INSTITUTE FOR DEFENSE ANALYSES

Acquisition Policy, Cost Growth, and Cancellations of Major Defense Acquisition Programs

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Executive Summary

Introduction

The Department of Defense (DoD) acquisition enterprise as a whole buys several million different products. Some items (weapon systems, automated information systems) require large development efforts before there is an end item to buy, while other items are in effect bought from a catalog and shipped directly to a DoD organization (e.g., a hospital) or to a DoD supply depot.

This study is concerned only with major defense acquisition programs (MDAPs). It is further confined to "acquisition costs," which is a term of art defined as the sum of Research, Development, Test and Evaluation (RDT&E) funding and procurement funding (that is, the cost of buying the system once it has been developed). Procurement cost is typically (although not invariably) on the order of five times RDT&E cost. As a rough rule of thumb, acquisition cost for the portfolio of MDAPs in development or procurement at a point in time ranges from 10 percent to 20 percent of total DoD funding.

The main question asked is whether changes in DoD acquisition policies and oversight processes over the period fiscal year (FY) 1964–FY 2009 significantly altered cost growth on MDAPs and the proportion of MDAPs cancelled. Cost growth and cancellations are singled out for examination because they often have been used in public and congressional discussions as tests of the success (or lack thereof) of DoD acquisition of major systems. They are not uniquely important, however. Within the context of an individual program, system performance usually, and schedule, in some cases, are more important than cost growth and on a comprehensive view, management of MDAPs is only one aspect of a much larger set of challenges presented by the DoD acquisition enterprise.

Several comparatively recent quantitative studies have considered whether changes in DoD acquisition policy had a statistically discernible effect on the cost growth of MDAPs. None of these studies found that changes in acquisition policy since the early 1970s have resulted in decreased cost growth on MDAPs. This is a striking result given the common perception that there were many changes in DoD acquisition policy during the 1980s and 1990s.

None of these studies compared cost growth of MDAPs initiated during the 1960s with cost growth of MDAPs initiated during the 1970s. This point is more important than may be readily apparent. Then-Deputy Secretary of Defense David Packard made basic changes in the Office of the Secretary of Defense (OSD)-level MDAP oversight policy and process in July of 1969. These reforms remained in place, and in some important respects had been strengthened, beyond the last year of the period covered by this study (FY 2009). If the 1969 Packard reforms were successful in reducing cost growth in the early 1970s, there is good reason to believe that they would still have this effect through the late 2000s and beyond.

The evidence in the literature on whether the 1969 Packard reforms did reduce cost growth is mixed. In a report published in 1979, Dews et al. found that the Packard reforms had reduced growth in unit cost.[1] A qualitative examination of the data published the following year by Asher and Maggelet reached the opposite conclusion.[2] Drezner et al. (1993) argued that the evidence that the 1969 Packard reforms resulted in lower cost growth disappeared when account was taken of program duration.[3] Tyson et al. (1992), however, found statistical evidence that some particular features of the 1969 Packard reforms had reduced cost growth.[4]

The quantitative literature moved on from here without resolving the issue. Because it presents a pivotal question and because the topic remains relevant, this study undertook a fresh and comprehensive analysis of the extent to which changes in acquisition policy over the period FY 1965–FY 2009 influenced MDAP cost growth and cancellations.

Although all readers are welcome and most of the report can profitably be read by those with little knowledge of statistics, it is directed to producers of analyses of DoD acquisition policy and to those weighing changes in acquisition policy. The report assumes that the reader is generally familiar with the DoD acquisition process and also has some understanding of the Planning, Programming, Budgeting, and Execution System (PPBES). Those who do not have a background in this field may wish to consult the references provided[5] and perhaps start this report by reading Chapters 5 and 6.

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1 E. Dews et al., *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s*, R-2516-DR&E (Santa Monica, CA: The RAND Corporation, 1979).

2 Norman J. Asher and Theodore F. Maggelet, "On Estimating the Cost Growth of Weapon Systems," IDA Paper P-1494 (Alexandria, VA. Institute for Defense Analyses, June 1980, revised September 1984).

3 J. A. Drezner et al., *An Analysis of Weapon System Cost Growth*, MR-291-AF (Santa Monica, CA: The RAND Corporation, 1993), 30.

4 Karen W. Tyson et al., "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs, Vol. I: Main Report," IDA Paper P-2722 (Alexandria, VA: Institute for Defense Analyses, November 1992).

5 Chapter 1 of J. Ronald Fox, *Defense Acquisition Reform, 1969 to 2009: An Elusive Goal* (Washington, DC: US Army Center of Military History, 2011) is a primer on the DoD acquisition process circa 2008. A description of the PPBES of the same period is provided by Chapter 5 of L. R. Jones and Jerry L. McCaffery, *Budgeting, Financial Management, and Acquisition Reform in the U.S. Department of Defense* (Charlotte, NC: Information Age Publishing, 2008).

Statistical Analysis

Like most other statistical studies of cost growth, this study uses “quantity adjusted” Program Acquisition Unit Cost (PAUC). PAUC is acquisition cost (the sum of RDT&E and procurement costs) divided by the number of fully configured units acquired. We measure PAUC growth from the start of Engineering and Manufacturing Development (EMD) through the completion of purchases of the system. Authority to begin EMD is granted at what has since FY 2000 been called Milestone (MS) B. PAUC growth is computed by comparing the MS B baseline value of PAUC—which can be thought of as a goal or a prediction—to the actual PAUC reported in the final Selected Acquisition Report (SAR) for the program. Both the MS B baseline and the final value of PAUC are stated in program base year dollars. The actual value is restated on the basis of the MS B baseline quantity by moving up or down the cost progress curve as is appropriate. The ratio of the MS B baseline value of PAUC to the quantity adjusted actual value is an estimate of what PAUC growth would have been had the MS B baseline quantity been acquired.

The report’s statistical analysis is about the clustering of PAUC growth: Do MDAPs with high cost growth cluster in an intelligible way with changes in acquisition policy? The nature of this approach is conveyed by a simple analogy. One part of the epidemiology of malaria involves the study of the way certain species of mosquitoes acquire the parasite Plasmodium, which causes malaria, and transmit it to humans. Another branch of the field studies the conditions that tend to increase (or limit) the populations of the relevant types of mosquitoes. This report is of the latter sort. It uses “before and after” comparisons involving changes in acquisition policy and process to study clustering of PAUC growth and MDAP cancellations.

The statistical analysis primarily uses four factors to identify and understand clustering of PAUC growth and cancellations:

- Acquisition policy and process
- Intensity of competition for funding (referred to as funding climate) in the months before MS B
- Program duration
- Post-MS B funding climate

Consideration of the first of these is required by the question asked: Have changes in acquisition policy and process had statistically discernible effects on MDAP outcomes? The intensity of competition for funds is generally understood to influence how realistic MS B baselines are and, in that way, PAUC growth. Program duration is associated with cost growth via stretches, “requirements creep,” and problems with measuring inflation, among others. Post-MS B funding climate suggests the possibility that costs grow when they can—that is, in a boom climate—and recognizes that in a bust climate what would otherwise be cost growth appears as performance shortfalls.

The results obtained are both extraordinarily strong in statistical terms and unequivocal. Normalizing for funding climate and program duration, the 1969 Packard reforms are associated with significantly lower PAUC growth. This was not achieved, as most would assume, by across-the-board reductions in PAUC growth. Instead, average PAUC growth fell because the proportion of MDAPs with very high cost growth significantly declined. This reduction and the resulting reduction in average PAUC growth persisted through the end of the period covered by this study and beyond. Additional changes in acquisition policy during the years FY 1980–FY 2009, however, were not associated with any further statistically significant reductions in the proportion of extremely high cost growth programs or of PAUC growth.

Five of the MDAPs for which we have a PAUC growth estimate and that passed MS B during the late 1990s experienced very high PAUC growth. While four of these had not been completed by the end of FY 2016 and therefore are not included in the statistical analysis, they do present a challenge to the conclusion that the 1969 Packard reforms resulted in a permanent reduction in the proportion of very high PAUC growth programs. The explanation may be that the high PAUC growth on these programs is due to specific initiatives on contract type that proved to be unsuccessful, rather than to broader changes in acquisition policy or process.

Historical Analyses—Net Assessment

The issue taken up in Chapters 5 through 7 is whether we can plausibly connect what we see in the statistical analysis with what we see in the historical record. To begin: Are we entitled to conclude that the 1969 Packard reforms caused the subsequent decline in average PAUC growth?

The first OSD process for overseeing MDAPs initiated at the Service level was instituted by Robert McNamara in February 1964 through DoD Directive (DoDD) 3200.9, Project Definition Phase. The DoDD 3200.9 process had three central features:

- Milestones beyond which an MDAP is not to proceed without the approval of the Secretary of Defense.
- A review of the program at milestones by OSD staff elements on the basis of information the program submitted.
- A decision by the Secretary of Defense, informed by staff reviews of information provided by the Service, to allow the program to proceed, perhaps with modifications, or to delay it.

