not address this cost increase.

Cost growth may be associated with a shift in the variants of MTVRs procured. As noted above, numerous variants of the MTVR are available including wrecker, tractor, dump, cargo, cargo XLWB, as well as armored versions of all the preceding. Differing variants have different unit costs. Unfortunately, Marine Corps budget justifications do not contain consistent and sufficient visibility into variant unit costs to definitively attribute cost growth to lot buys containing a higher ratio of expensive variants. However, limited glimpses into varying unit costs lend credence to this idea. In the FY2012 Marine Corps Procurement Budget Justification Book, six MTVR variants are differentiated in the MTVR Exhibit P-5, which presents cost analysis informa-

Figure 3.15
Unit Cost and Quantity, MTVR



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[48] U.S. Senate, *Report on the National Defense Authorization Act for Fiscal Year 2012,* Washington, D.C.: U.S. Government Printing Office, 2012.

tion (see Department of the Navy, 2012c). The FY2010 appropriation procured variants with unit costs that ranged from $226,000 for the cargo version to $609,000 for the wrecker variant.

Also noteworthy is the sharp reduction in acquisition targets for the MTVR program in the FY2013 Defense Appropriations Bill and the Marine Corps request for the reallocation of MTVR funds to other high-priority needs. This may reflect a response to the more resource-constrained environment faced by DoD, waning interest in the MTVR as wars in Iraq and Afghanistan draw to a close, or some combination of the two. However, it raises some concern about the future viability of the program. The Army's participation in and commitment to the program is another issue that may have affected program performance. Specifically, Army procurement of MTVR variants qualified as an MDAP. The volume of this purchase and the Army's participation in the program may have held unit cost down or kept it more stable than it might otherwise have been. Congressional reports and other secondary sources do not report any additional major problems with the MTVR program.

If the performance of the MTVR program continues to be an area of interest, future analyses might assess the unit cost and quantity of each variant of MTVR separately to tease out the specific drivers of cost growth more carefully.

RAM, Navy, Weapons Procurement

RAM is a high-fire-power, low-cost, lightweight ship self-defense system used to engage antiship missiles. RAM was first operational in November 1992, constructed as a North Atlantic Treaty Organization collaborative project with the Federal Republic of Germany. Approval for FRP , given at MS III, was granted on May 6, 1993. In January 1998, Raytheon acquired Hughes Missile Systems Co., making Raytheon the U.S. prime contractor.[49]

The program faced some challenges in its development phase. In 1991, the HAC recommended terminating the RAM program because of concerns about its ability to defeat future threats and the level of commitment within the Navy for the program.[50] The Navy subsequently initiated a review of the program, focused on improving the system and eventually deploying it on additional ships. The FY1992 appropriation included $2.95 million for research and development efforts to improve the RAM and $5 million for an infrared upgrade to the system. At this time, HAC requested a restructured program that reflected the Navy's planned upgrades in the FY1993 budget request.

In April 1993, the decision was made to implement a block upgrade (the initial RAM is known as Block 0). The upgraded Block 1 missile added the capability of

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[49] Department of the Navy, *FY2006 Budget Estimates Justification Book, Weapons Procurement,* February 2005.

[50] U.S. House of Representatives, *Committee on Appropriations: Report on the Department of Defense Appropriations Bill, 1992,* Washington, D.C.: U.S. Government Printing Office, 1991.

infrared all-the-way guidance to the original missile technology. The FY1995 appropriation included $5 million recommended by HASC to support additional research on a dual-thrust motor upgrade. This effort was incorporated into the Block 1 redesign. Approval for major modification (Block 1) was granted in the MS IV decision of May 6, 1994. A successful preliminary design review of the Block 1 IR upgrade was conducted in September 1995.

Although purchases of the Block 0 missile continued during the development of the Block 1 missile, the quantities of these purchases were scaled back somewhat, reflecting a desire within Congress and the Navy not to spend money on weapon systems that would soon be outdated. In discussions over the FY1994 budget, for example, the Navy asked for $58.5 million to buy 240 RAMs, but HASC recommended only $43.9 for 180 missiles, noting that "that the [immediate] need for RAM missiles should be tempered by minimizing costly retrofit requirements for the current missile" once the improved version was complete.[51] Purchases of Block 0 missiles were gradually phased out over the period between FY1996 and FY1999. However, concerns about the viability and efficacy of the RAM continued. FY1998 funding for the RAM was authorized only after the Secretary of the Navy reported on the Navy's ability to address close-in defense of Navy surface ships and how the RAM would support that effort.

In the FY2000 appropriation report, HASC noted "unexplained cost growth for component improvement, government in-house engineering, and production acceptance" and recommended a cut in the Navy's request by $1 million, another sign of potential problems in the program.[52] Funds that year procured 90 Block 1 missiles.

Approval for FRP, MS III, of the Block 1 missile was granted on January 20, 2000. The United States and the Federal Republic of Germany signed a new Block 1 production memorandum of agreement (MOA) on December 18, 2001, to cooperatively produce Block 1 missiles, launchers, and ordnance alterations (ORDALTs) with block upgrades for older missiles. The ORDALTs are included in P-1 budget appropriation requests but were excluded from the unit cost calculations in our analysis.

Combined developmental test/operational test began in June 2003 and extended into FY2004, using the existing self-defense test ship to ensure operationally realistic tests for determining that RAM with the new helicopter-air-surface software retained capability against antiship cruise missiles. The United States and the Federal Republic of Germany continue to cooperatively produce Block 1 missiles, launchers, and ORDALTs through the Block 1 production MOA, Amendment 2, signed September 28, 2010.

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[51] U.S. House of Representatives, *National Defense Authorization Act for Fiscal Year 1994 Report,* Washington, D.C.: U.S. Government Printing Office, 1993.

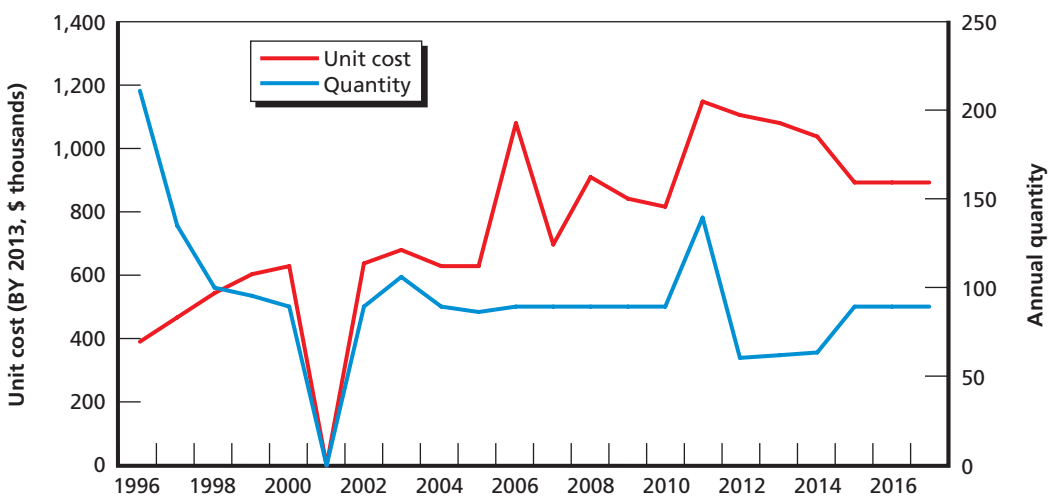
[52] U.S. House of Representatives, *National Defense Authorization Act for Fiscal Year 2000 Report,* Washington, D.C.: U.S. Government Printing Office, 1999b.

The Block 2 missile upgrade is intended to more effectively counter maneuverable antiship missiles. The U.S. Navy awarded Raytheon Missile Systems a $105 million Block 2 RAM development contract on May 8, 2007. Missile development was complete in December 2010, with guided test flights in 2011 and LRIP beginning in late 2012. Appropriations for the RAM purchased only Block 2 missiles starting with FY2010.

The quantity of missiles purchased has been fairly consistent, suggesting continued commitment to the program over time. Appropriations in recent years have gone to fund Block 2 missiles as well as ORDALTs.

The RAM program is one that raises some more significant concerns about program health and unit cost growth, as suggested in Figure 3.16. First, the program experienced some gradual cost growth over the first eight or so years of its life, through about 2003. This cost growth was initially associated with declining procurement quantities but continued even after procurement stabilized. Procurement quantity was mostly stable over the period between 2003 and 2010, although unit cost crept up almost 28 percent during this period. In addition, large buys of ORDALTs in 2006 (120) and 2008 (57) caused unit cost to spike while quantity remained constant. However, projected program performance after 2011 suggests significantly more program performance problems, including an increase in quantity and a sharp increase in unit cost. This jump in unit cost can be explained by the transition of RAM procurement from Block 1 to Block 2. In addition, once quantity returns to its original level in FY2012, costs remain significantly higher than they were pre-2012. Block 2 missiles are significantly more expensive, given their technological advances. It may also be

Figure 3.16
Unit Cost and Quantity, RAM



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that falling demand from other consumers, such as Germany, has affected unit cost. Although congressional testimony and budget markups do not specifically flag this cost growth, it is also not explained in Navy budget justifications.

The large increase in unit cost for the new missile, general instability, unit costs that have gradually but consistently risen over time, and an unclear relationship between procurement quantity and unit cost suggest some reason for concern about RAM program health. These issues warrant further investigation.

Summary

Overall, the ACAT II programs in our selected set perform fairly effectively. Instability in cost and quantity are more significant problems for the ACAT II programs in the selected set than any runaway cost growth or major slippage in schedule and performance. We can make a number of general assessments about the performance of the sample ACAT II programs. First, across programs, there is a strong relationship between unit cost and annual quantity procured. Unit cost rises as annual quantity procured declines. For some programs (the healthiest ones), the relationship between cost and annual quantity is fairly stable and systematic over time. This is true of the LCAC SLEP and the RAM for most of the program life. However, overall, there is too much variation to define a consistent or predictive relationship between cost and quantity that would be useful to policymakers. As noted above, some of the observed instability observed in several of our programs can be explained by changes in demand associated with the end of contingency operations in Iraq and Afghanistan.

To offer a more quantitative perspective on the performance of our ACAT II set, we calculated the average total cost growth for all programs over the period from FY2010 to FY2011. We found that average total cost rises, but average unit cost falls an average 4.4 percent. This number is only an estimate but, as will be discussed below, it is at least as good as the performance of the MDAPs.

In addition to the relationship between unit cost and quantity, another key observation is the frequent challenge posed by program instability. As noted above, instability in cost and annual quantity procured, not runaway cost growth, is the biggest challenge faced by the ACAT II programs in our set of programs. However, although this instability is somewhat problematic, it does not cripple the programs in our program set. Instability is often associated with challenges during the development stages, driven by accelerated time lines, failure to use prototypes, unstable funding, and weak commitment to the program by the leading military department.

Finally, there is some evidence that cost growth is greater among more costly ACAT II programs, younger programs, and programs with lower total procurement quantities. Examples and the relationship between program size and cost growth will be explored in more detail below, after the assessment of MDAP programs.

Two contracting strategies are used in several cases and appear to be associated with program success and sometimes program stability. These are the use of partner-

ships and the purchase of off-the-shelf technology. Cross-service and cross-national partnerships support success when they spread development costs and increase total production quantities, keeping unit costs lower. Partnerships may also allow for program starts and stops without normally associated "penalties," such as the costs to rebuild the industrial base. However, partnerships also come with risk, as each partner is vulnerable to changes in the demand by the other. The ABV is a good example of a partnership between the Army and Marine Corps that had both costs and benefits. It spread development costs and contributed to stability in unit costs for the Marine Corps. The Army also benefited from having the Marine Corps be the lead service and from reduced unit costs but has experienced more significant program instability, especially as demand from the Marine Corps has declined. Partnerships also affected the performance of the M2 .50 caliber, allowing for program stability despite starts and stops. The Hellfire missile, used by all services, also reaped the benefits of cross-service partnerships. The purchase of off-the-shelf technology has also supported success for several of our programs, including the Hellfire missile and the C-37A. This is largely because of reduced development costs and shorter time lines. However, cost savings and stability benefits are smaller than expected in some instances, including the C-37A.

Although most ACAT II programs perform fairly well, some seem to experience more problems than others. Some programs in the selected set are affected by such problems as rebaselining, development delays, incomplete or incorrect program documentation, contractor incentive issues, and program execution issues. Although cost/schedule/quantity revisions exist, they are still not crippling in every case. In fact, of the three, only the Army's program has been cancelled, because of low priority. The Evolved SeaSparrow Missile program is currently performing fairly well, and the verdict is still out on the large aircraft infrared countermeasures (LAIRCMs).