Versions of these three features remained the foundation of the OSD-level acquisition process throughout the period covered by this study and beyond.

The process initially had only a single milestone. A second milestone was added by a revision of DoDD 3200.9 issued in July 1965. The distinctive features of the definitions of the milestones stemmed from McNamara's policy that Total Package Procurement (TPP) be used in all cases in which it was practicable to do so. A TPP contract covered EMD, procurement, and usually some aspects of operations and maintenance, each on a fixed price (FP) basis. These contracts were awarded after a competition.

Packard ruled out the use of TPP and discouraged the use of FP contracts for development. This change undercut the rationale for the DoDD 3200.9 milestone structure. The new milestone definitions adopted by Packard stemmed from his policy of "fly before you buy." That policy was the rationale for the introduction of a new acquisition phase, then called Demonstrational and Validation (now Technology Development). The intent was to ensure that critical technologies to be used in the program had been adequately matured by the point at which it was authorized to begin EMD.

Packard's change in policy on contract types alone accounts for a substantial part of the reduction in PAUC growth. There is more to the story than that, however, because the Packard reforms are associated with a dramatic reduction in the frequency of high PAUC growth programs, which persisted over the four decades after 1969.

Did this reduction occur because the post-Packard process was better at establishing a minimum standard of realism in MS B baselines? Two features of the Packard reforms together plausibly had this result. First, and probably most important, Packard's "fly before you buy" policy required a more extensive risk reduction phase prior to entry into EMD. Second, the OSD-level process introduced by Packard was more fully specified than that of the McNamara-Clifford period, possibly more rigorous, and probably better accepted by the Services because of the care Packard took to coordinate it with them.

Another statistical result subjected to historical analysis is the absence of an association between PAUC growth and changes in acquisition policy post Packard. This needs to be done because there were many dozen, possibly hundreds, of changes in acquisition policy over this period and some of these seemed major enough to move PAUC growth.

Four screens were used to reduce the number of changes in acquisition policy to manageable proportions:

- Many of the changes in acquisition policy can be dismissed because they were simply name changes or were clearly trivial changes in wording, and other dismissed because they were only briefly in effect.

- The study is concerned with the subset of policies and processes that directly influence PAUC growth.
- A large portion of the changes made through the Acquisition Reform effort of the Clinton Administration were concerned with DoD access to commercial technologies and the defense industrial base, not PAUC growth.
- Policy initiatives on contract types and relaxation of acquisition regulations during the 1980s and 1990s were identified and their association with PAUC growth examined.

Once full account is taken of these factors, a remarkable conclusion appears: The policies and process installed by Packard in 1969 remained essentially intact, and in fact in some respects were strengthened, over the period covered by this study. Consequently, the statistical result is what would be expected.

Implications for Categories of Cost Changes

This is not a satisfactory place to conclude the discussion because it leaves a considerable amount of cost growth unexamined. Average PAUC growth during the McNamara-Clifford years was about 74 percent. Ignoring the effect of program duration, the Packard reforms cut that in half to 37 percent, which also was the average for bust years FY 1987–FY 2002. This is considerable cost growth, and 12 of the 45 MDAPs that passed MS B during that period eventually had PAUC growth of more than 50 percent. The question then needs to be asked: What does this report's analysis have to say about this "ordinary"—that is, less than extremely high—portion of cost growth?

The association between the funding climate that prevailed when an MDAP received MS B authority and PAUC growth (excluding very high cost growth programs) suggests that ordinary cost growth also is mainly caused by unrealistic elements in the baselines adopted at MS B. This conclusion in fact seems easy since most would assume that the competition for funding is more intense in bust than in boom periods and that the more intense competition for funds sharply increases the incentive to embed unrealistic assumptions in the program baseline adopted at MS B.

In fact, the relevant statistical facts are not so straightforward. Some programs that passed MS B in a bust climate were completed within that climate while others continued forward into a boom period. The former set of programs have comparatively low PAUC growth, not much above that of programs that passed MS B in boom periods. The latter have significantly higher PAUC growth and account for most of the cost growth of programs that passed MS B in bust climates. So it is not just the funding climate at MS B (when the baseline is set) that is relevant to PAUC growth but also entry into a boom climate post MS B.

Many programs that passed MS B in a bust climate and then eventually entered a boom period presumably did have unrealistic baselines. For these programs the boom period offered a chance to "get well;" that is, the availability of additional funding turned what otherwise would have been performance shortfalls into PAUC growth. Another possibility is that many programs that pass MS B in bust climates were relatively austere when approved but their scope expanded when the program subsequently entered a boom climate.

The only data we have on this issue for a substantial number of programs are those collected by the OSD Office of Program Analysis and Evaluation (PA&E) over a 20-year period starting in 1989. (The successor to PA&E is the Office of Cost Assessment and Program Evaluation, CAPE.) PA&E created a database that separated cost growth due to program changes from cost growth due to what PA&E called "mistakes." The first of these categories is defined as the cost growth attributable to decisions to acquire more (or less) capability than that specified in the MS B baseline. As defined by PA&E, "mistakes" was composed of three parts: (1) cost growth due to unrealistic aspects of the MS B baselines; (2) cost growth from problems that arose post MS B (e.g., management lapses); and (3) the costs of adjustments due to events external to the program.

The database used in this study includes a PAUC growth estimate for 45 MDAPs that passed MS B during the long post-Cold War bust climate (FY 1987–FY 2002) and were completed by the end of FY 2016. As was noted above, average quantity normalized PAUC growth from the MS B baseline for these 45 programs was 37 percent. The PA&E data suggest that about one-third of the total—about 12 percentage points—was cost growth due to program changes. The remaining two-thirds—roughly 25 percentage points—was due to mistakes. Cost growth due to program changes does not have the same significance as cost growth due to mistakes. First, as a broad generality, decisions to upgrade an MDAP rather than undertake a new start have been consistent with acquisition policy since at least 1981, initially under the heading Preplanned Product Improvements and then from the mid-1990s as Evolutionary Acquisition. Second, program changes are a matter of DoD paying more for capability beyond that in the MS B baseline, while cost growth due to mistakes is a matter of paying more for the MS B capability, or possibly even less than the MS B capability. Cost growth due to program changes should not be on the rap sheet of the acquisition process.

A comparison of the data for boom and bust years suggests that management lapses and the costs of adjustments due to events external to the program averaged no more than about 4 percentage points. If this is accepted, errors baked into MS B baselines were the largest single source of PAUC growth for the MDAPs that passed MS B during the post-Cold War bust years, an average of about 21 percentage points.

The estimated amount of funding added to the MS B baselines because of Errors of Inception (21 percent) is much larger than the estimated amount that needed to be added because of Errors of Execution (4 percent). This is consistent with the conventional wisdom about the predominant importance of Errors of Inception.

Some, however, argue that the additional funding required by unrealistically optimistic MS B baselines is a delayed recognition of the cost of a program (or portfolio of programs), not an increase in it. This argument assumes that the program adopted by DoD at MS B is defined by the performance and technical specifications in the MS B baseline, not by the funding provided for it. DoD policy requires that the MS B funding be based on a realistic cost estimate and that MDAPs be fully funded at MS B. Consequently, large inconsistencies between the performance and technical specifications placed on contract and funding should not occur. Of course they do, especially in programs that pass MS B in bust climates. Using a familiar metaphor, for some programs the technical description of the system placed on contract describes a Cadillac while the funding provided is only enough to acquire a Chevrolet.

Not all will be comfortable with the premise that MS B funding is not the crucial constraint on what is placed on contract. Waiving this concern for the sake of the argument, the initial underfunding probably does not appreciably increase the amount eventually paid for the Cadillac. Given this point, much of what is called cost growth due to Errors of Inception does reflect delays in funding rather than an increase in the amount of funding required. The argument is not entirely correct, however. Underfunding does increase the cost of the acquisition portfolio. The increase in the cost of the acquisition portfolio is the cost of the adjustments that must be made to accommodate the added funding required to acquire the Cadillac. DoD must make the necessary budgetary adjustments within a given top line—usually within funding for acquisitions. These adjustments include such measures as stretches, delays, cancellations, and descoping of programs. (The adjustments made are not necessarily confined to the program that requires additional funding.)

The literature on cost growth includes only one published attempt to compute the tax caused by adjustments associated with unrealistic MS B baselines. The result was 2 to 8 percent of the MS B baseline cost. Subsequent work on the effect of stretches on cost progress curve slopes suggests that the upper end of the range could be higher.[6] For several reasons, the 2 percent to 8 percent estimate of the tax is not entirely comparable to the estimates of the PAUC growth due to Errors of Inception (21 percent) and Errors of Execution (at most 4 percent) provided above for the 45 MDAPs that passed MS B during FY 1987–FY 2002. What we learn is that the average increased cost at the portfolio level very probably is considerably less than 21 percent.

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[6] Patricia F. Bronson, "A Model for Cost Progress on Defense Department Procurement Contracts," IDA Paper NS P-4437 (Alexandria, VA: Institute for Defense Analyses, July 2009).

This conclusion fails to recognize the full importance of Errors of Inception that result in very high cost growth. Such MDAPs, particularly very large MDAPs, are a major impediment to rational allocation of DoD resources. As cost growth emerges, plans are to a significant extent dictated by force of circumstances rather than measured choices among available alternatives. This not only disrupts rationally formulated plans but in effect shifts authority for DoD resource allocation towards the Service acquisition organizations and away from the President, the Secretary and Deputy Secretary of Defense, the USD(AT&L), and the Congress. If it is in fact the case that an unrealistically funded program that makes reasonable technical progress will eventually be fully funded, those programs muscle their way to the head of the funding line, apart from their comparative merits.

Concluding Comment

Each of the Services has a portfolio of programs across mission areas and commodity types, extending from efforts in the technology base through programs nearing the end of production. When a program is completed, it opens a resource "hole" that programs emerging from EMD can occupy. In turn, programs earlier in the acquisition cycle can move forward as well. When funding for acquisition turns down, these holes get smaller, or close entirely, or require cuts in funding for ongoing programs. The alternatives available in this circumstance are cancellations of programs, delays in new starts, programs that are more austere than is cost-effective on a long-term view, stretches, and unrealistic baselines—in particular, unrealistic cost and schedule estimates.

Taking the DoD guidance in effect over the period covered by this study at face value, one role assigned to the OSD-level oversight process was that of precluding one class of options—unrealistic MS B baselines. Doing this does not address the underlying problem, however, which is an inconsistency between force structure, the capabilities that the Department was expected to provide, and funding. These factors almost certainly were inconsistent during the 1970s and for more than a decade after the end of the Cold War. That inconsistency was the context in which high average PAUC growth and most cancellations arose and presumably should be a major factor to be considered in designing proposals for improved outcomes.

Acknowledgments

This paper is a synthesis and an elaboration of analyses initially published in the seven papers listed below. Five of these appeared as publications of the Institute for Defense Analyses (IDA) over the period 2014–2017; the other two were published in 2018 in the *Proceedings of the Fifteenth Annual Acquisition Research Symposium* of the Naval Postgraduate School.

The reviewers of the various IDA papers were Dr. Sarah K. Burns, Dr. Daniel L. Cuda, Dr. Gregory A. Davis, Mr. Brian G. Gladstone, Dr. Philip M. Lurie, Dr. Prashant R. Patel, Dr. Brian Q. Rieksts, Dr. David A. Sparrow, and Dr. David M. Tate, all of IDA; and Dr. D. Mark Husband of the Defense Acquisition University. Special thanks are due to Dr. Tate, who reviewed the four IDA papers on which he was not a co-author, and Dr. Sparrow, who reviewed four of the five IDA papers.

Chapters of the report were reviewed within IDA before they were sent to a panel of distinguished outside reviewers. The bulk of these reviews were done by Dr. Tate, the dean of the reviewers on this project, Dr. Cuda, Dr. Patel, and Dr. Davis. Dr. Davis read all chapters before they went to the editor. Dr. Matthew S. Goldberg of IDA read and commented on the entire draft as it neared completion.

In accordance with IDA practice for Reports, a panel of highly regarded outside experts both provided guidance on the direction of the work and reviewed chapters as they were drafted. The Senior Review Panel for this project was composed of Dr. Paul G. Kaminski, Under Secretary of Defense (Acquisition and Technology), 1994–1997; Mr. Frank Kendall III, Under Secretary of Defense (Acquisition, Technology and Logistics), 2012–2017; and Dr. Jamie M. Morin, Director, Cost Analysis and Program Evaluation, 2014–2017. The Panel met at IDA on May 20, 2017, August 21, 2017, and March 7, 2018.

Papers

McNicol, David L., and Linda Wu. "Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs." IDA Paper P-5126. Alexandria, VA: Institute for Defense Analyses, September 2014.

———, Sarah K. Burns, and Linda Wu. "Evidence on the Effect of DoD Acquisition Policy and Process and Funding Climate on Cancellation of Major Defense Acquisition Programs." IDA Paper P-5218. Alexandria, VA: Institute for Defense Analyses, May 2015.

———, David M. Tate, Sarah K. Burns, and Linda Wu. “Further Evidence on the Effect of Acquisition Policy on Cost Growth of Major Defense Acquisition Programs.” IDA Paper P-5330 (Revised). Alexandria, VA: Institute for Defense Analyses, August 2016.

———. “Influences on the Timing and Frequency of Cancellations and Truncations of Major Defense Acquisition Programs.” IDA Paper P-8280. Alexandria, VA: Institute for Defense Analyses, March 2017.

———. “Post-Milestone B Funding Climate and Cost Growth in Major Defense Acquisition Programs.” IDA Paper P-8091. Alexandria, VA: Institute for Defense Analyses, March 2017.

———. “Further Evidence on Program Duration and Unit Cost Growth.” In Vol. I of *Proceedings of the Fifteenth Annual Acquisition Research Symposium*, 89–105. Monterey, CA: Naval Postgraduate School, April 30, 2018.

———. “Have Changes in Acquisition Policy Influenced Cost Growth of Major Defense Acquisition Programs?” In Vol. I of *Proceedings of the Fifteenth Annual Acquisition Research Symposium*, 304–22. Monterey, CA: Naval Postgraduate School, April 30, 2018.

The first two of these papers (P-5126 and P-5218) were respectively superseded by the third (P-5330 (R)) and the fourth (P-8280). In each of these cases, additional work was undertaken that went well beyond that presented in the initial paper and, rather than burdening readers with two papers, the analyses of the initial paper were folded into its expanded successor.

Contents

1. Introduction

A. Introduction

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This study is concerned only with major defense acquisition programs (MDAPs), a category defined by statute.[1] It is further confined to "acquisition costs," which is a term of art defined as the sum of Research, Development, Test and Evaluation (RDT&E) cost and procurement cost (that is, the cost of buying the system once it has been developed). Procurement cost is typically (although not invariably) on the order of five times the RDT&E cost. As a rough rule of thumb, acquisition cost for the portfolio of MDAPs in development or procurement at any point in time ranges from 10 percent to 20 percent of total DoD funding.

The main question asked by the study is whether changes in DoD acquisition policies and oversight processes over the period of fiscal year (FY) 1965–FY 2009 significantly altered cost growth (defined below) on MDAPs and the proportion of MDAPs cancelled. Cost growth and cancellations are examined because they often have been used in public and congressional discussions as tests of the success (or lack thereof) of the DoD acquisition enterprise. They are not uniquely important, however. Within the context of an individual program, system performance (usually) and schedule (in some cases) are more important than cost growth. On a comprehensive view, program management is only one of a set of problems that includes, among others, questions about how acquisition programs should be structured, the health of the defense technology and industrial bases, concentration of the defense industrial base, the direction and pace of development of technologies related to defense, and the relationship of the defense sector to the commercial sector.

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[1] 10 U.S.C. 2430.

Several previous studies have considered whether changes in DoD acquisition policy and process have had a discernible effect on the cost growth of MDAPs. There is a consensus among quantitative studies of the topic that changes in acquisition policy since the early 1970s have not resulted in decreased cost growth on MDAPs.[2] None of these studies, however, compared acquisition cost growth of MDAPs initiated during the 1960s with that on MDAPs initiated during the 1970s. This point is more important than may be readily apparent. Then-Deputy Secretary of Defense David Packard made basic changes in the Office of the Secretary of Defense (OSD)-level MDAP oversight policy and process in July of 1969, near the start of FY 1970. (The fiscal year then started on July 1.) These reforms remained in place, and in some important respects had been strengthened, beyond the last year of the period covered by this study (FY 2009). If the 1969 Packard reforms were successful in reducing cost growth in the early 1970s, there is good reason to believe that they would still have this effect through the late 2000s and beyond.

The evidence on whether the 1969 Packard reforms did reduce cost growth is mixed. In a report published in 1979, Dews et al. found that the Packard reforms had reduced growth in unit cost.[3] A qualitative examination of the data published the following year by Asher and Maggelet reached the opposite conclusion.[4] Drezner et al., in 1993, argued that the evidence that the 1969 Packard reforms resulted in lower cost growth disappears when account is taken of program duration.[5] Tyson et al., in a paper published in 1992, however, found statistical evidence that some particular features of the 1969 Packard reforms had reduced cost growth.[6]

The quantitative literature moved on from here without resolving the issue. Because it presents a pivotal question and because the topic remains relevant, this study undertook

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2 D. S. Christensen, D. A. Searle, and C. Vickery, "The Impact of the Packard Commission's Recommendations on Reducing Cost Overruns on Defense Acquisition Contracts," *Acquisition Review Quarterly* (Summer 1999): 251–62; and W. D. O'Neil, "Cost Growth in Major Defense Acquisition: Is There a Problem? Is There a Solution?" *Acquisition Research Journal* (July 2011): 277–94. Christensen, Searle, and Vickery, and O'Neil, provide references to other studies on the topic. The most recent contribution seems to be David L. McNicol, "Post-Milestone B Funding Climate and Cost Growth in Major Defense Acquisition Programs," IDA Paper P-8091 (Alexandria, VA: Institute for Defense Analyses, March 2017).