To conclude the assessment of ACAT II programs, it is worth returning to our original questions regarding ACAT performance. First, do ACAT II programs face cost and schedule issues and, if so, what are they? The answer appears to be yes, but these problems are not permanent or crippling. We observe some instability in unit cost and annual quantity procured, especially early in the program life cycle, but stabilization is common and likely over time. We did not find evidence of runaway cost increases and massive schedule slippage. Our overall assessment is that the military departments are fairly effective at managing ACAT II programs. Also important is the observation that the problems ACAT II programs do face are fairly diverse and program-specific and not suggestive of a single serious systemic failure on the part of the military departments. The next step is to compare the performance of these programs to that of a reasonably comparable set of MDAPs.

Comparison of MDAPs and ACAT II Programs

As noted at the outset, to determine if additional guidance for ACAT II programs is needed, we need to evaluate whether there are problems with the decentralized oversight mechanisms currently used to manage non-MDAPs that could be addressed with centralized reporting and control guidelines. One way to make such an assessment is to compare the performance of our ACAT II set with a set of MDAP programs, which already benefit from (or at least are subject to) more rigorous reporting and control requirements. To conduct such a comparison we pursued two lines of analysis. First, we reviewed relevant literature on MDAP performance to identify challenges faced by MDAPs and factors that tend to support their success. This includes reports by GAO as well as root cause and cost growth analyses conducted by RAND. Second, we directly evaluate the performance of a selected set of MDAPs, using data and an approach (described in detail below) that are identical to those used in our assessment of ACAT II programs, and we compare these results with our selected set of ACAT II programs, assessed in the previous section.

Factors Supporting Success and Failure

A review of recent GAO assessments of MDAP performance identifies common factors that predict or support the success of these programs as well as challenges and problems they often encounter. According to a 2010 GAO report, the factors that contribute to the success of MDAPs are similar to those that support the success of ACAT II programs that were included in our program set.[53] These include stable funding, use of prototypes, shorter time lines, incremental development and modest development goals, clear and well-defined requirements, use of developed technologies, the formation of realistic cost and schedule estimates, and use of independent reviews where possible.

Turning to the challenges and performance issues faced by MDAPs, GAO assessments show that, once again, the problems that plague MDAPs are similar in nature to those faced by ACAT IIs. They include fluctuation in quantity, costly modernizations, upgrades, production inefficiencies, accelerated time lines without prototypes, slippage and delays, revisions and instability in program demand and quantity procured, inaccurate initial cost estimates, and missing documentation. However, the problems faced by MDAPs and ACAT IIs appear to diverge in scope, severity, and duration. First, MDAP cost growth and schedule delays are more extensive and severe when they occur. It is worth noting that one reason for this may be the greater complexity of MDAP programs, which makes them more prone to development and other technical delays and problems. Although there is no way to account fully for this difference in

[53] U.S. Government Accountability Office, *Defense Acquisition: Strong Leadership Is Key to Planning and Executing Stable Weapons Programs,* GAO-10-522, Washington, D.C., May 2010a.

our analysis, our approach of selecting the largest ACAT II programs should mitigate some of the differences in complexity. We return to this question of comparability below.

Cost Growth and Program Size

One way ACAT IIs and MDAPs may be different is in the relationship between program size and cost growth. Several previous studies have reported that smaller MDAP programs tend to show more cost growth. For example, Drezner et al. (1993) and a study of the cost estimation methods utilized by Ballistic Missile Defense Organization[54] both report evidence of such a relationship.[55] A 2001 NAVAIR study, in contrast, found no statistically significant difference between cost growth and program size, although its authors report that the variance in cost growth across a selected set of smaller MDAPs is more significant (smaller programs are more likely to have extremely high or extremely low cost growth).[56]

The Drezner et al. study suggests several explanations for the inverse relationship between cost growth and program size. First, the authors observe that smaller programs may have less oversight, leading ultimately to more severe problems, delays, and cost overruns. Second, it may simply be that variance in unit cost is more visible in percentage terms in smaller programs. Third, RDT&E costs make up a larger percentage of total cost in small programs, and this is where programs are more susceptible to cost growth and schedule delays. Finally, it may be that cost growth in small programs is tolerated because it is smaller in size, whereas large programs that experience cost growth in early stages are terminated.

The comparison of our analysis with previous work comes with a number of important caveats. First, past work considered only MDAP programs and included cost growth resulting from growth in RDT&E costs, which we did not include because of limited data availability. Second, the programs assessed by previous studies were not subject to the same reporting and control requirements as today's MDAPs, because the majority of these requirements and guidelines came into effect only in the late 1980s and 1990s. Third, there are a number of differences between the fiscal and competitive environment now and that examined in previous work (in the 1980s and 1990s) that may affect this relationship. For example, there has been significant consolidation among defense contractors, which has reduced competition and affected program per-

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[54] R. L. Coleman, J. R. Summerville, M. DuBois, and B. Myers, *Risk in Cost Estimating: General Introduction & BMDO Approach,* paper presented at the 33rd Annual DoD Cost Analysis Symposium, Williamsburg, Va., February 2, 2000.

[55] Jeffrey A. Drezner, Jeanne M. Jarvaise, Ronald Hess, Paul G. Hough, and Daniel M. Norton, *An Analysis of Weapon System Cost Growth,* Santa Monica, Calif.: RAND Corporation, MR-291-AF, 1993.

[56] Capt. Vince Sipple, Maj. Edward White, and Maj. Michael Greiner, *Surveying Cost Growth,* Washington, D.C.: Office of the Under Secretary of Defense, AT&L, 2004.

formance. In addition, the budget situation and recent wars in Iraq and Afghanistan have altered the fiscal environment faced by both contractors and DoD.

Evaluating MDAPs

A comparison of trends in ACAT II and MDAP performance is useful, but a more direct comparison of MDAP and ACAT II performance on cost growth and quantity can provide clearer insight into the relative performance of the two types of programs. To provide this direct comparison, we evaluate a selected set of MDAPs using an approach identical to that used to evaluate ACAT II programs in the previous chapter. We intentionally do not rely on SARs or DAMIR—data sources that are traditionally used for research on MDAP performance but are not available for ACAT II programs. Programs are selected across military departments and procurement program categories using the budget Exhibit P-1. A range of different program types is included to increase the generalizability of results. We selected both large and smaller MDAPs, but we intentionally exclude programs with serious and well-publicized breaches, since they may be outliers, and their inclusion could result in a biased assessment of MDAP programs overall. We rely, as in the previous chapter, on the budget Exhibit P-1 and Exhibit P-40 to collect annual cost and procurement quantity data and to build time series datasets that track unit cost growth over the life of each program in the set. Finally, also to ensure comparability of the two selected sets of equipment, we do not include RDT&E costs and assess programs only after they have entered production.

We selected MDAP programs to include from across military departments and procurement program categories but exclude the most well-known and problematic MDAPs. We selected a total of seven MDAPs: the light utility helicopter (LUH), joint direct attack munition (JDAM), High-Mobility Artillery Rocket System (HIMARS), the *Virginia*-class submarine, the MQ-9, the C-27J, and the standard missile (SM-2 and SM-6). As in the case of the ACAT II set, we selected programs from a mix of military departments and commodity types. These programs are classified and categorized in Table 3.5. In this section, we assess these MDAP programs, using unit cost graphs similar to those presented for ACAT IIs. Once again, the assessments and observations that we make about performance are specific to our set of programs, but the method we used to select MDAPs from the set of programs (selecting from each department, across procurement types and levels of complexity) should allow for some generalizability. In our evaluation of MDAPS, we do not include program narratives but instead focus more narrowly on program performance, including cost growth and annual quantity procured. We chose not to include this additional detail because information on MDAP program history is readily and publicly available.

Comparing Technological Complexity

One concern about the comparison of MDAPs and ACAT IIs is that MDAPs are fundamentally more complex than ACAT II programs and so more likely to experience

Table 3.5
MDAP Program Selections

Program	Service	Procurement Type
C-27J	Air Force	Aircraft
JDAM	Air Force	Missiles
MQ-9	Air Force	Aircraft
LUH	Army	Aircraft
HIMARS	Army	Weapons and tracked combat vehicles
Standard missile (SM-2, SM-6)	Navy	Weapons
Virginia-class submarine	Navy	Shipbuilding and construction

cost overruns and slippage during development, production, and modernizations. To assess and control for this, we collected information on the technical specifications of our set of MDAP and ACAT II programs from Jane's defense database and then across the two sets of programs. Table 3.6 shows that, although the technical characteristics differ in each sample, the two sets share a number of similar technical features and overall an apparently similar level of complexity. This suggests that the technological demands of our two sets of equipment are largely similar and should not affect our results.

Overview and Summary of Results

Table 3.7 summarizes our assessment of the MDAP programs that we included in our analysis. The programs are again distributed across the three performance categories, with two showing no serious concerns, four showing minor concerns, and three showing some more significant concerns. Overall, the MDAPs in the selected perform reasonably well. Although a few show some cost growth over their program life (including projected out-years) and some have experienced periods of instability, several also show a decrease in average unit cost. However, as will be clear from the program assessments presented in this section, they also do not appear to perform significantly better than the ACAT II set of programs, despite being subject to more formal reviews and more rigorous reporting and control requirements.

MDAP Program Assessments

No Serious Concerns

***Virginia*-Class Submarine, Navy, Shipbuilding and Conversion.** There are no concerns associated with the Virginia-class submarine program (Figure 3.17), which shows stable unit cost and quantity procured since about 2001. The program experienced an

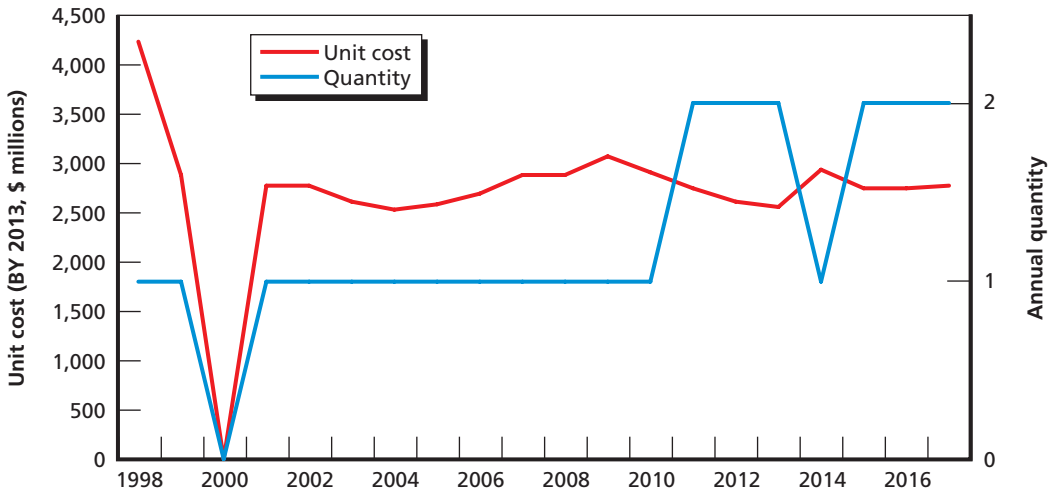
Table 3.6
Comparative Technological Complexity

Technical Characteristics of Selected ACAT II Programs	Technical Characteristics of Selected MDAPs
Aircraft	
Moveable delta wings, truncated delta fins	Self-loading guns
Infrared (IR) seeker and camera	Main rotor hub and blades
Charge-coupled device (CCD) color TV with two-CCD switcher	IR camera
RS-232 interface	Precision strike capabilities
Compact guidance and control unit	
Self-propelled rocket launcher	
Missiles and Weapons	
Guidance system with course alterations	Single, two color imaging infrared (IIR)-seeker with midcourse correction or command, inertial, and global positioning system (GPS)
Radio frequency (RF) seeker	Strakes to improve life and range
High Explosive Anti-Tank warhead	GPS-aided guidance electronics
Four-channel, switchable RF command link and GPS-based navigation	Proximity sensor detonation system
	Ejectable cover, kinetic
Tracked Combat Vehicles	
Rapid ordnance removal system	Upgraded suspension and fishplates to stabilize vehicles during weapon firing
Remote control and heat sensors	Modular construction
Direct view optical scope	V-shaped hull
Quick-change machine gun barrel	Remotely controlled weapons stations
Explosive reactive armor	Energy absorbing seats
Linear demolition charge system	Advanced protective armor
Full width, surface mine ploughs	
On-board vehicle power	
Shipbuilding and Conversion	
Double rudders and planning stern seal	Modular construction design
Reduced noise gearbox	Anechoic coating
Four-blade, variable reversible-pitch propellers	Lock-in/lock-out hull
Double-inlet centrifugal fan	Large diameter launch tubes
	Command and control systems module
	Universal modular mast

Table 3.7
MDAP Program Assessments

No Serious Concerns	Minor Concerns	Some Concerns
Virginia-class submarine	JDAM	MQ-9
HIMARS	Standard missile (SM-2 and SM-6)	
C-27J	LUH	

Figure 3.17
Unit Cost and Quantity, *Virginia*-Class Submarine



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overall decrease in unit cost since its first year and is projected to remain stable in the out years.