3 E. Dews et al., *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s,* R-2516-DR&E (Santa Monica, CA: The RAND Corporation, 1979).

4 Norman J. Asher and Theodore F. Maggelet, "On Estimating the Cost Growth of Weapon Systems," IDA Paper P-1494-REV (Alexandria, VA. Institute for Defense Analyses, June 1980, revised September 1984).

5 J. A. Drezner et al., *An Analysis of Weapon System Cost Growth,* MR-291-AF (Santa Monica, CA: The RAND Corporation, 1993), 30.

6 Karen W. Tyson et al., "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs, Vol. I: Main Report." IDA Paper P-2722 (Alexandria, VA: Institute for Defense Analyses, November 1992).

a fresh and comprehensive analysis of the extent to which changes in acquisition policy over the period FY 1965 through FY 2009 influenced MDAP cost growth and cancellations. In order to place this topic in context, Section B of this chapter briefly identifies the main issues considered in the previous cost growth literature. Section C describes in general terms the plan of the study.

Although all readers are welcome and most of the report can profitably be read by those with little knowledge of statistics, it is directed to producers of analyses of DoD acquisition policy and to those weighing changes in acquisition policy. The report assumes that the reader is generally familiar with the DoD acquisition process and also has some understanding of the Planning, Programming, Budgeting, and Execution System (PPBES). Those who do not have a background in this field may wish to consult the references provided[7] and perhaps start this report by reading Chapters 5 and 6.

B. Cliffs Notes on Cost Growth

One of the two major strands of the cost growth literature concerns the unit costs of successive generations of particular types of weapon systems—for example, from the DDG-963 Spruance Class destroyer, to the DDG-51 Arleigh Burke, to the DDG-1000 Zumwalt class. Several trends are widely thought to influence intergenerational cost growth:

- Increases in systems' capabilities and complexity
- Increases in the size of software in MDAPs
- Increased concentration of the defense sector and reduced competition
- Increases in indirect costs

Studies in this segment of the literature attempt to account for the cost growth from one generation to the next in terms of factors such as those listed.[8]

The second major strand of the literature is concerned with the growth in the costs of individual MDAPs, typically from program inception through the completion of the procurement phase. Program initiation is typically assumed to occur at Milestone (MS) B,

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7 Chapter 1 of J. Ronald Fox, *Defense Acquisition Reform, 1969 to 2009: An Elusive Goal* (Washington, DC: US Army Center of Military History, 2011), is a primer on the DoD acquisition process circa 2008. A description of the PPBES of the same period is provided by Chapter 5 of L. R. Jones and Jerry L. McCaffery, *Budgeting, Financial Management, and Acquisition Reform in the U.S. Department of Defense* (Charlotte, NC: Information Age Publishing, 2008).

8 See, for example, Mark V. Arena et al., *Why Has the Cost of Navy Ships Risen?*, MG 484 (Santa Monica, CA: The RAND Corporation, 2006).

which marks the start of Engineering and Manufacturing Development (EMD) and the adoption of a baseline for costs and quantities.

Cost estimates used in MS B reviews are based to a large extent on actual costs of analogous past systems, usually at about the subsystem level. The crux of the estimation task is to identify the appropriate analogies. In doing this, estimators have available descriptions of the proposed program and data on previous programs, at about the same level of detail. For example, the description of the program includes the projected size of the software that will need to be written and its complexity. Estimators also generally can find information on the growth of software size in preceding systems. In contrast, overhead rates (and overhead tends to account for about half of acquisition cost) are negotiated between the government and the prime contractor and typically are available for several years into the future at the time the estimate is made.

Like most other statistical studies of cost growth, this study uses "quantity-adjusted" Program Acquisition Unit Cost (PAUC). PAUC is acquisition cost divided by the number of fully configured units acquired. PAUC growth is computed by comparing the MS B baseline value of PAUC—which can be thought of as a goal or a prediction—to the actual PAUC reported in the final Selected Acquisition Report (SAR) for the program. Both the MS B baseline and the final value[9] of PAUC are stated in program base year dollars. The actual value is restated on the basis of the MS B baseline quantity by moving up or down the cost progress curve as is appropriate. The ratio of the MS B baseline value of PAUC to the quantity-adjusted actual value is an estimate of what PAUC growth would have been had the MS B baseline quantity been acquired. Appendix A provides the conventions used in assembling the data, identifies the sources of the data, and describes the quantity adjustment processes. Throughout the remainder of this report, the term *PAUC growth* is as defined here: PAUC growth from the MS B baseline computed using constant program base year dollars and adjusted for changes in quantity acquired from that specified in the MS B baseline.[10]

Only MDAPs that had passed MS B by the end of FY 2009 were included in the study to ensure that programs included had been in EMD (and possibly experiencing cost growth) for several years. (The December 2014 SARs were the most recent available

[9] For a program still underway, the most recent estimate (as reported in the SAR) of the final value is used.

[10] Under current law, programs that have a critical Nunn-McCurdy breach must recertify their last milestone, which does establish a new baseline. Even for these programs, however, this report would use the original MS B in measuring PAUC growth. PAUC growth used for purposes of Nunn-McCurdy Act reporting is not quantity normalized. Compared to the PAUC growth measures used in Nunn-McCurdy reporting, quantity adjustment decreased measured PAUC growth for about half of the programs in the sample and increased it for the other half.

when the MDAPs included in the database were identified.) PAUC growth estimates were updated through the December 2015 SARs. Of these programs, only those that had been completed by the end of FY 2016 were in the computations presented in this report. Thus, all of the PAUC growth estimates are computed using an MS B baseline PAUC (or as close to one as was available) and the actual PAUC reported in the final SAR, adjusted back to the MS B baseline quantity.

Figure 1 is a scatter diagram of PAUC growth for 156 MDAPs.[11] Fourteen of these had PAUC growth of at least 100 percent—that is, the unit cost of these programs was at least twice what had been projected at MS B. Forty-three of the 156 programs—nearly 30 percent of the total—had PAUC growth of at least 50 percent. Not all programs experienced increases in unit cost, however. For 28 of the 156 MDAPs, after adjusting for quantity changes, unit cost was lower than that projected at MS B.

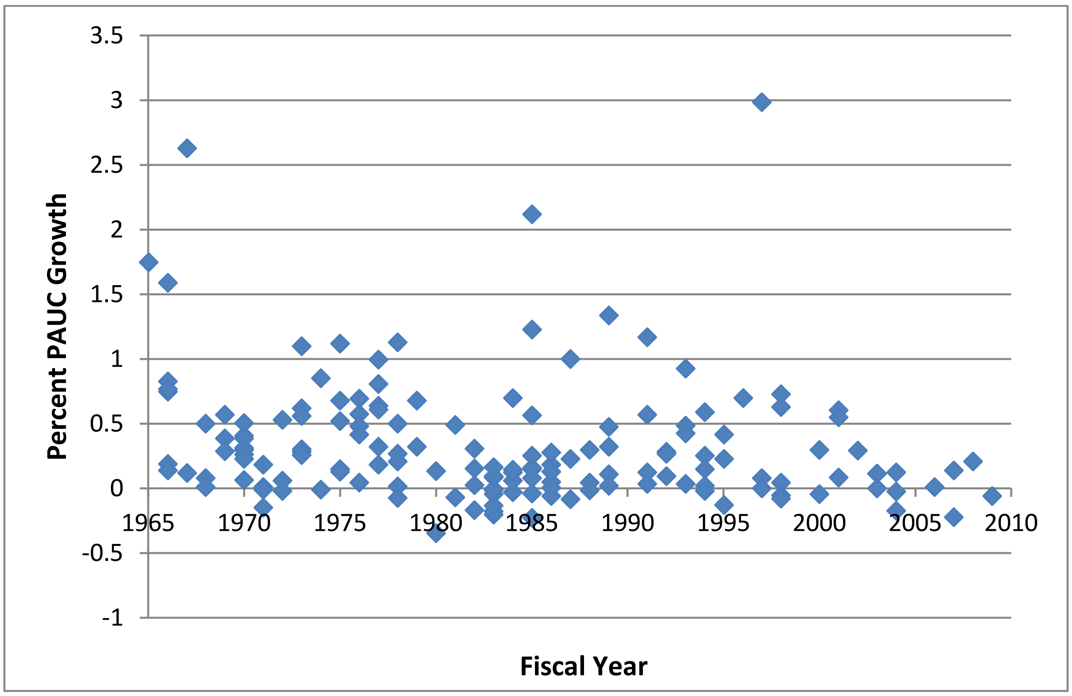

Figure 1. Scatter Diagram of Quantity Normalized PAUC Growth from the MS B Baseline for 156 Completed MDAPs

Some studies of growth in the costs of individual MDAPs are descriptive; they are concerned with average unit cost growth of different types of systems (e.g., ships, tactical

[11] The PAUC estimates used are for the 311 MDAPs in the database that passed MS B during the period FY 1965 through FY 2009. Of these programs, 58 were cancelled and 253 went into full-rate production. The database includes a cost estimate for 185 MDAPs that entered full-rate production, of which 156 had been completed by the end of FY 2016.

aircraft, and helicopters, among others), differences in cost growth of MDAPs among the Services, differences by program size, or trends in cost growth.[12] A few other studies have used "before and after" comparisons to tease out the effects of changes in acquisition policy and process.[13] Finally, some ambitious studies examine the association between program characteristics and cost growth to identify program "do's and don'ts," that is, characteristics that influence program success in terms of cost, schedule, and performance.[14]

The following is a representative list of such characteristics identified in the literature:

- The maturity of the technologies employed,
- Whether the program involved a full-scale prototype prior to MS B,
- The degree of concurrency between development and production,
- The appropriateness of the contract type used,
- Whether program requirements are technically feasible and remain stable,
- Funding stability,
- Whether the MS B cost estimate is realistic,
- The quality of government and contractor program management, and
- Changes post-MS B in capabilities to be acquired.

This report assumes that such factors are the proximate causes of most instances of cost growth and makes no attempt to expand or refine the list. In that respect, it is not about the causes of cost growth as that term was understood in previous studies.

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12 A comprehensive example is Drezner et al., *An Analysis of Weapon System Cost Growth*.

13 Dews et al., *Acquisition Policy Effectiveness*. As noted above, Drezner et al., *An Analysis of Weapon System Cost Growth*, 30, provides an important criticism of the Dews et al. study.

14 For a recent example based on case studies, see Gene H. Porter et al., "The Major Causes of Cost Growth in Defense Acquisition, Volume I: Executive Summary," IDA Paper P-4531-VOL-I (Alexandria, VA: Institute for Defense Analyses, December 2009). Robert F. Coulam, *Illusions of Choice: The F-111 and the Problem of Weapons Acquisition Reform* (Princeton, NJ: Princeton University Press, 1977) is an early and excellent case study. A useful review of statistical analyses of the causes of cost growth is provided in Chapter 2 of Mark V. Arena et al., *Historical Cost Growth of Completed Weapon System Programs*, TR-343 (Santa Monica, CA: The RAND Corporation, 2006). Tyson et al., "The Effects of Management Initiatives," is one of the first examples of a statistical analysis of cost growth.

C. Plan of the Study

The statistical analyses presented in the following chapters are basically about the clustering of high cost growth MDAPs and the MDAPs that were cancelled: Do high cost growth programs and cancellations cluster in an intelligible way with changes in acquisition policy? The nature of this approach is conveyed by a simple analogy. One part of the epidemiology of malaria involves the study of the way certain species of mosquitoes acquire the parasite Plasmodium, which causes malaria, and transmit it to humans. Another branch of the field studies the conditions that tend to increase (or limit) the populations of the relevant types of mosquitoes.

This report is of the latter sort. It uses “before and after” comparisons involving changes in acquisition policy and process to study clustering of PAUC growth and MDAP cancellations. An initial phase of the analysis uses two of the factors—acquisition policy and funding climate—to define several “bins” of MDAPs. The bins are then examined in an orderly way for clusters. The hope is that the results provide some insight into the conditions that favor the decisions that cause high cost growth and cancellations.

This is a reasonable hope because the bins line up with the questions that the study seeks to answer. One bin, for example, is composed of the MDAPs that were initiated during the period FY 1965 through FY 1969, when the first OSD-level MDAP oversight process was in effect. This was a period of comparatively intense competition for funding for new MDAPs; that is, a bust funding climate. Considering only acquisition policy and funding climate, a relevant second bin is composed of MDAPs initiated during FY 1970–FY 1980; the Packard reforms introduced at the start of FY 1970 were in effect throughout this period, which also was a bust funding climate. Comparison of these two bins provides a first look at the implications for PAUC growth and cancellations of the changes in acquisition policy introduced by Packard. It is a “first look” because only acquisition policy and cost growth are considered. A second look extends the analysis to include funding climate post-MS B and program duration.

The study does not end at that point because each acquisition policy bin is a bundle of several distinct changes. Continuing with the example used earlier, suppose (which is the case) that the early 1969 Packard reforms are associated with lower average PAUC growth. Most would be willing to make the judgment that the Packard reforms caused the reduction in average PAUC growth. But that conclusion would not tell us just which of the Packard reforms were instrumental in producing the result. This point is important because many changes in acquisition policy—including some of those introduced by Packard—were not directed to reducing cost growth or cancellations.

A statistical approach would have a chance of providing a more detailed conclusion only if the database contained far more MDAPs than are actually available for study. As a practical matter, it is necessary to look to historical and institutional information. The questions are: What tools were available to senior decision makers in OSD to directly influence PAUC growth and cancellations? How did these tools change over the period covered by the study?

Chapter 2 discusses in detail the factors used in the analysis of clustering. Along with a better understanding of cost growth, this discussion leads to a format for a statistical analysis. The analysis of PAUC growth is provided in Chapter 3 and that of cancellations in Chapter 4. The historical and institutional analyses are presented in Chapters 5 through 7. The final chapter offers some observations about the basic characteristics of the OSD-level oversight process during FY 1965–FY 2009.

2. Finding the Model

A. Introduction

The statistical analysis presented in the following two chapters primarily uses four factors to identify and understand clustering of PAUC growth and cancellations:

- Acquisition policy and process,
- Competition for funding at MS B,
- Program duration, and
- Post-MS B funding climate.

Consideration of the first of these is required by the question: Have changes in acquisition policy and process had statistically discernible effects on MDAP outcomes? The intensity of competition for funds is generally understood to influence how realistic MS B baselines are and, in that way, PAUC growth.[15] Program duration is associated with cost growth[16] via stretches, "requirements creep," and problems with measuring inflation, among others. Post-MS B funding climate suggests the possibility that costs grow when they can—that is, in a boom climate—and recognizes that in a bust climate what would otherwise be cost growth appears as performance shortfalls.[17]

The Devil here is in the details, not the general idea behind these factors. Each presents a distinct challenge:

- That of acquisition policy and process lies in the fact that there have been dozens of possibly important changes over the period covered by this study.
- MDAPs experience competition for funding both within DoD and in the Congress. Which of these is relevant to cost growth and cancellations?
- Program duration and post-MS B funding climate are intertwined.

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15 This point is clearly articulated in Asher and Maggelet, "On Estimating the Cost Growth of Weapon Systems" and remains the conventional wisdom.

16 Drezner et al., *An Analysis of Weapon System Cost Growth*, especially pp. 39–43, calls attention to the importance of program duration.

17 McNicol, "Post-Milestone B Funding Climate and Cost Growth in Major Defense Acquisition Programs."

Sections B, C, and D of this chapter take up these issues in turn. Section E considers whether there are other factors that need to be introduced into the analysis.

Over the 45 years covered by this study, some features of the acquisition process were renamed, and sometimes modestly redefined, and new features were introduced. These changes are noted only when necessary. Generally, the text adopts the names in use during the period FY 2000–FY 2009.[18]

B. Acquisition Policy

Policy and process tend to be intertwined; process typically is required to implement policy, and the most successful and durable policies are those embedded in process. For this reason, and to avoid constant repetition of "process and policy," the term *acquisition policy* is used here to encompass both policy on particular topics (for example, contract types) and the OSD-level MDAP oversight process (for example, definition of the milestones).

Over the period considered by this study (FY 1965–FY 2009), the main elements of DoD acquisition policy were set out in documents that changed at irregular intervals. The earliest of these was DoD Directive (DoDD) 3200.9, issued February 26, 1964, which marks the start of the first OSD-level process for authorizing MDAPs to proceed from one stage of the acquisition process to the next. The top-level acquisition policy and process documents in force in FY 2009 were DoDD 5000.01 (May 12, 2003) and Department of Defense Instruction (DoDI) 5000.02 (December 8, 2008). In between, about 22 revisions of these documents were issued.

Anyone with sufficient patience and an eye for detail can identify hundreds of changes in successive versions of these documents. Many of these can be dismissed because they were simply name changes or were clearly trivial changes in wording, and others because they were only briefly in effect. When these have been culled, we are left with on the order of two dozen changes that perhaps were important. To these it would be necessary to add at least as many statutory changes that were not captured in the relevant OSD-level acquisition policy documents.