HIMARS, Army, Weapons and Tracked Vehicles Procurement. Figure 3.18 suggests no serious concerns about the HIMARS program. The graph suggests that unit cost is stable and even declines, over the life of the program, and quantity procured rises until 2009 before declining slightly through the final year of available data, 2011. Although there appears to be a slight increase in unit cost associated with this drop in quantity procured, it is relatively small. Furthermore, there is no acquisition planned after 2011, so the effects of any cost increase appear truncated.

C27J, Air Force, Aircraft Procurement. Although an assessment of the C-27J program is constrained by the very limited amount of data available, we believe there is no cause for concern with the program. Figure 3.19 shows that hardware unit costs remain consistent over the three years of procurement, although the number of aircraft pro-

Figure 3.18
Unit Cost and Quantity, HIMARS

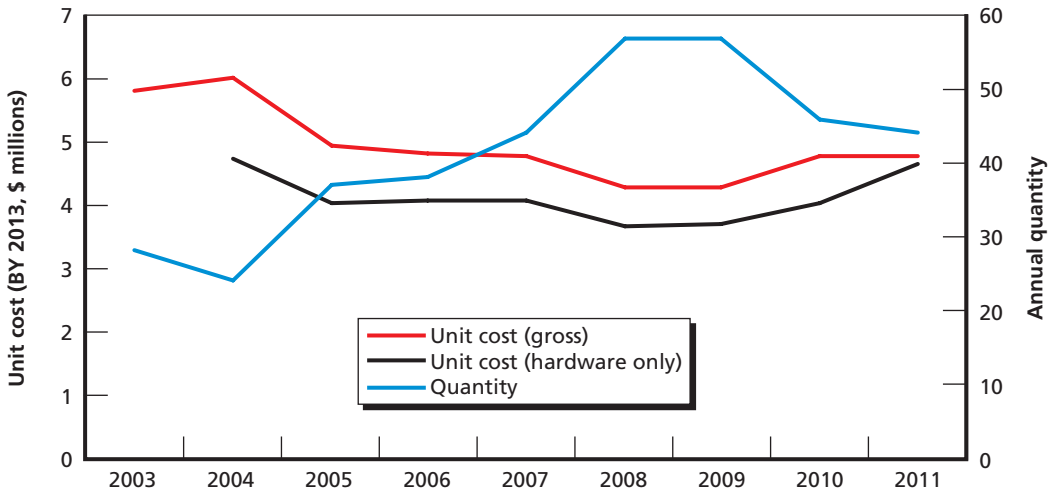

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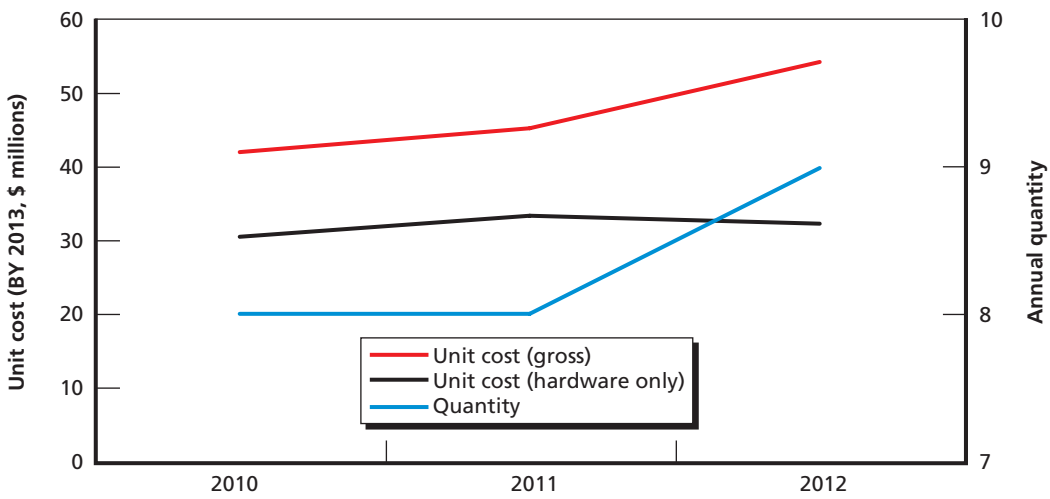
Figure 3.19
C-27J Unit Cost and Quantity



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cured each year increases. The increased FY2012 gross unit cost is due to an additional $18 million in engineering change orders, $18 million in organic depot activation, $82 million in aircrew training devices, and changes to interim contractor support, rather than to production problems or inefficiencies. None of these expenses are present in the first two years of procurement. If costs such as these continue to push overall program costs up in future years, this may be some cause for addition investigation. As of now, however, the program appears to be performing reasonably well.

Some Concerns

JDAM, Air Force, Missile Procurement. Figure 3.20 suggests some cause for minor concerns associated with the performance of the JDAM program, including an increase in unit cost starting in 2011 and continuing into the future. Initially, this increase in unit cost is associated with a drop in quantity procured. However, even after projected quantity procured stabilizes after 2014, projected unit cost continues to increase. Because this increase is only projected, it is only a minor concern at this point, but one that warrants continuing attention. There is also some instability in annual quantity procured over the life of the program, including a sharp drop in 2010–2011. This drop in quantity procured continues in the projected years and may reflect reduced demand after the end of wars in Afghanistan and Iraq.

Standard Missile, Navy, Missile Procurement. There are at least minor concerns associated with the standard missile program's two primary variants, the SM-2 and SM-6. Figure 3.21 shows trends in unit cost and quantity for the program as a whole aggregating across the different types of standard missiles. Although the program

Figure 3.20
Unit Cost and Quantity, JDAM

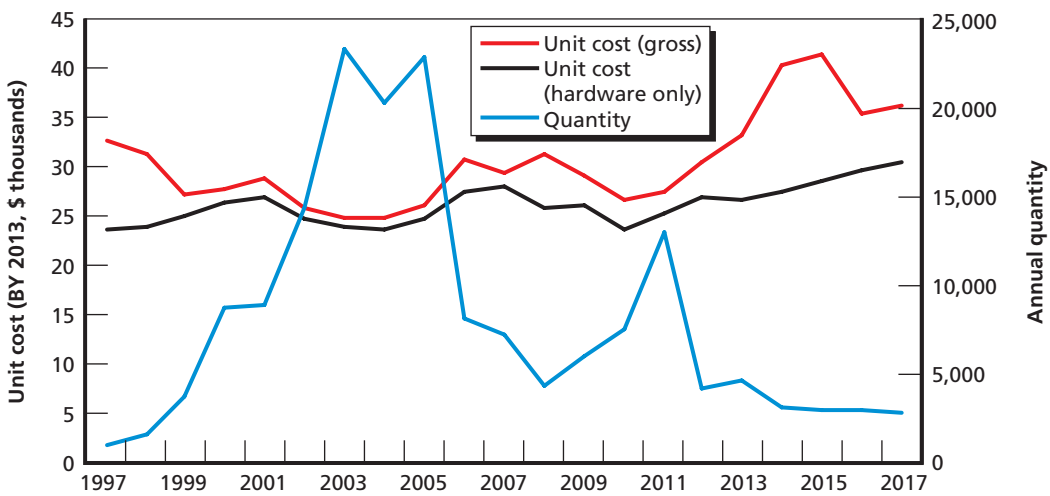

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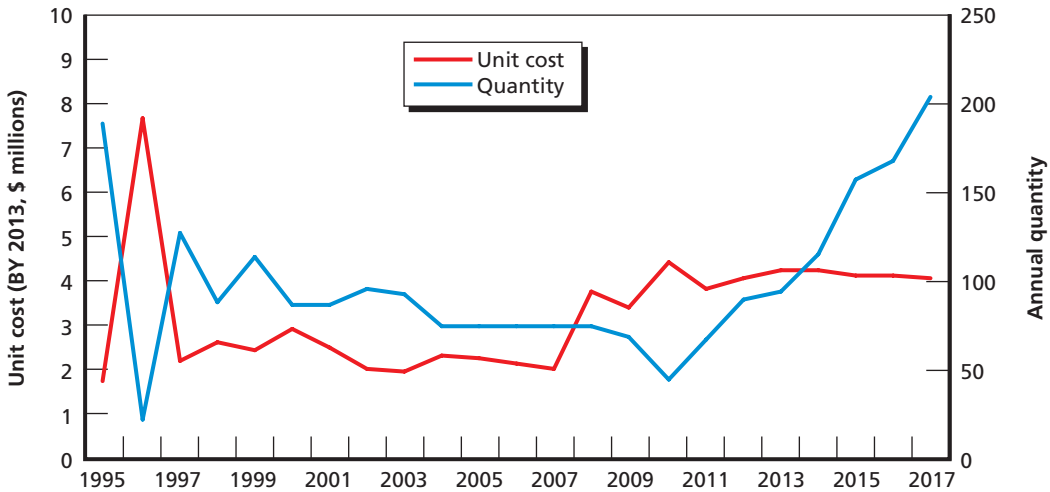
Figure 3.21
Unit Cost and Quantity, Standard Missile



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shows stable unit cost over the period from 1998 through 2007, in 2008 it experiences a sharp increase in unit cost, because of the transition from SM-2 to the more expensive SM-6. An additional increase occurs in 2010, and unit cost does not return to its original level, despite a sharp increase in quantity procured starting in 2010 that continues into future years. However, unit cost does stabilize in the projected years. This stabilization, combined with the fact that the program has been stable in the past, moderates concerns about program performance.

Assessing and explaining the overall program performance of the standard missile become much easier when we inspect the two variants of the standard missile, the SM-2 and SM-6, shown in Figures 3.22 and 3.23. The SM-2 shows significant variation in unit cost over time as well as both cost growth and a decline in annual quantity procured starting in 2009. The SM-6 has many fewer years of associated data but similarly shows some variation and instability in both unit cost and quantity procured, including a sudden cessation of all procurement in 2013 (there is no procurement projected in the out-years). However, the limited data available prevent a decisive assessment of the SM-6 program. The instability in cost and quantity observed in the two programs together are consistent with our rating of minor concerns for the standard missile program.

Light Utility Helicopter, Army, Aircraft Procurement. The LUH (Figure 3.24) shows little evidence of growth in unit cost or problematic instability to suggest poor program health. Unit cost is relatively stable over the life span of the program, at least until the projected future years, when quantity procured begins to fall. In these years, most of the money spent on the program is for peripherals and repairs rather than for

Figure 3.22
Unit Cost and Quantity, SM-2

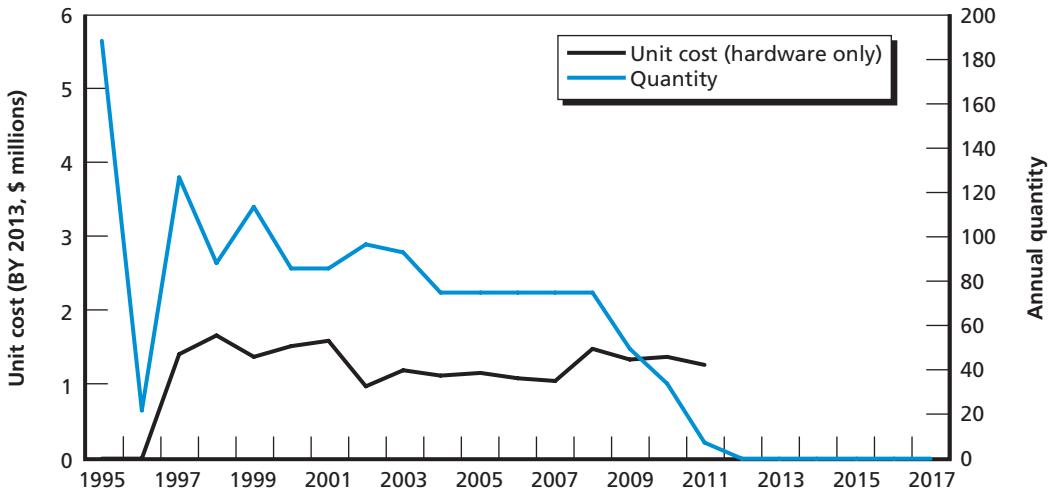

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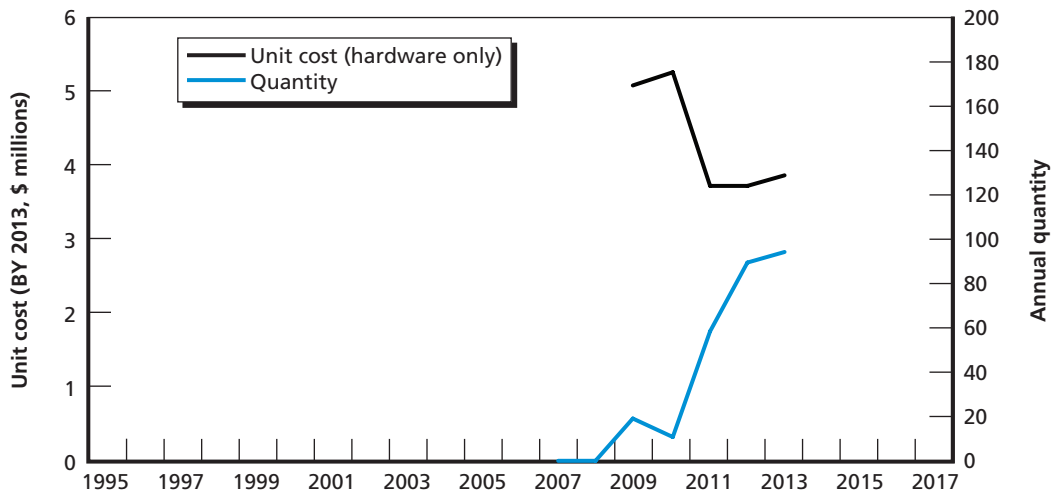
Figure 3.23
Unit Cost and Quantity, SM-6