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[18] For example, during FY 1966–FY 1969, there were two milestones in the OSD-level acquisition process, neither of which had a name. Reforms instituted early in FY 1970 provided for three milestones, labeled MS I, MS II, and MS III. An MS 0 was added in 1977. MS 0 was moved from the acquisition process to the Planning, Programming, and Budgeting System (PPBS) in 1981. It was restored to the acquisition process in 1987 and MS IV and MS V were added. By 1991, MS IV had been eliminated and what had been MS V became MS IV. MS IV was eliminated by 1996. In 2000, the milestones were changed to MS A, MS B, and MS C, and the definition of MS B modestly changed. See Appendix B, especially Section C.

This study opted for radical simplification, specifying a small number of bins that capture the largest changes in the elements of acquisition policy that directly touched PAUC growth and cancellations. These include, for example, the definitions of the milestones, the milestone review process, policy on contract types, and policies on realistic costing and full funding. In a few instances, an administration "adopted" changes in acquisition policy that were not implemented. These were excluded from the definition of the policy bins. Absent clear contrary evidence, inclusion in the DoD 5000 documents or, for the period FY 1965–FY 1969, DoDD 3200.9, was taken to mean that a policy change had been implemented.

The bins used are listed in Table 1. Identification of the breakpoints for the first two bins—McNamara-Clifford and Defense System Acquisition Review Council (DSARC)—is straightforward. In each of these cases, packages of policy changes and process changes adapted to them were implemented at known times. Definition of the other bins requires judgments about which of a set of changes adopted were implemented and when the changes took effect. The events used to anchor the breakpoints between the bins are shown in notes to the table along with a reference to the parts of Chapters 5 and 6 that discuss them.

Table 1. Acquisition Policy Bins

Acquisition Policy Configuration	Short Name	Period (Fiscal Years)
McNamara-Clifford[a]	McNamara-Clifford	1964–1969
Defense System Acquisition Review Council[b]	DSARC	1970–1982
Post-Carlucci DSARC[c]	P-C DSARC	1983–1989
Defense Acquisition Board[d, f]	DAB	1990–1993 2001–2009
Acquisition Reform[e]	AR	1994–2000

[a] DoDD issued in February 1964 (Section 5.B).

[b] Packard reforms instituted in July 1969 (first month of FY 1970) (Section 5.C).

[c] Frank Carlucci was Deputy Secretary of Defense in the first Reagan Administration. He proposed a set of changes to the acquisition process, called the Carlucci Initiatives. Service proposals for major system new starts submitted with their Program Objective Memoranda (POMs) and acted on through the Program Review process—summer 1982 (FY 1983 began October 1, 1982) (Appendix B, Section C).

[d] Full implementation of the Program Manager (PM)/Program Executive Officer (PEO)/Service Acquisition Executive (SAE)/Defense Acquisition Executive (DAE) in 1990 after Secretary of Defense *Management Review* (Appendix B, Section E).

[e] William Perry becomes Secretary of Defense; issues *Acquisition Reform*. FY 1994 (Note 140, p. 92).

[f] Donald Rumsfeld becomes Secretary of Defense, and USD(AT&L) Aldridge does not pursue AR agenda. FY 2001–FY 2002 (Section 7.C).

Simplicity and practicality are the main advantages of using a small number of acquisition policy bins. Those are purchased at the price of two disadvantages. The first arises from the fact that there were changes in acquisition policy within each of the bins. Some of these changes were a matter of phasing in changes that had been adopted near the start of the period while others were new initiatives. Lumping together in a single bin all changes within a period apparently throws away information. In practice, it probably does to only a limited extent because the number of MDAPs in the sample is not large enough to provide reasonable estimates of the individual effects of dozens of changes in acquisition policy. This is particularly so in view of the large inherent variability of cost growth.

The second disadvantage is a limitation on what can be inferred from statistical comparisons. For example, Chapter 3 reports that average PAUC growth in the DSARC period was significantly less than average unit cost growth in the preceding period (McNamara-Clifford). The DSARC bin is defined by the set of reforms introduced by Packard in July 1969. Even at a summary level of description, Packard's reforms included about half a dozen distinct elements, and the statistical result tells us nothing about which of these were of crucial importance to the reduction of cost growth. Viewed from this angle, the statistical results frame qualitative questions about how the OSD-level MDAP oversight process functioned in various periods of the past four-plus decades.

The data reported in Table 2 are constructed by binning each MDAP by the acquisition policy configuration in place when the program passed MS B.[19] One important feature of the data is the high average PAUC growth for the McNamara-Clifford period (74 percent), which is set aside for now. Another is the comparatively low average PAUC growth—24 percent—for the P-C DSARC and DAB periods. Those two periods have in common a factor largely absent from the others: several years in which the DoD budget was high and increasing rapidly. This similarity suggests an association between funding climate and PAUC growth.

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[19] Programs for which an MS B date could not be established were binned by the first fiscal year in which they filed a SAR.

Table 2. Average PAUC Growth for Completed MDAPs by Acquisition Policy Configuration

Acquisition Policy Configuration	Period (Fiscal Years)	PAUC Growth
McNamara-Clifford	1965–1969	74% (16)
Defense System Acquisition Review Council (DSARC)	1970–1982	35% (55)
Post Carlucci DSARC (P-C DSARC)	1983–1989	24% (40)
Defense Acquisition Board (DAB)	1990–1993 2001–2009	24% (26)
Acquisition Reform (AR)	1994–2000	31% (19)
Total	**1965–2009**	**34% (156)**

C. Competition for Funding

Several past studies have suggested a link between the intensity of competition for funding and cost growth.[20] Little evidence of such a link has been found, but it has been hiding in plain sight. Setting aside for a moment how the breakpoints are established, Table 3 compares PAUC growth in each of the two bust-boom cycles and for the total sample. In each of the comparisons, the average PAUC growth for MDAPs that passed MS B during the bust phase of the cycle is much larger than the average for MDAPs that passed during the boom phase. The most striking feature of the data in Table 3 is that the same pattern appears so strongly in each of the bust-boom cycles.

Table 3. Average PAUC Growth for Completed MDAPs that Passed MS B in Bust and Boom Climates

Bust (Fiscal Years)		Boom (Fiscal Years)	
1965–1980	46% (65)	1981–1986	18% (35)
1987–2002	37% (45)	2003–2009	2% (11)
Total	**42% (110)**	**Total**	**15% (46)**

The pattern also appears at the aggregate level for growth in Average Procurement Unit Cost (APUC); RDT&E cost growth; for several subdivisions of the data (e.g., Army, Navy, Air Force, Joint); the set of programs assessed in Tyson et al. (1992); and schedule slips, cancellations, and MDAP new starts (see Table 4). The fact that the bust-boom pattern of cost growth shows up in so many different segments of the data implies that it is very unlikely to reflect some quirk in how the cost estimates were made or some odd

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20 Competition among new starts for funds is listed as a major cause of cost growth by Asher and Maggelet, "On Estimating the Cost Growth of Weapon Systems," 9. See also Drezner et al., *An Analysis of Weapon System Cost Growth*, 45–7, and, for a relatively recent example, David L. McNicol, *Cost Growth in Major Weapon Procurement Programs*, 2nd ed. (Alexandria, VA: Institute for Defense Analyses, 2004), 40.

clustering. If funding climate is a proxy for another variable or variables, they must also exhibit this rhythm—as Ellington famously noted, "It don't mean a thing if it ain't got that swing"—and it is not obvious what other variable or variables would "swing."

Table 4. A Variety of Bust-Boom Comparisons

Category	Bust	Boom
PAUC	49% (123)	16% (62)
APUC	52% (121)	16% (60)
RDT&E	86% (117)	41% (60)
Army (PAUC)	59% (36)	12% (10)
Navy (PAUC)	34% (39)	12% (26)
Air Force (PAUC)	61% (31)	16% (17)
Joint (PAUC)	36% (14)	29% (9)
New Start (PAUC)	49% (79)	20% (38)
VMR[a] (PAUC)	49% (44)	9% (24)
Satellites (PAUC)	94% (7)	13% (3)
Helicopters (PAUC)	70% (11)	30% (5)
P-2722[b] (PAUC)	53% (67)	-2% (10)
Schedule Slips of Major Subsystems (%)	28%[b] (138)	17%[c] (86)
Cancellations	2.3/yr.[d]	0.68/yr.[d]
New Starts per Year	6.3/yr.	8.5/yr.

[a] VMR – Variant, Modification, or Remanufacture

[b] Karen W. Tyson et al., "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs, Vol. I: Main Report," IDA Paper P-2722 (Alexandria, VA: Institute for Defense Analyses, November 1992).

[c] This analysis did not use the bust-boom funding climate demarcations, but instead used periods when the DoD budget was contracting and periods when it was growing. Estimates from a linear model estimated by Ordinary Least Squares. Personal communication from Dr. David Tate of unpublished results from research for the Office of Acquisition Resource Analysis of the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics.