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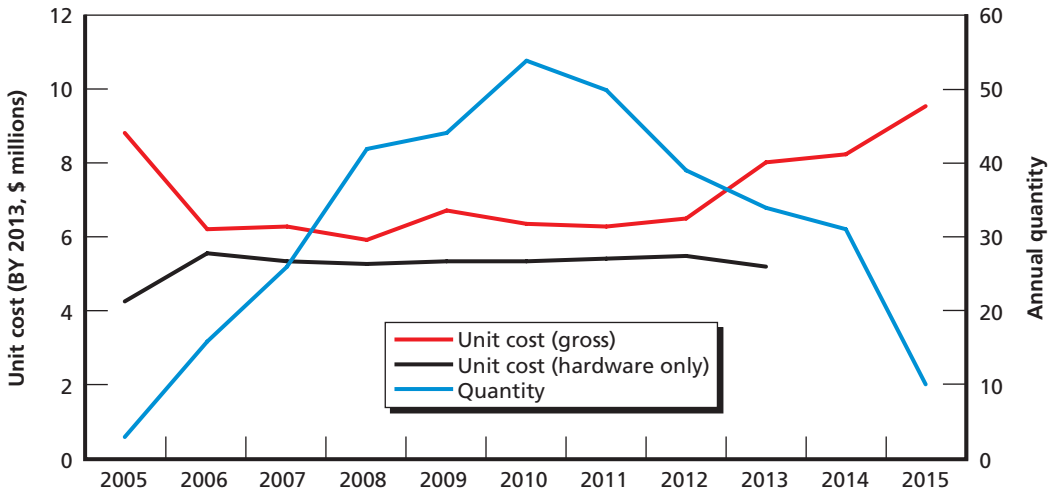
new hardware, so the growth in gross unit cost reflects a shift in what is being procured rather than any sort of problem in program performance. Quantity procured varies more significantly over the life of the program, rising consistently to 2010 and then falling afterward into the out-years. The projected cost growth in future years creates

Figure 3.24
Unit Cost and Quantity, Light Utility Helicopter



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some cause for concern, but since this cost growth is projected and has not yet materialized, these concerns are only minor.

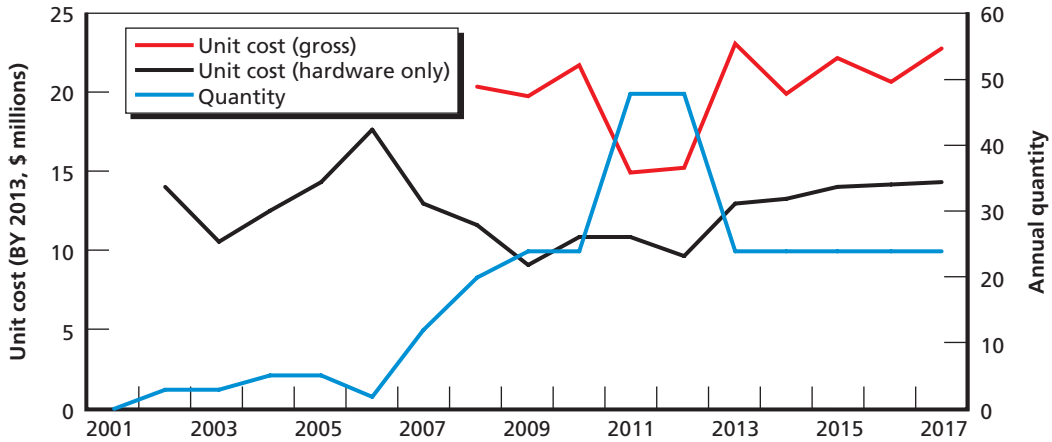
Some Concerns

MQ-9, Air Force, Aircraft Procurement. There are some more significant concerns about the performance of the MQ-9. Figure 3.25 shows that unit cost over the life of the program fluctuates rather substantially and shows a fairly consistent increase in the period after 2011, despite no change in quantity procured over those same years. Annualized quantity procured rises in 2012 but then falls in 2013 estimates and remains at this lower level in future years. The instability and projected increase in unit cost, together with a fairly high projected annual procurement in future years, create some cause for concern about the health of the program.

One potential root cause of cost growth and schedule delays for MQ-9 is its rapid fielding. The program began in January 2002 with system development starting in February 2004. Because of urgent operational need and direction from the commander of Air Combat Command, the MQ-9 was fielded with incomplete testing, before all technologies were mature and even before the completion of design drawings.[57] Unless the system is given additional development time, extensive testing, and refined production processes, MQ-9 is apt to encounter additional production delays

[57] Selected Acquisition Report, *MQ-9 UAS Reaper,* December 31, 2011.

Figure 3.25
Unit Cost and Quantity, MQ-9



NOTE: No gross cost data exist before FY2008. MQ-9 was procured under the MQ-1 Predator appropriation before FY2008.

RAND *MG1171/4-3.25*

and cost growth. These risks must be balanced against the pressing need to field the system.

Another possible root cause for increasing unit costs, especially in later years of MQ-9's life, are new, more capable, and more expensive models of the aircraft, also known as blocks. The original production standard was known as Increment 1 Block 1. MQ-9 was scheduled to transition to the more capable Increment 1 Block 5 in FY2012,[58] which will fulfill all capabilities described in the Capability Production Document as Reaper was originally planned, but these are also more expensive because of their more advanced technology. There are plans to eventually move to an Increment II Block 10 with enhanced sensors and weapons. As capabilities are incrementally improved and new production blocks rolled out, unit cost will likely grow.

Summary

Overall, the MDAPs in our selection perform reasonably well over the time period we consider, specifically, once they have entered into production (we did not consider the development phase or any problems these programs encountered at that time). Although several programs had some areas of concern, including some evidence of cost growth over time and instability in procurement quantity, the problems did not yet appear to be severe or even close to Nunn-McCurdy breach thresholds.

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[58] Department of the Air Force, *FY2012 Budget Estimates Justification Book, Aircraft Procurement,* February 2011.

Several other observations emerge from our assessment of MDAP programs. First, returning to the question of how program size is related to cost growth, we found some evidence that smaller MDAPs may be more prone to unit cost growth over their program life, a finding consistent with previous work on MDAPs and different from the pattern observed in our set of ACAT IIs. For most programs, average unit cost and unit cost in the final year of the program were lower than unit cost in year one (in constant dollar terms). Programs that did experience cost growth included both programs with significant total costs, such as the C-27J, and those with smaller total program costs, such as the standard missile.[59] Since the cost increase in the C-27J program was due to service contracts, not hardware, the balance tips slightly toward a conclusion that smaller MDAPs experience greater cost growth. The same caveats noted above are important when comparing these findings to previous work on the relationship between size and MDAP performance. First, we did not include RDT&E costs and considered programs only once they had entered into production. Second, as noted above, the time period considered in some previous work, specifically, that relating cost growth and program size, looks at programs from the 1990s, when the fiscal and competitive environment and the acquisition workforce looked significantly different.

Performance of ACAT II Programs Compared to MDAPs

A comparison of the MDAP and ACAT II set of programs suggests that ACAT II programs perform about as well as MDAPs overall, when both types of programs are assessed after they have entered production. In both sets, once they have entered into production, programs perform reasonably effectively, with some instability in unit cost and annual quantity procured but few instances of rapid, long-term cost growth or significant slippage in schedule. In both cases, cost growth and instability in quantity procured are associated with modernizations, contingency operations, and accelerated time lines but tend to be limited in size and often duration. Table 3.8 offers a more quantitative way to compare the performance of the two programs, namely, by comparing the aggregate changes in quantity procured and unit cost across the two sets between 2010 and 2011. The table shows that MDAPs and ACAT IIs trend in the same direction on these dimensions. Quantity procured increases, and this increase is significantly larger for the MDAP selections. Unit cost for hardware rises in both cases, and this increase is also larger for the MDAP set. However, gross unit cost falls for ACAT IIs and MDAPs. These numbers are only rough estimates and are limited in their value by the fact that they average across a large number of very different program types. However, these estimates are sufficient to support our overall argument and assessment that the ACAT II and MDAP sets perform similarly on a large number of important dimensions.

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[59] The C-27J cost increase was, as noted above, largely due to factors not associated with hardware or system costs.

Table 3.8
Comparison of MDAP and ACAT II Performance (FY2010–FY2011)

	Selected ACAT II Programs	Selected MDAP Programs
Quantity	↑ 23.0%	↑ 77.7%
Unit cost (gross)	↓ 4.4%	↓ 8.2%
Total cost (gross)	↑ 8.8%	↑ 50.0%

As stated at the start, adding new guidance and reporting and control requirements for ACAT II programs makes sense only if there is evidence of a problem in their current performance that suggests that the military departments are unable to manage these programs on their own or that additional centralized oversight would solve the performance problems faced by ACAT IIs.

Conclusion

Our assessment suggests that ACAT IIs reach a level of performance currently, without rigorous centralized oversight, that is at least equal to that of MDAPs operating with centralized reporting and control requirements and oversight. As a result, it appears that the military departments are already doing a fairly effective job at managing these programs and that additional guidance may not be warranted. Furthermore, the problems that ACAT II programs do seem to suffer from are diverse and program-specific and unlikely to be solved simply by the addition of a more centralized performance reporting system.

CHAPTER FOUR

Framing Assumptions

Introduction

Most defense acquisition programs face the challenge of forecasting cost, schedule, and technical expectations far in advance of actual work—sometimes decades beforehand. Moreover, programs must also account for differences in acquisition strategy and marketplace environment in these forecasts. As a result, program managers must make assumptions regarding these uncertain elements of program execution. Although necessary, such assumptions expose the program to risk of cost growth and schedule slip.

PARCA office research has noted that incorrect assumptions (or conditions that make the assumptions invalid) can cause a program to miss its budget forecasts. More important, these incorrect assumptions often lead to breaches of Nunn-McCurdy thresholds if they are central to program expectations. Such key assumptions are called "framing assumptions," because they so shape the program performance expectations that, if incorrect, they lead to significant cost growth, performance shortfalls, schedule slippage, or all three.

This exploratory research conducted for the PARCA office attempts to accomplish the following goals:

- define framing assumptions so that others can better identify them and that there are some standards for consistent application
- explore the possibility of identifying framing assumptions for a sampling of programs (both established and relatively new) using readily available information (e.g., publicly available program documents, congressional testimony, SARs, and press articles).

The potential benefit of this research is showing that the concept of framing assumptions is a feasible and practical paradigm for understanding potential risks to programs. If program risks can be identified early, they can be tracked and managed during program execution.

Assumptions in Planning

The defense acquisition and business literature touches indirectly on identifying assumptions underlying planning and execution through discussions of risk management and uncertainty management.[1] However, there is little discussion on how to identify, prioritize, and then vet assumptions vital to a project plan. Work by James Dewar concerning assumption-based planning offers several techniques to identify explicit or implicit assumptions that are both vulnerable as well as "load bearing."[2] In APB, a planning assumption is defined as "a judgment or evaluation about some characteristic of the future that underlies the plans of an organization."[3]

A planning assumption can have several different characteristics. The first is whether it is explicit and articulated or implicit. Particularly problematic, implicit assumptions may be so because of suppression for organizational or external political reasons, repression by planners, "cultural blinders," or cognitive blocks.[4] However, true risk lies in whether an assumption is load bearing and vulnerable. An assumption is load bearing "if its failure would require significant changes in the organization's plans."[5] Vulnerability is inherent when plausible events could cause it to fail within the expected lifetime of the plan. According to Dewar, assumptions identified as both load bearing and vulnerable must receive special scrutiny as the project progresses.

Dewar identifies two major sources for assumption identification: project documentation and people involved in the planning. Drawing on these sources, it is possible to apply several techniques that vary as to the time and number of people required, ease in application, breadth of applicability, and point in time during the project when assumption identification should be used.[6] The techniques Dewar lists include the following: Telling actions the long way, looking for wills/musts, rationalizing a plan, asking journalist's questions, strategic assumption surfacing and testing, driving force analysis, core belief identification squad, and an annual key bets contract. Particularly when using documentation, the identification of wills/musts and their derivatives present an easy method to identify explicit assumptions. "Rationalizing a plan" entails list-

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1 See, for example, Young Hoon Kwak and Brian M. Smith, "Managing Risks in Mega Defense Acquisition Projects: Performance, Policy, and Opportunities," *International Journal of Project Management,* Vol. 27, 2009, pp. 819–820; Chris Chapman, "Key Points of Contention in Framing Assumptions for Risk and Uncertainty Management; " *International Journal of Project Management,* Vol. 24, 2006, pp. 303–313; Corporate Strategy Board, "Proceeding in Daylight: Frontier Practices for Challenging Strategic Assumptions," Washington, D.C.: Foundations of Strategy Development series, 1999.

2 James A. Dewar, *Assumption-Based Planning: A Tool for Reducing Avoidable Surprises,* New York: Cambridge University Press, 2002.

3 Dewar 2002, p. 14.

4 Dewar 2002, pp. 20–21.

5 Dewar 2002, p. 22.

6 Dewar 2002, p. 57

ing separately the actions the organization will take and assumptions about the future and then connecting the assumptions to the actions. Some assumptions will connect strongly, weakly, or not at all, and some actions may not have any connected assumptions. These isolated actions represent instances of potential implicit assumptions and should be explored further.

Once the assumptions are identified, Dewar suggests identifying "signposts," or indicators, or warning signals that the validity or vulnerability of an assumption is changing. To create signposts, analysts can use formal indicator systems, such as economic indices; derive them from formal project goals, targets, or objectives; or simply brainstorming paths or turning points where assumptions could fail. The identified signposts allow for "reality checks" as the project and its environment evolve.

Definition of a Framing Assumption

Before we can explore example framing assumptions, we first need to define what a framing assumption is. Such a definition is particularly challenging in that it is easy to recognize a key assumption (particularly after the fact when it is shown to be invalid) but not to come up with an all-encompassing definition. In fact, the definition for a framing assumption was the last task we undertook after having looked at a range of assumptions on programs. We arrived at the following definition:

A framing assumption is any explicit or implicit assumption that is central in shaping cost, schedule, or performance expectations. In other words, framing assumptions can be viewed as "bets" that, if not realized, can lead to major problems in execution. Framing assumptions may change over the course of execution or new ones can be added. A few criteria further refine this definition:

- Determinative: The consequences of the assumption being wrong will significantly affect the program in a way that matters (e.g., significant cost growth or schedule slippage). In other words, the assumption is important to the success of the program. For example, an incorrect framing assumption could lead to a significant or critical Nunn-McCurdy breach. The assumption must be explicitly tied to how it affects the value chain (e.g., a particular acquisition strategy will result in lower procurement cost).
- Unmitigable: The consequences are unavoidable if the assumption is wrong through other actions. There is no easy workaround or mitigating action the PM can take. For example, the electromagnetic launch system not working on the carrier CVN 78 would have unavoidable cost, schedule, and technical implications for the carrier program. There is no simple workaround—going back to a steam catapult option would be very costly and time-consuming.
- Uncertain: The outcome or certainty with respect to the assumption is unknown. There is some inherent risk. For example, a framing assumption is not a funda-

mental physical law or property, such as the gravitational constant. Indeed, if this constant were to change, there would be consequences; but it will not happen.

- Independent: The consequences of the assumption failing or being realized do not hinge on other events or a chain of events. As a simple example, a framing assumption is not "the contract price is stable." Price stability could depend on many separate issues, such as industrial base stability, inflation of materials, or technical maturity.
- Distinctive: A framing assumption should generally set a program apart from other programs (or groups of programs). So a framing assumption is not "the contractor will perform well," because that assumption is common to all programs. But a framing assumption might be, "the contractor is capable of successfully producing a type of system that it has not produced in the past." Think of the advanced SEAL delivery system program—the original contractor had never made a deep submergence vehicle or submarine.[7]

An example of a framing assumption might be, "competitive prototyping will result in a savings of 5 percent in procurement cost," rather than, "the contractor will perform well" (common to all programs). Another example is that a particular weapon system being replaced "will last until 2015" and all schedule plans are predicated on that end date. A framing assumption is not a program characteristic, e.g., the program is part of a family of systems. As a final example, a framing assumption might be that the program "can leverage specific COTS hardware and/or software to reduce risk and save cost." A framing assumption is not "the program is affordable."

To help make the concept of framing assumptions more concrete, we organized them into three categories, as shown in Table 4.1. The categories are technical (both component and integration issues); management approaches, incentives, and program structures; and mission requirements. Note that the table does not list specific assumptions but rather identifies areas where a program may have framing assumptions. Also, some issues may not be entirely separable into specific areas and drive multiple consequences. For example, quantity expectations might also affect industrial base expectations.

One important issue to note is that a framing assumption is not necessarily a "bad" thing or incorrect. All programs make assumptions, and many may turn out to be valid. The important point is that program outcomes depend heavily on making the correct framing assumptions.

It is also possible to go overboard in identifying framing assumptions. The concept is to develop a few concrete, high-level assumptions that can be easily tracked. On the order of three to five assumptions is probably a good number for most programs.

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[7] U.S. Government Accountability Office, *Success of Advanced SEAL Delivery System Hinges on Establishing a Sound Contracting Strategy and Performance Criteria,* Washington, D.C., GAO-07-745, 2007b.

Table 4.1
Example Program Areas for Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Manufacturing expectations	Program/interprogram dependencies	Stability and compatibility of operational needs
Testing expectations	Contractual incentives and strategies	Quantity
Industrial base and market expectations	Organizational management structures	Capabilities
Technical approach	Risk assessment	Joint/international needs
Risk expectations	Risk management	Possibility of substitute item/system
Simulation utility	Interface and environment management	

Example Programs

Approach

The PARCA office identified five exemplar programs for which it wanted us to explore developing framing assumptions. These programs are as follows:

- advanced pilot training (APT) system
- joint light tactical vehicle (JLTV)
- joint precision approach and landing system (JPALS)
- LCS modules
- space fence.

Part of the ground rules for this analysis was to develop these framing assumptions *independently* from program offices or any other organization in OSD. To do so, we reviewed available program literature. We specifically used the following sources: ADMs, open source program briefings, trade literature (*Inside Defense*, *Jane's*, or other relevant trade literature), DAES, SARs, Acquisition Strategies, congressional authorization and appropriations documents, enabling concept documents, SEPs, GAO reports, Congressional Research Service reports, DAES risk summary and issue summary charts, Exhibit R-2, RDT&E budget item justification documents, TEMPs, technology readiness are (TRA), AoA, and independent cost estimates (ICEs) that were available. Not all material was available for each program.

Beyond these five programs, we summarize the prior RAND PARCA research on root causes, by identifying framing assumptions that caused Nunn-McCurdy breaches. We did not do such an extensive literature review for the programs listed above.

Note that the framing assumptions are *our* interpretation of these sources and required that we make inferences about program expectations. None of the information we reviewed explicitly listed key assumptions, nor did we interview program office personnel to verify our findings. Thus, our assessments may not be inclusive or list all the important framing assumptions. Also, note that it is easier to recognize a failed or incorrect assumption after the fact than it is to recognize a correct or valid one. Therefore, our analysis is more likely to have identified incorrect assumptions.

Advanced Pilot Training System

The APT is a pre-MDAP Air Force aircraft and ground training system that will replace the T-38 aircraft training system. The last awarded milestone was Milestone A on May 10, 2010.[8] APT will be an integrated family of systems that will use both ground (simulators and computer-based training) and flight training systems.[9] The program is expected to supply an advanced trainer, known as the T-X aircraft, for the fighter/bomber APT track. Market research was conducted in 2008 for possible sources for the APT; however, initial operational capability was moved from 2017 to 2020 because of budgetary concerns.[10]

Given the early stage of program planning, little information was available to generate framing assumptions from open source reporting; however, we were able to glean some framing assumptions that are presented in Table 4.2.

The first framing assumption we were able to identify for the APT is that it will be nondevelopmental, meaning that the program will leverage commercial or foreign aircraft's airframe and avionics capabilities.[11] This is a technologically related assumption.[12] Use of COTS and other nondevelopmental items is frequently done in defense acquisition to maintain lower costs. This strategy has produced mixed results.[13] In this

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8 Ashton B. Carter, "Memorandum for Secretary of the Air Force and Secretary of the Navy; Subject: Advanced pilot Training (APT) System Materiel Development Decision (MDD) Acquisition Decision Memorandum," Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, May 10, 2010. Not available to the general public.

9 Col. John Thompson, "The Future of Air Force Education and Training: an Advance Planning Briefing to Industry," Randolph, Tex.: Air Education and Training Command, May 12, 2009, p. 12.

10 Gabe Starosta, "Cautions Against Living 'on the Leading Edge of Technology': AETC Chief Confident in T-38 Capability with IOC Delayed Until 2020," *Inside the Air Force,* March 2, 2012.

11 Carter, 2010.

12 One could alternatively create a different framing assumption under mission requirements that the "Mission requirements can be met with non-developmental aircraft." Sometimes framing will not cleanly fit into one specific category. But this indeterminacy is not critical; it is more important to identify the assumption than to categorize it.

13 See, for example, Office of the Under Secretary of Defense for Acquisition Technology, and Logistics, "Buying Commercial: Gaining the Cost/Schedule Benefits for Defense Systems," *Report of the Defense Science Board Task Force on Integrating Commercial Systems into the DOD, Effectively and Efficiently,* Washington, D.C., February 2009.

Table 4.2
APT Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Training aircraft (both airframe and avionics) will be nondevelopmental	Possible customers (e.g., the U.S. Navy and foreign militaries) will want to buy the APT with minimal modifications	Current training scenario is valid: Use of existing T-38 can be extended until 2020 Simulators can be used instead of actual flight time (to save money)

particular program, using a proven airframe may produce a positive outcome if minimal modifications are needed to the weight and size of the airframe. Using COTS for the avionics will also be positive if there are minimal modifications and if integration does not prove to be difficult.

The second framing assumption falls under the "management, incentives, and program structures" category. This framing assumption for the APT program assumes that any possible future customers for the APT (outside the Air Force) would want to buy the APT with minimal modifications.[14] Such parties may include other services or foreign militaries. This is another cost-savings assumption that reflects a frequently used cost saving mechanism in defense acquisition. By producing more units of the same aircraft for outside parties, the Air Force would be able to maintain lower unit costs in production.

The final framing assumption relates to the systems mission requirements, namely, that the current training scenario is valid: (a) the use of existing T-38 can be extended until 2020, and (b) simulators can be used instead of actual flight time (to save money). In the case of the APT, the Air Force made a recent, critical assumption that the current platform that is being used for training, the T-38, is sufficient to meet operational needs until 2020, when the APT will reach initial operational capability. Recently, the Air Force

> opted to delay the initial operational capability of a replacement trainer aircraft by three years until fiscal year 2020 . . . [because] the T-38 trainer's airframe is in good enough shape to operate until the end of the decade . . . AETC's commander, acknowledged that . . . the delay will cause few problems in terms of sustaining the T-38.[15]

As long as the Air Force's calculations for the T-38 are accurate, there should be little problem with this framing assumption; however, if the APT is delayed even further because of budgetary constraints or canceled outright, then the absence of a read-

[14] Carter, 2010.

[15] Starosta, 2012.

ily available alternative may be problematic for the Air Force. Also as part of the mission requirements' risk is the use of simulators instead of actual flight time. One reason for the use of simulators is to save flight time costs. In addition, given the changing environment for technology, the Air Force is focusing on other ways to use technology through the following:

- instructional design
- knowledge systems
- virtual environments
- mobile learning
- simulations and gaming.[16]

APT is one program that the Air Force has developed in a way that shifts its acquisition to reflect changing technologies.

Joint Light Tactical Vehicle

The JLTV is a pre-MDAP, joint acquisition program under the Army and the Marine Corps that seeks to replace the 11 versions of the high mobility, multi-wheeled vehicle that have been in service since 1985. A ground combat vehicle, the JLTV is planned to provide substantial improvements over the existing light tactical wheeled fleet in technology, operational capability, and survivability. In particular, the Army has sought to acquire the JLTV. It was awarded Milestone A on December 22, 2007.

One major technological framing assumption entailed embracing benefits implied with the "incremental/open architecture" concept (see Table 4.3). This concept has been used in other acquisition programs as well, with mixed results.[17] In particular, the JLTV was envisioned to have an initial "basic capability" with the potential to add "enhanced force protection, increased fuel efficiency, greater payload, and other improvements" to integrate future technologies.[18] Basically, capabilities would be scaled to fit various operational needs. Another technological framing assumption is that that competitive prototyping will also reduce risk and cost. Multiple vendors, it was assumed, would be able to "increase their knowledge of the needed technologies, determine the technologies' maturity level, and determine which combination of requirements were achievable."[19] This assumption is also born out of the belief that the

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16 Thompson, 2009, p. 9.