[d] These data are for cancellations in periods of rapidly declining DoD procurement funding (FY 1987–FY 1984 and FY 2010–FY 2013) and periods when procurement funding was stable or increasing.

The relevant criterion in defining the breakpoints between funding climates is not the congressional appropriation for DoD procurement or the DoD topline. While there is competition between MDAPs for funding at the congressional level, this occurs well after MS B. What really is at issue in PAUC growth is the intensity of competition for funds faced by MDAPs to the point at which the MS B baseline is established—that is, MS B.

Up to MS B, the competition occurs within DoD, particularly within the Services (or, to use the more inclusive term, within Components). Its main arena is the Program Objective Memorandum (POM) process. POMs are built annually as part of the PPBES, through which DoD develops its annual Budget Request and the Future Years Defense

Program (FYDP). The FYDP covers the budget year and the four years beyond it.[21] A very large MDAP, or one that is especially challenging technologically, might appear in the out years of the FYDP for several years before it passes MS B and funding for it is included in the President's Budget (PB). Even smaller and less challenging MDAPs would ordinarily enter the out years of the FYDP at least a year before MS B. The fact that an MDAP has obtained a foothold in the FYDP during the POM build does not mean that its funding is entirely secure, however. Some programs are cancelled after they have been included in the out years of the FYDP and have filed SARs, but before they passed MS B or become Acquisition Category (ACAT) I programs.[22]

For most of the period covered by this report, Service POMs were reviewed annually at the OSD level.[23] Some programs—for example, the Star Wars programs of the 1980s—were followed by the White House and the Congress pre-MS B. Those were exceptions. As a rule, the most significant competition for funds faced by prospective MDAPs pre-MS B was at the Service level.

The intensity of the competition for procurement funds depends on both the demand for funds and the availability of funds. The demand for funds is influenced by such factors as changes in missions, changes in the threats to national security, advances or prospective advances in technology, and the age and condition of the equipment inventories. The funding constraints for the POM builds are derived from Fiscal Guidance (FG) issued annually by the Secretary or Deputy Secretary of Defense. FG specifies the top-line funding constraint for each Component for each year of the FYDP. These limits were enforced through the OSD-level program and budget reviews.[24]

We do not have any comprehensive and objective measures of the level of DoD demand for acquisition funding. Moreover, DoD does not release the specific funding constraints provided by FG. What we have as a gauge of changes in the intensity of the

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21 This has not always been the case. The FYDP was instituted in 1961 as a central part of McNamara's reform of the DoD resource allocation process. At that point the acronym meant "Five Year Defense Plan." It continued to mean the "Five Year Defense Plan" until about 1990, when, to reflect changes in the PPBS, it became the Future Years Defense Program. The PPBS reverted to a five-year horizon in 2010, but the term "Future Years Defense Program" had become entrenched and eventually was retained.

22 The definitions of MDAP and ACAT I are different and a few MDAPs are not ACAT I programs.

23 The exceptions are 1961–1969. During these years, the portions of the FYDP covering RDT&E, major acquisition programs, and force structure were built in OSD. POMs and an OSD POM review of them were introduced in 1969 in conjunction with basic revisions of the PPBS initiated by Secretary of Defense Laird.

24 FG for the POM builds probably was first imposed on the Services in 1969. Top-level limits on the DoD budget request apparently were imposed during FY 1964–FY 1969. It is not clear whether these were observed by OSD during the FYDP build or imposed *ex post* by the Office of Management and Budget.

competition for acquisition funds are events that led to major, sustained changes in DoD funding, coupled with statements by the President or the Secretary of Defense linking the change in DoD funding to those events.

The funding climates' turning points were marked by four events:

- The Soviet invasion of Afghanistan in December 1979 (bust → boom)
- Passage of the Gramm-Rudman-Hollings (GRH) Act in December 1985 (boom → bust)
- The 9/11 Al Qaeda attacks on the United States in 2001 (bust → boom)
- Passage of the Budget Control Act in August 2011 (boom → bust)

We use the first of these to illustrate what is involved in moving from the event to a specific fiscal year as the start of a phase of the bust-boom cycle.

The Soviet invasion of Afghanistan prompted a change in the Carter administration's policy on defense spending. The invasion occurred in December 1979 (the first quarter of FY 1980). The FY 1981 President's Budget went to the Congress a few weeks later. The "Defense Spending" portion of Carter's State of the Union address stated that he requested a 5 percent increase in DoD FY 1981 funding in constant dollar terms over the FY 1980 level. It goes on to characterize this as "a growth rate for defense that we can sustain over the long haul."

The start of the first boom period is taken to be FY 1981; that is, MDAPs were counted as having passed MS B in a boom climate starting October 1, 1980. In fact, the boom started several months earlier—probably in late February—after the issuance of the FG for the summer 1980 POM process. That Guidance presumably showed a 5 percent constant dollar year-on-year increase at least at the DoD level. MDAPs that passed MS B during about the latter half of FY 1980—say, March through September—could have benefited from the higher FG levels. No effort was made to split fiscal years in the statistical analyses, however.

D. The Boom Effect and Program Duration

It is a reasonable conjecture that PAUC growth was higher for MDAPs that entered a boom climate sometime after passing MS B than it was for those that did not. MDAPs that passed MS B in bust climates probably were especially influenced by a post-MS B boom. Some of these programs had unrealistic baselines and would find a post-MS B boom climate a good time to "get well." Other programs, with realistic MS B baseline, would have been less capable than the Service wanted and good candidates for added capability when the funding climate improved.

This section examines these conjectures, looking first at the association of post-MS B funding climate and PAUC growth and then program duration and PAUC growth.

1. The Boom Effect

A two-part naming convention is used to label groups of programs that entered a boom climate post-MS B and those that did not. The first part of the label gives the funding climate prevailing when the program passed MS B—bust or boom. The second part—0, 1, or 2—denotes the number of subsequent boom climates the programs entered post-MS B. For example, programs that were completed entirely within a single bust phase will be referred to as Bust0—Bust because they passed MS B in a bust funding climate and zero because they were completed without entering a boom climate. Programs that passed MS B in a bust period and continued into a subsequent boom period make up Bust1 or, for the four programs that extended into two boom periods, Bust2.

For reasons that will become apparent, the analysis initially is limited to the DSARC, P-C DSARC, and DAB periods (collectively abbreviated DSARC/DAB).

Averages of PAUC growth for Bust0, Bust1, and Bust2 are presented in Table 5 for each of the two bust climates of DSARC/DAB. Note that only data for completed programs are used in this study. In both climates, average PAUC growth for the treatment group (Bust1) is higher than it is for the control group (Bust0)—42 percent compared to 18 percent for the first period, and 51 percent compared to 13 percent for the second. While they do not account for the effects of program duration, with that caveat these differences are statistically significant.[25] PAUC growth for the four programs of Bust2 is higher than that of Bust0 and less than that of Bust1,[26] but is not significantly different from either.

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[25] Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) find the PAUC growth data in each of the three bins of the first bust period to be consistent with a normal distribution. An F-test found the variances for Bust0 and Bust1to be significantly different. A two-tailed t-test assuming unequal sample variances found the means of Bust1 and Bust0 for the first period to be significantly different ($p = 0.003$). K-S and A-D also find the PAUC growth data in each of the two bins of the second bust period to be consistent with a normal distribution. Again, an F-test found the two variances to be significantly different. A two-tailed t-test assuming unequal sample variances found the means of Bust1 and Bust0 for the first period to be significantly different ($p = 0.007$).

[26] The programs in Bust2 are the CVN 68, with a PAUC growth of 7 percent; the NAVSTAR GPS (85 percent); ATCCS-MCS (-34 percent); and the UH-60A (54 percent). A two-tailed t-test, with unequal variances as appropriate, found the mean of Bust2 not to be significantly different from that of Bust0 ($p = 0.732$) or Bust1 ($p = 0.440$).

Table 5. Average PAUC Growth for Completed MDAPs in DSARC/DAB Bust by the Number of Boom Periods Experienced

Bin	1st Bust Climate FY 1970–FY 1980	2nd Bust Climate FY 1987–FY 1993 and FY 2001–FY 2002
Bust0	18% (7)	13% (9)
Bust1	42% (38)	51% (17)
Bust2	28% (4)	none

The most striking and unexpected feature in Table 5 is the relatively low average PAUC growth for Bust0 programs in each of the two bust climates, which is little higher than the average PAUC growth for MDAPs that passed MS B during the boom climates. This could be read as suggesting that Bust0 programs have about the same (low) propensity for PAUC growth due to unrealistic elements in the MS B baseline.