17 For example, see Mark A Lorell, Julia F. Lowell, and Obaid Younossi, *Evolutionary Acquisition: Implementation Challenges for Defense Space Programs,* Santa Monica, Calif.: RAND Corporation, MG-431-AF, 2006.

18 U.S. Government Accountability Office, *Defense Acquisitions: Issues to be Considered as DOD Modernizes Its Fleet of Tactical Wheeled Vehicles,* Washington, D.C., GAO-11-33, November 2010b, p. 11; LTC Wolfgang Petermann and LtCol Ruben Garza, "JLTV EMD Industry Day," briefing presented on April 26, 2010.

19 U.S. Government Accountability Office, *Defense Acquisitions: Future Ground-Based Vehicles and Network Initiatives Face Development and Funding Challenges,* GAO-12-181T, Washington, D.C., October 2006, p. 10.

Table 4.3
JLTV Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Incremental/open architecture will reduce risk and allow for more efficient upgrades	A joint Army and Marine Corps program will save money as requirements are compatible	The services have effectively assessed long-term versus short-term needs
Competitive prototyping will reduce risk/cost	Export opportunities could decrease cost	

use of "one bidder based on a paper proposal has proven to be a formula for risk, cost growth and schedule delays."[20]

The management framing assumption is that a partnership between the Army and the Marine Corps, despite differing requirement tradeoffs between the two services, would reduce overall program costs through the use of similar equipment.[21] These two framing assumptions, that "unique service requirements have been minimized"[22] and that competition within the industry would overcome the technical difficulties in merging the services' differing mission goals, reinforced each other. In particular, force protection and transportability represented the greatest challenge to joint development. The Army's key goal was "scalable protection,"[23] yet the resulting armor requirement drove up the total weight of the vehicle and ran directly counter to the Marine Corps requirement that the vehicle be transportable by the CH-47 and CH-53 helicopters as well as the C-130 cargo aircraft. After ACTD, size requirements were adjusted in an effort to harmonize the tradeoffs between the two requirements, although the decreased size led to limited space for other mission-essential equipment and payload.[24]

[20] As stated by Young, 2008, p. 71. According to the PEO for Land Systems, "the purpose of the TD phase was to better inform the requirements communities by allowing them to get a glimpse of what the realm of the possible with respect to what those requirements cost." "Amphibious Combat Vehicle AOA Scheduled to Wrap Up in June," *InsideDefense.com: Inside the Navy,* March 9, 2012.

[21] "It always bothers me that we may not be totally efficient in buying things that should maybe be joint. In other words, the idea of the Army and Marines using similar equipment is a good idea. But I value the Marines' understanding of their mission, which is slightly different than the Army mission," according to Army acquisition executive Malcolm O'Neill. Sebastian Sprenger and Tony Bertuca, "Army Acquisition Chief Backs JLTV, But Acknowledges Unknowns," *InsideDefense.com: Inside the Army*, October 18, 2010.

[22] JLTV R-2 Budget, February 2012, p. 1.

[23] Department of the Army, "The Army Tactical Wheeled Vehicle (TWV) Strategy," 2010, p. 13.

[24] COL Steve Meyers and LtCol Ben Garza, "TWV Transformation Efforts," presentation at the NDIA TWV Conference, February 6, 2007, slides 12, 15.

Other management/program structure framing assumptions included the belief that export opportunities to countries such as Australia could decrease cost.[25] In addition, the program was viewed as a good "test-bed" for new OSD acquisition initiatives to improve program performance. The JLTV was labeled specifically as the "designated pilot for new OSD acquisition initiatives" such as "Concept Decision, Fully Burdened Cost of Fuel, Competitive Prototyping, (and) Increased RAM." [26]

In terms of mission requirement framing assumptions, "the JLTV CONOPS (were) expected to evolve in synchronization with the program development . . . the design, test, and trade study efforts in the TD are expected to influence the solidification of CONOPS."[27] Balancing longer-term requirements with shorter-term operational needs was deemed feasible, as the heavier mine resistant ambush protected vehicles "fill(ed) a near-term, urgent joint service requirement" for the high improvised explosive device threat, whereas the JLTV was supposed to be used in other threat environments. The unexpected rapid acquisition and deployment of the mine-resistant ambush protected vehicle, however, altered requirements and expectations for the JLTV, particularly in its curb weight and transportability requirements.[28]

Joint Precision Approach and Landing System

The JPALS program is an ACAT 1D MDAP. The Navy is the lead service, but both the Air Force and Army provide additional support to the program. It can be categorized as a command and control program but is specifically a GPS-based precision approach and landing system.[29] According to the mission description in the SAR, this system

> will replace several aging and obsolete aircraft landing systems with a family of systems that is more affordable and will function in more operational environments, and support all Department of Defense (DoD) Land and Sea Based applications . . . [and] will eventually support unmanned and highly automated aircraft. . . . The approved JPALS Acquisition Strategy has acquisition broken into seven increments, based on technology maturity and Service needs. Increment 1, Sea Based

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[25] "International participation in the JLTV program will reduce overall program risk through the testing and evaluation of additional prototype vehicles," according to Lt. Col. Wolfgang Petermann, Army product manager for JLTV. Marjorie Censer, "DOD Inks Formal JLTV Agreement with Australia; More Partnerships Planned," *InsideDefense.com: DefenseAlert,* February 26, 2009.

[26] David Holm, "'Milestone A' Costing: Joint Light Tactical Vehicle, Presentation for the U.S. Army Tank-Automotive Command (TACOM), slide 6, n.d.

[27] "JLTV Systems Engineering Plan Milestone A," November 21, 2007, p. 25.

[28] "The Army and Marine Corps have agreed on a new set of base requirements for the Joint Light Tactical Vehicle, including a heavier curb weight and relaxed transportability requirements, in what may be an effort to shield the program from lawmakers seeking to terminate it." Tony Bertuca, "Army and Marines Agree on Requirements Change for Embattled JLTV," *InsideDefense.com: Inside the Navy,* September 30, 2011.

[29] "JPALS Increment 1A Selected Acquisition Report," Defense Acquisition Management Information Retrieval (DAMIR), December 31, 2011, p. 4.

> JPALS, is separated into two phases: Increment 1A ship based systems and Increment 1B aircraft integration.[30]

The program's last major milestone awarded was Milestone B on July 14, 2008. Table 4.4 provides the major framing assumptions for the JPALS program.

The first major faming assumption examined is a technological one stating that incremental development will lower risk and COTS/GOTS hardware and software will lower costs. Incremental development and the use of COTS/GOTS are strategies that are frequently combined in acquisition of weapons systems. JPALS is using incremental development (i.e., an evolutionary acquisition approach) to lower risk.[31] Evolutionary acquisition is used in defense acquisition as a way to fulfill warfighter needs incrementally as technology matures. It also allows programs to put off fulfilling some of the requirements until cost and technology are better understood. In the case of JPALS, the current ACAT 1D encompasses all seven increments, but the program is primarily focusing on the Navy requirements of landing on a carrier in Increment 1. The program office has started preparing the technology for Increment 2.

The program is using an incremental acquisition strategy to manage both risks and costs. In addition, the program is leveraging COTS/GOTS hardware and software also as a cost savings tool. The program uses mature technologies: P(Y)-code GPS, anti-jam GPS, and military radios for data link.[32] According to GAO:

> JPALS is primarily a software development effort but also includes commercial hardware components. . . . The JPALS program began development in July 2008 with two critical technologies—the geometry extra redundant almost fixed solution and the vertical protection level/lateral protection level—nearing maturity. Program officials expect both critical technologies to be mature and demonstrated in a realistic environment by the JPALS production decision in

Table 4.4
JPALS Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Incremental development will lower risk, while COTS/GOTS hardware and software will lower costs	Navy is the best service to lead acquisition with the ordering of the increments driven by the Navy's more demanding requirements	System is suitable for a variety of air vehicles

[30] "JPALS Increment 1A Selected Acquisition Report," 2011, p. 4.

[31] JPALS Program Office, "Joint Precision Approach and Landing System (JPALS): Acquisition Strategy in Support of Milestone B for JPALS Increment 1A," Patuxent River, Md.: Naval Air Systems Command, June 2008, p. 2. Not available to the general public.

[32] Jeff Stevens and Brian Pierce, *Joint Precision Approach and Landing System (JPALS), Land-Based JPALS Technical Overview,* JPALS Program Office, AFCEA CNS/ATM 2011, June 15, 2011, p. 25.

> 2013. While JPALS utilizes existing commercial components for most of its hardware, its functionality will be enabled by over 700,000 lines of software code. The program plans to rely heavily on reused code with 77 percent of the program's total lines of code expected to be reused. If less software is reused than originally estimated, the potential consequences are longer development time and greater cost.[33]

In addition, the program is also using analogous manufacturing processes/costs, open architecture, and simple retrofitting of existing aircraft.

> JPALS will reduce the number of required navigation systems onboard aircraft carriers, cutting cost and weight, and freeing valuable avionics space. . . . JPALS will eliminate expensive legacy systems, yielding large infrastructure, operation, and support cost savings . . . JPALS simplicity and standardization will reduce pilot training requirements and will lower training costs.[34]

The second major framing assumption falls under the category of "management, incentives, and program structures." This assumption says that the Navy will be the best service to lead acquisition. On July 21, 2007, the Navy was designated as the lead service for the EMD phase.[35] The Navy took over from the Air Force, which led the program to Milestone B. The Navy's requirements for the sea-based system begin with Increment 1 and are refined in subsequent increments. The fact that the Navy has the first increment and has the more difficult technical problem makes the Navy's role as lead a natural fit. Other services play a critical role in the program for the other increments after Increment 1. Budgetary concerns have forced both the Air Force and the Army to take a serious look at their role in the system. Without the Air Force and Army involvement, this program would not achieve its goal of supporting "all Department of Defense (DoD) Land and Sea Based applications." See Figure 4.1 for an understanding of how the program is structured.

The final major framing assumption is that the system is suitable for all types of air vehicles. This is a critical framing assumption because if the program finds that integration of a variety of vehicles from the different services is harder than anticipated, then this will likely produce cost and schedule problems as was the case with the C-130 AMP program. According to an open source briefing by the JPALS program office, JPALS "aircraft system design flexibility [is] extremely important . . . [there is a] large

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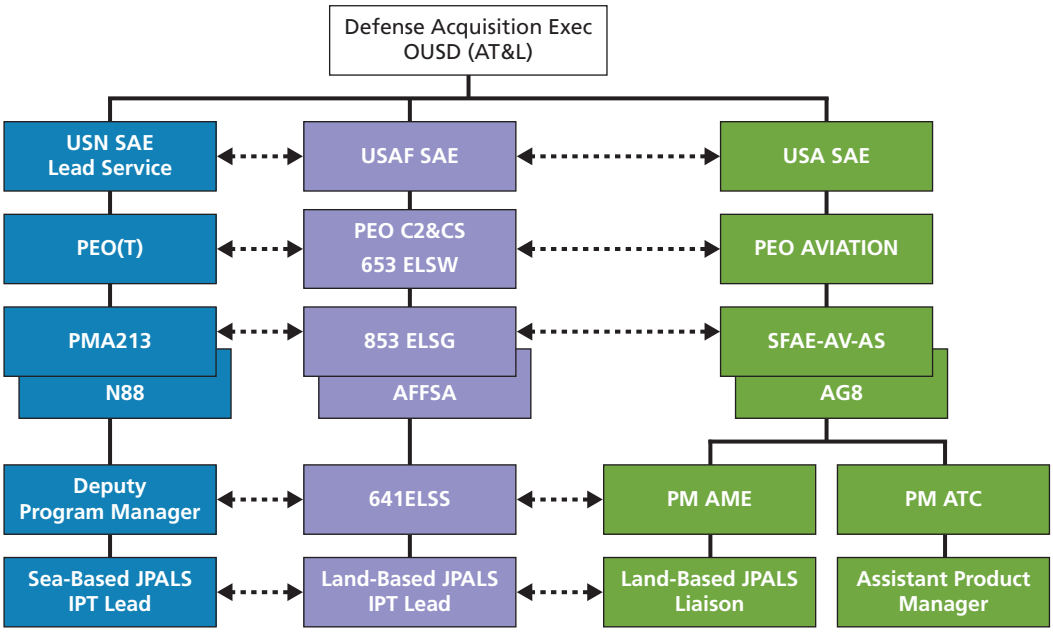
[33] U.S. Government Accountability Office, *Defense Acquisitions: Assessments of Selected Weapon Programs,* Washington, D.C., GAO-11-233SP, March 2011a, pp. 89–90.

[34] Defense Technical Information Center, "Defense Standardization Program Case Study: Joint Precision Approach and Landing System," date unknown.

[35] U.S. Department of Defense, "Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Air Force: JPALS," February 2011, p. 1.

Figure 4.1
JPALS Tri-Service Structure



SOURCE: Col Jimmie Schuman, Laura Dionne, Steele Kenyon, Chuck Churchward, Capt Michael Scales, Sandy Frey, Ben Brandt, Tin Ying, Jeff Stevens, and Tammy Place, "Joint Precision Approach and Landing System (JPALS): Land-Based JPALS Industry Day," JPALS Program Office, December 8–10, 2009, p. 11.
RAND *MG1171/4-4.1*

variation in aircraft architectures."[36] In addition, the JPALS program has also stressed the importance of worldwide and civil interoperability in defense budget documents:

> Because a cornerstone of the JPALS implementation strategy is worldwide and civil interoperability, JPALS must harmonize with U.S. and International Civil Global Navigation Satellite Systems. This is being accomplished through participation in the development testing, and implementation of international standards through the North American Treaty Organization (NATO) the International Civil Aviation Organization (ICAO). Interoperability of the JPALS ground systems with all military and civil aircraft is a key aspect of the planned system. Military aircraft must have worldwide access to civil and military airfields/air stations/operating locations in benign and hostile (jamming) environments. The JPALS Land-based Increment 2 system will provide a civil interoperable capability and also a military interoperable encrypted, jam-resistant capability.[37]

[36] Schuman et al., 2009, p. 27.

[37] U.S. Department of Defense, 2011, p. 1.

In addition to the above major framing assumptions it is also worth noting that JPALS relies heavily on GPS, so a minor assumption is that the GPS constellation will be robust. According to the JPALS program office, the program uses a differential GPS-based system that comprises ground systems and aircraft systems. The program also uses a JPALS-specific data link and existing GPS satellites.[38]

Littoral Combat Ship Modules

The LCS modules is a Navy mission systems program that is transitioning from pre-MDAP to MDAP status. This major acquisition program is a recent spinoff of the main LCS program that includes the ships. "LCS operates with focused-mission packages that deploy manned and unmanned vehicles to execute a variety of missions, including littoral anti-submarine warfare (ASW), surface warfare (SUW), and mine countermeasures (MCM)."[39] The mission modules are being acquired using an evolutionary acquisition strategy, and the LCS program office is incrementally adding mature mission systems.[40] The mission modules will also be flexible and scalable. The program office has chosen to use open architecture, which may enable rapid insertion of new technologies. The program's last milestone awarded was Milestone A on May 27, 2004, and underwent a Milestone A update in FY2009 as part of the Littoral Combat Systems program.

The LCS mission modules program has a longer list of framing assumptions than other programs (see Table 4.5). We chose the major assumptions to discuss first. The first major framing assumption is a technological one, which says that the sea frames and modules can be independently developed. "Mission package procurement and delivery are aligned with the ship delivery schedule, mission area demand signal from the combatant commanders, and the retirement of legacy platforms. This means that 64 interchangeable mission packages will be available for use among the 55 ships of the LCS class to support global warfighting and peacetime presence requirements."[41] If the schedules between the two coincide and neither gets behind schedule, then this strategy can succeed.

This main framing assumption has some relevant subordinate points. First, the program is using spiral or incremental development that will lower risk and possibly costs. "An incremental development approach to delivering capability allows the continued insertion of mature capabilities throughout the life of the program without the need for modifications to the sea frames. Future mission package increments will be considered when joint warfighting objectives or changing threats create new opera-

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[38] Schuman et al., 2009, p. 10.

[39] U.S. Department of Defense, "Exhibit R-2, Exhibit R-2A, RDT&E Project Justification: PB 2013 Navy: LCS Mission Package Development," February 2012, p. 39.

[40] U.S. Department of Defense, 2012, p. 29.

[41] U.S. Department of Defense, 2012, p. 15.

Table 4.5
LCS Modules Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Sea frames and modules can be independently developed: Spiral/incremental development will lower program risk Ability to successfully test modules on other ship platforms New capabilities can be easily added to meet future needs	A new, open business model approach will allow for independent development of sea frames and modules: The Navy can leverage PARMs and other programs to field a capability Open architecture/commercial practices will facilitate development and rapid updates The government is suited to act as system integrator RDA can be the program focal point (4 PMs, 3 PEOs, 2 SYSCOMS) for the program	The Navy will be willing to drop requirements (in a spiral development context) to keep to schedule

tional capability requirements that cannot be met by current mission package designs, or when new technological opportunities allow significant progress toward delivering cost effective, enhanced capabilities. Future mission module increments can be tested, constructed, and incorporated into existing mission packages, one of the most important benefits of LCS modular design."[42] In addition, this incremental development strategy will allow new capabilities to be added easily, which is another minor assumption. Also, the program is relying on its ability to test modules successfully on other ship platforms. This assumption is important, because if ships are not available for testing because of operational constraints, then this may delay testing and overall schedule.

The second major framing assumption falls under the management, incentives, and program structures category. For the LCS mission modules program, a new, open business model approach allows for independent development of sea frames and modules. According to PEO LCS: "Naval Open Architecture . . . Increases opportunities for innovation . . . Facilitates rapid technology insertion . . . [and] Reduces maintenance constraints."[43] The use of an open business model also allows for better management of technical data management, which is a key to reusing technical data for the

[42] U.S. Department of Defense, 2012, p. 15.

[43] Megan Cramer, "Program Executive Office Littoral Combat Ships (PEO LCS) Science and Technology Overview," PEO LCS, August 31, 2011, p. 18.

program.[44] In the case of the LCS program, this concept will be successful as long as the time lines for development of both do not significantly divert.

There are several other points to make regarding this framing assumption. First, the program will successfully leverage PARMs and other programs. "The modules leverage considerable amounts of technology from existing POR [programs of record]."[45] Also, the "Warfare Centers are able to rapidly mature prototype concepts and support transition to production via existing contract vehicles."[46] By using Navy resources outside Program Manager, Ship (PMS) 420, the Navy believes it will be able to handle the lead system integrator duties more effectively. See Figure 4.2 for the various Navy PARMs involved in the LCS mission modules program.

In addition, the Navy will benefit from using open architecture and commercial practices. For example, the Navy is implementing commonality across disperse product lines as a way to reduce both cost and schedule.[47] The Navy will also motivate the Navy labs to design toward producible designs as a way to minimize redesign.[48] This program also assumes that the government is suited to act as system integrator. In this program, PMS 420's acquisition approach relies heavily on using the Navy Warfare Centers as lead system integrators (LSIs).[49] "Using the Warfare Centers as LSIs gives the freedom to implement commonality without multiple contract modifications." [50] Finally, the ASN(RDA) will successfully be the program focal point, since there are four PMs, three PEOs, and two SYSCOMS involved in managing portions of the program. Effective July 11, 2011, the offices that manage the sea frame and mission module programs were combined under PEO LCS—largely simplifying this issue. Before this reorganization, the ASN (RDA) established the LCS program office on February 1, 2002. On March 17, 2003, PEO (Ships) was given overall responsibility for program management, PEO (LMW) for mission modules, and PEO (IWS) for warfare system development and integration. In addition, on May 5, 2011, the ASN (RDA) directed the formation of PEO LCS, which included the following six offices:

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[44] Robin Kime and Wayne Gafford, "LCS Mission Modules Program: Training Strategy Increasing Modularity for Maximum Adaptability; Brief for Implementation Fest 2010," PEO LMW and PMS 420, August 10, 2010, p. 3.

[45] Lance Harper, Art Van Nostrand, Mike Pennock, and William Algoso, "System of Systems Technology Analysis and Selection Methodology 2010 NDIA Systems Engineering Conference," Northrop Grumman, October 28, 2010, p. 6.

[46] Cecil Whitfield, Richard Volkert, and Carly Jackson, "Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development 13th Annual NDIA Systems Engineering Conference, PMS 420 LCS Mission Modules, October 27, 2010, p. 8.

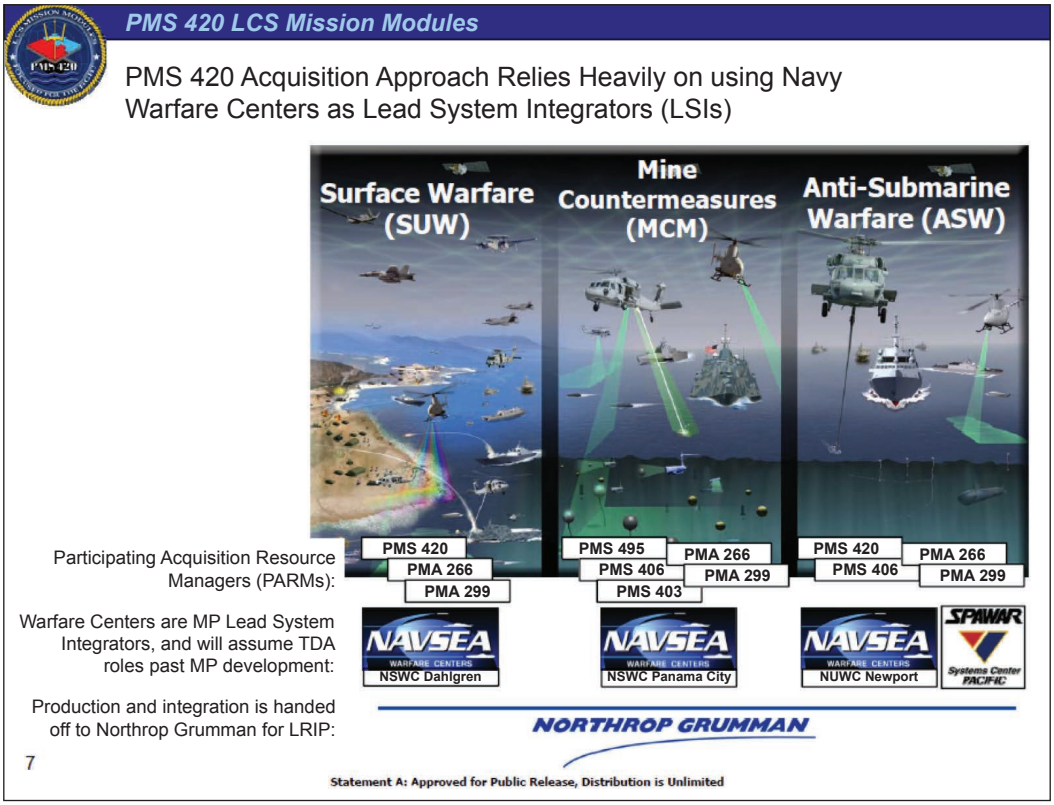
[47] Whitfield, Volkert, and Jackson, 2010, p. 17.

[48] Whitfield, Volkert, and Jackson, 2010, p. 17.

[49] Whitfield, Volkert, and Jackson, 2010, p. 7.

[50] Whitfield, Volkert, and Jackson, 2010, p. 11.

Figure 4.2
PMS 420's Use of Lead System Integrators and Other Navy PARMs



SOURCE: Whitfield, Volkert, and Jackson, 2010, p. 7.
RAND *MG1171/4-4.2*

- LCS program (PMS 501)
- LCS mission modules (PMS 420)
- remote minehunting system (PMS 403)
- unmanned maritime systems (PMS 406)
- mine warfare (PMS 495)
- fleet introduction (PMS 505).[51]

This framing assumption is a critical one, because so many parties are involved in the management of the LCS system. Without proper communication among the various pieces of the program, this framing assumption could be problematic.

[51] RDML Jim Murdoch, USN, *Expeditionary Warfare Systems Acquisition Challenges,* Washington, D.C.: U.S. Navy, PEO LCS, October 26, 2011, p. 4.

The third major framing assumption is the willingness of the Navy to drop requirements (in spiral context) to keep to schedule. The mission modules program set a goal of to "implement effective requirements management and drive towards commonality early in the design process."[52] This is being done through the establishment of a cross organization requirements database. Also, staying on schedule is important in this program's acquisition strategy, because the sea frame and modules are being independently developed, yet the modules must be available when needed.

The LCS mission modules program had two other secondary assumptions that are important to note but would not be considered the primary framing assumptions for the program. However, both secondary assumptions relate to the decoupling of the mission modules from the sea frames. The first of these secondary assumptions is that any organizational-, intermediate-, and depot-level maintenance will be done successfully at a common facility, i.e., "a hub for all in-service mission modules." Thus, maintenance of the modules is independent of the ship's maintenance and not done at a traditional ship maintenance facility. The objectives of this facility include the following:

- Provide distance support for deployed mission modules.
- Configure certified deployable assets.
- Troubleshoot and repair.
- Conduct system operability tests.
- Conduct inventory management/visibility.
- Validate ready-for-use status of the mission package (MP).
- Perform packaging, handling, storage, and transportation.
- Ensure material shelf life.
- Ensure that authorized spares are onboard.
- Replenish spares and consumables.
- Expedite parts requests as required.
- Arrange transportation of mission modules.
- Arrange embark and debark services.[53]

The use of a common facility can be advantageous if the mission modules can be rotated so that there are no operational deficiencies. Also, as long as minor maintenance can be done offsite, then this would not require mission modules to be transported from all over the world to this facility.

The other secondary assumption is that the mission modules will be funded with a different account—Other Procurement, Navy—rather than using Shipbuilding and Conversion, Navy. This different funding approach for the modules formally discon-

[52] Whitfield, Volkert, and Jackson, 2010, p. 17.

[53] Kime and Gafford, 2010, p. 8.

nects the deliveries and quantities of modules with that for the ships. It also implicitly declares that a module is not an inherent part of the sea frame.

Space Fence

Space Fence is an Air Force, pre-MDAP acquisition program that seeks to provide a radar system to replace the Air Force Space Surveillance System Very High Frequency (AFSSS VHF) Fence radar that currently detects orbiting space objects. Its S-band radar will have modern, net-centric architecture that is able to detect much smaller objects in low earth orbit and medium earth orbit with greater accuracy and timeliness to meet warfighter requirements for space situational awareness (SSA). Two radar sites are to be built outside the continental United States.

Despite identified technological risks of "defining software requirements" and "identify interoperability and integrated architectures," the Space Fence acquisition strategy determined "that the U.S. technology and industrial base is more than adequate to develop, produce, maintain, and support the system" for SSA at a far greater magnitude of objects than attempted before.[54] Two framing assumptions are embedded here (see Table 4.6). The first is that the operational capability can be achieved (successfully) despite having some immature technologies. The second is that one can scale the technology to track an order of magnitude greater number of objects that is currently done. In addition to assumptions about technological feasibility, the program also assumes that competitive prototyping will reduce the risk and cost as well as be representative of the final integration challenge. Lockheed Martin and Raytheon were each tasked to create a Space Fence preliminary design with prototype designs with a Technology Readiness Level 6, and all five critical technologies identified by the program office were considered "immature" at the initial stages.[55] Although the risks of

Table 4.6
Space Fence Framing Assumptions

Technological	Management, Incentives, and Program Structures	Mission Requirements
Capability is achievable despite some immature technologies at the outset	A block approach is a more effective acquisition strategy	Minimal manpower will be required to operate and support the system
Can scale technology to track an order of magnitude greater number of objects (radar components, software interoperability)	Legal, diplomatic, and political issues with site decisions can be resolved easily and will not delay the program	Two instead of three sites will be sufficient to meet operational needs
Competitive prototyping will reduce risk and cost		

[54] "Acquisition Strategy for the Space Fence Program," Space Control Sensors Division, January 5, 2009.

[55] U.S. Government Accountability Office, *DOD Faces Challenges in Fully Realizing Benefits of Satellite Acquisition Improvements,* Washington, D.C.: Government Accountability Office, GAO-12-563T, March 21, 2012.

final integration and scalability challenge after the prototype selection are understood, "there are no major concerns in dealing with these issues in the future," according to the program manager.[56]

Under the management, incentives, and program structures framing assumptions, it was assumed that "the block approach will deliver Space Fence capabilities that follow the principles of time-certain capability/development and consider user needs and required delivery dates, technology maturity, program risk, and fiscal constraints."[57] In addition to the acquisition plan, although program managers were aware that "legal, diplomatic, and political considerations could impact site decisions," it appears that assumptions concerning the ease and implications of obtaining host nation agreements for the radar sites, because of the unknowns at the time, framed costing and scheduling estimations.[58]

Another important assumption (although not a framing assumption because it is not unique) was that the Air Force could overcome the problems it had on recent space program acquisitions through the "Acquisition Improvement Plan":

> The Secretary of the Air Force and Chief of Staff of the Air Force issued the *Acquisition Improvement Plan* to recapture acquisition excellence by rebuilding an Air Force acquisition culture that delivers products and services as promised—on time, within budget, and in compliance with all laws, policies, and regulations. The plan consists of five initiatives: (1) revitalize the Air Force acquisition workforce, (2) improve the requirements generation process, (3) instill budget and financial discipline, (4) improve major Air Force systems source selections, and (5) establish clear lines of authority and accountability within acquisition organizations.[59]

In terms of longer-term sustainment, the total SSA family of systems, of which Space Fence is a component, is assumed able to help the Joint Space Operations Center, "do its job without a huge increase in personnel."[60] In addition to a minimal need of manpower to operate and support the system, the Space Fence program assumed that its mission would require "the capability to process satellite numbers up to seven digits" as the number of objects in space from civil, military, and commercial use will

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[56] Telephone interview with Linda Haines, Space Fence Program Manager, June 2, 2011; Titus Ledbetter III, "Air Force Confident Space Fence Contractors Will Resolve Program Risks," *InsideDefense.com: Inside the Air Force*, June 2, 2011.

[57] "Space Fence Acquisition Strategy," February 23, 2009.

[58] Air Force Space Command, "Enabling Concept for the Space Fence," August 4, 2008, p. 6.

[59] Cristina T. Chaplain, *Space Acquisitions: DOD Delivering New Generations of Satellites, but Space System Acquisition Challenges Remain*, Washington, D.C.: U.S. Government Accountability Office, GAO 11-590T, May 11, 2011.

[60] As stated by the Air Force's top intelligence, surveillance, and reconnaissance official at the time, Lt. Gen. David Deptula. Jason Simpson, "Payton: New Missions System Will Mitigate SSA Information Overload," *InsideDefense.com: Inside the Air Force*, November 6, 2009.

continue to grow.[61] The final framing assumption concerns the number of radar sites. The Space Fence Enabling Concept Plan[62] stated that, "The Space Fence will consist of three radars globally dispersed [one in Continental United States (CONUS) and two outside of the Continental United States (OCONUS)] to ensure the most effective combined [Space Surveillance Network] coverage." More recent documents describe the scope as only two sites.[63] A GAO report suggests that the third site might be dropped for cost-effectiveness reasons.[64]

Framing Assumptions Based on Prior RAND Root Cause Analyses

RAND has conducted a number of RCAs on programs that have breached Nunn-McCurdy thresholds.[65] We abstracted a number of framing assumptions that those reports identify and organized them into our three categories (as shown in Table 4.7).

Table 4.7
Framing Assumptions from Prior RCAs

Technical	Management/Program Structures	Mission Requirements
Reliance on commercial technology increases likelihood of achieving technical program goals (P-8A, WGS, ERP) Successful subsystem testing predicts overall technical program success (JSF, Excalibur, AB3, DDG-1000). Simulations can substitute for or reduce full-scale testing (JTRS, JSF) New testing/manufacturing approaches can reduce historic number of test articles (JTRS, JSF, P-8A)	Reliance on commercial initiative/ standards insulates the program from risk (P-8A, WGS, ERP) Threats to program funding are an incentive to manage program risk (ERP, DDG-1000, JSF) Management changes do not detract from program outlook (JTRS, JSF) Program subcomponent/ integration risks not a geometric risk function (JSF, AB3, DDG-1000, JTRS, Excalibur)	Low possibility for emergence of a substitute good (JTRS) Constancy with joint capability requirements (JSF) Reliance on commercial technology shields program from risk and allows program to adapt quicker to changing operational requirements (P-8A)

SOURCES: Blickstein et al., 2011, 2012, and Irv Blickstein, Chelsa Kahoi Duran, Daniel Gonzales, Jennifer Lamping Lewis, Charles Nemfakos, Jessie Riposo, Rena Rudavsky, Jerry M. Sollinger, and Daniel Tremblay, *Root Cause Analyses of Nunn-McCurdy Breaches Volume 3, Joint Tactical Radio System, P-8A Poseidon, and Global Hawk Modifications,* Santa Monica, Calif.: RAND Corporation, MG-1171/3, 2013. Not available to the general public.

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61 Air Force Space Command, 2008, p. 6.

62 Air Force Space Command, 2008.

63 "Space Fence Contractors Complete PDRs, Praise USAF Review Process," *Inside the Air Force,* March 9, 2012.

64 U.S. Government Accountability Office, *Space Acquisitions: Developing and Oversight Challenges in Delivering Improved Space Situational Awareness Capabilities,* GAO-11-545, May 2011b.

65 See Blickstein et al., 2011, 2012, and 2013.

It is important to recognize that those reports are focused on why the programs had cost and schedule problems. So, their emphasis is on what went wrong. The framing assumptions identified are ones that turned out to be incorrect or invalid. We did not do a comprehensive literature review for these programs.

Observations

In this chapter, we have explored the definition and application of framing assumptions to defense acquisition planning. Framing assumptions have the following characteristics:

- They drive multiple program consequences (with respect to cost, schedule performance).
- They are specific to the nature of the program effort.

We also found it practical to define and review framing assumptions, even early in a program's life cycle. We were able to establish framing assumptions for all the programs despite having limited access to program information. There are some useful observations in using framing assumptions in a risk management role:

- The assumptions should be kept at a high level and not focus on minutiae to be more useful as a management tool. About three to five is a good number to track for most programs. However, complicated programs or those with a rich history may become challenging to reduce to a few key assumptions, as the importance of the assumptions is difficult to know ahead of time.
- As a program moves through the acquisition process, framing assumptions may change or new ones emerge. Therefore, it is necessary to review and update framing assumptions periodically.
- For programs early in the process, it is relatively easy to identify a narrow set of explicit assumptions. However, it is difficult to uncover implicit ones. For mature programs, it is more complicated to identify a core set of framing assumptions because of the wealth of, and potentially conflicting, information.
- It is easier to recognize after-the-fact failed assumptions than it is to recognize good ones.

How successful the use of framing assumptions can be in managing risk remains to be seen. A potentially useful extension of this work would be to examine framing assumptions on a broader range of programs to see if particular assumptions are problematic. Overall, this analysis suggests that framing assumptions are a potentially useful tool for tracking risks and that early identification of them in programs could be an important part of risk mitigation.

CHAPTER FIVE

Conclusions

PM Tenure

It is difficult to assess whether policies implemented to foster longer tenures have been successful judging by previous data and studies and current data. Given that the same themes have reoccurred in policies over the past 40 years, the intent of these policies may not have been achieved. Furthermore, an enforcement mechanism has not been readily apparent over time. A fundamental conflict exists between what military officers need to do to be promoted and their tenure as PMs. Unless these two objectives are connected so that lengthy tenure in a program can be advantageous for promotion, it is unlikely that these tenure policies will consistently yield positive results.

PMs who started in 2006 or 2007 had about the same probability of remaining in their position for at least two years but a greater probability of staying for three or more years than PMs who started in 2005 or earlier. PMs starting in 2008 or later had about an 87 percent chance of remaining in their positions for two or more years and about a 50 percent chance of remaining for three or more years, suggesting an increase in PM tenure after the second policy change.

By taking into account closed PM tenure periods, we found that PM tenure averages 33 months. This result is much higher than the GAO's 2007 figure of 17.2 months (based on a sample of 39 programs). However, our figure reflects a larger set of programs covering more years and does not include any open periods.

In conclusion, our analysis was able to quantify PM tenure using current data but could not definitely say whether recent policies regarding PM tenure have had any positive effect on lengthening tenure over the past several years, because there were still too many open tenure periods at the time of data collection.

ACAT II Oversight

Our analysis suggests that ACAT II programs perform about as well as MDAPs overall. Once they have entered into production, programs perform reasonably effectively, with some instability in unit cost and annual quantity procured but few instances of rapid,

long-term cost growth or significant slippage in schedule. In both cases, cost growth and instability in quantity procured are associated with modernizations, contingency operations, and accelerated time lines but tend to be limited in size and often duration.

As to whether the PARCA office should issue guidance for ACAT II programs, we recommend that it not do so at this time. The performance of the programs indicates that they are doing reasonably well, and any new reporting requirements would place additional burdens on programs that already have much to do. Absent a clear need for such guidance, the PARCA office should not impose additional requirements but should continue to monitor programs to ensure that performance continues to be acceptable.

Framing Assumptions

Our research in this area explores the question of whether identifying framing assumptions can help with risk identification and amelioration. At issue is whether such assumptions could be reasonably identified in acquisition programs. We defined a framing assumption as any explicit or implicit assumption that is central in shaping cost, schedule, or performance expectations and identified key characteristics.

- They drive multiple program consequences (with respect to cost, schedule performance).
- They are specific to the nature of the program effort.

Armed with this definition and characteristics, we found that it is practical to define and review framing assumptions, even early in a program's life cycle. We were able to establish framing assumptions for all the programs despite having limited access to program information. Some useful observations in using framing assumptions in a risk management role are as follows:

- Assumptions should be kept at a high level and not focus on minutiae to be more useful as a management tool. About three to five is a good number to track for most programs. However, complicated programs or those with a rich history may become challenging to reduce to a few key assumptions.
- As a program moves through the acquisition process, framing assumptions may change or new ones emerge. Therefore, it is necessary to review and update framing assumptions periodically.
- For programs early in the process, it is relatively easy to identify a narrow set of explicit assumptions. However, it is difficult to uncover implicit ones. For mature programs, it is more complicated to identify a core set of framing assumptions because of the wealth of, and potentially conflicting, information.

- It is easier to recognize after-the-fact failed assumptions than it is to recognize good ones.

How successful the use of framing assumptions can be in managing risk remains to be seen. A potentially useful extension of this work would be to examine framing assumptions in a broader range of programs to see if particular assumptions are problematic.

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