A further step can be taken on the reasonable assumption that Bust1 programs do not have more unrealistic MS B baselines than do Bust0 programs—at MS B, the two cannot be distinguished reliably. If this is granted, the higher average PAUC growth of Bust1 programs must reflect program changes—that is, decisions to acquire more than the MS B baseline capability—and such factors as management shortcomings and cost growth linked to duration. Cost growth due to program changes is likely to be the largest of these. It would follow from this that many of the MDAPs in Bust1 are relatively austere at MS B but their scope expands when the program subsequently enters a boom climate. Data presented in Chapter 3 (specifically, Section 3.E) suggest that that there is some substance to this conjecture, as about 35 percent of the cost growth of programs that passed MS B in bust climates is due to program changes. The proportion could be modestly higher for Bust1 programs.

A second question that needs to be asked is whether MDAPs that passed MS B in boom climates show the same pattern as that found for those that passed in bust climates. The nomenclature used for the boom periods parallels that used for bust periods. Boom0 programs passed MS B in a boom climate and were completed in that boom or the succeeding bust climate. Boom1 programs passed MS B during the Carter-Reagan defense buildup and were completed during the post-9/11 boom or during the following three years. There is no treatment group (i.e., no Boom1 group) for the second boom period and, hence, no natural experiment to examine.

There is less reason to expect a boom effect to appear in the data for programs that passed MS B in a boom climate because they presumably had more realistic baselines and were more robustly funded, at least initially. Average PAUC growth for the Boom1 programs of the first boom period (45 percent), however, is significantly higher than that for the Boom0 programs (12 percent) (see Table 6).[27]

Table 6. Average PAUC Growth for Completed MDAPs in DSARC/DAB-Boom by the Number of Boom Periods Experienced

Bin	1st Boom Period FY 1981–FY 1986	2nd Boom Period FY 2003–FY 2009
Boom0	12% (28)	2% (11)
Boom1	45% (7)	none

In fact, this finding may be spurious. Average PAUC growth for the Boom1 bin of the first boom period is dominated by three MDAPs, each of which had PAUC growth of more than 50 percent: C-17 (57 percent), T-45 Goshawk (70 percent), and JSTARS (123 percent). These programs were acquired with contracts that had the essential features of Total Package Procurement (TPP). A TPP contract covered EMD and procurement on a fixed price or not-to-exceed basis, and usually included some aspects of operations and maintenance. These contracts were competitively awarded. In almost all cases, TPP contracts were associated with high cost growth and schedule slips.[28] The PAUC growths of the C-17, T-45, and JSTARS programs were on a par with that of TPP programs that passed MS B during FY 1965–FY 1969 and did not continue into the Carter-Reagan boom. Their contracting strategy, then, not their continuation into a boom funding climate, probably accounts for their high PAUC growth. If the three TPP programs are excluded, the average PAUC growth for Boom1 is 17 percent, which is not significantly higher than the average for Boom0.[29] Three of the other four programs in Boom1 had conventional cost plus incentive fee contracts for EMD. The exception is Titan IV; its initial contract included some production satellites as well as EMD and satellites funded with RDT&E funds. This apparently is a fairly typical approach for satellite programs.

The data in Table 7, which combines that from Table 5 and Table 6, point to the implications of this discussion. There are two. First, these data make it clear that the higher PAUC growth of MDAPs that passed MS B in bust climates reflects a subset of those programs—those that passed MS B in a bust climate and continued on into a boom

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[27] K-S found the distribution of PAUC growth of the 28 Boom0 programs that passed MS B in the first bust phase to be non-normal. The Mann-Whitney U test (M-W U) found the difference between average PAUC growth of Boom0 and Boom1 for the first boom phase to be significant ($p = 0.007$, $U = 164.5$, $n_1 = 28$, $n_2 = 7$).

[28] See Chapter 7, pp. 89–90, especially Table 31.

[29] M-W U, $p = 0.117$ ($U_A = 83.5$, $U_B = 28.5$, $n_1 = 28$, $n_2 = 4$).

climate. Second, the average for Bust0 is significantly different from that for Boom0, although the difference is not large.[30]

Table 7. PAUC Growth for Completed Programs for the Combined Bust and the Combined Boom Phases of DSARC/DAB, excluding Bust2 and Selected TPP Programs in Climate

Bust Climates		Boom Climates	
Bust0	15% (16)	Boom0	9% (39)
Bust1	45% (55)	Boom1	17% (4)
Combined Bust	**38% (71)†**	**Combined Boom**	**10% (43)‡**

† Excludes the four programs in Bust2.

‡ Excludes three programs from the mid-1980s procured using a TPP-like contract.

The discussion now turns briefly to the McNamara-Clifford and AR periods. Table 8 presents average PAUC growth for these periods. In contrast to what was found for the DSARC/DAB-Bust period, for McNamara-Clifford, average PAUC growth for Bust0 programs is about two and one-half times that of Bust1 programs. The difference is statistically significant.[31] The anomaly here is not the average PAUC growth for Bust1—which is in line with the averages for the DSARC/DAB bust periods—but the exceptionally high cost growth of Bust0 for McNamara-Clifford. The cost growth data for AR are not useful for statistical analysis because only one Bust0 program (AV-8B Remanufacture) that passed MS B during that period had been completed by the December 2015 SARs.

Table 8. Average PAUC Growth for Completed Programs for McNamara-Clifford and AR

Acquisition Policy Configuration	Bin	Average PAUC Growth
McNamara-Clifford	**Bust0**	87% (12)
	Bust1	34% (4)
Acquisition Reform	**Bust0**	2% (1)
	Bust1	38% (18)

2. Program Duration

Figure 2 is a scatter diagram of PAUC growth versus program duration for completed MDAPs that passed MS B during the DSARC/DAB period in bust climates.

30 M-W U P = 0.072 (U = 409.5, n_1 = 39, n_2 = 16).

31 K-S and A-D find the distributions of PAUC growth in Bust0 and Bust1, respectively, to be consistent with a normal distribution. For a two-tailed t-test with correction for unequal variances p = 0.048.

As would be expected based on earlier studies, PAUC growth tends to increase with program duration.

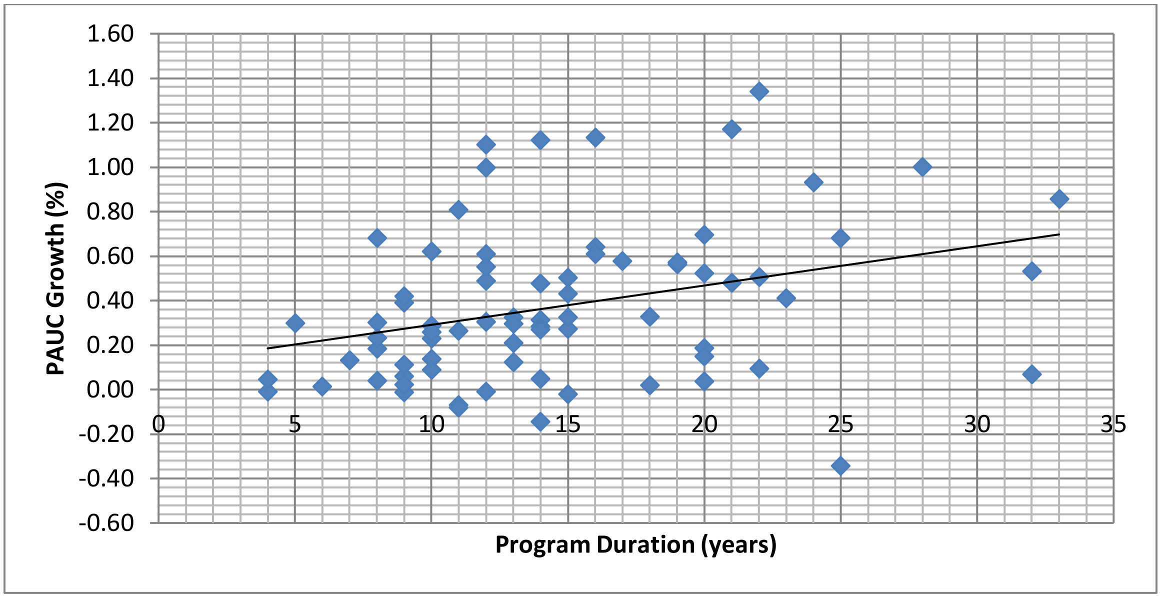

Figure 2. PAUC Growth and Duration for 75 MDAPs that Passed MS B during the Bust Funding Climates of DSARC (FY 1970–FY 1980) or DAB (FY 1990–FY 1993 and FY 2000–FY 2001)

It is useful to begin discussion of program duration by briefly calling to mind elements of PAUC growth that probably are associated with it. First, most MDAPs experience some degree of "requirements creep," that is modest changes, usually below the requirements level, in the capabilities of the program. Second, the conventional wisdom is that most programs are beset more or less annually by small across-the-board cuts used to redirect funding from ongoing MDAPs to other priorities. Third, the use of program base year dollars in computing PAUC growth is intended to remove inflation, but it may not do so to the extent that actual inflation differs from the inflation assumed in computations of costs in program base year dollars.

These comments imply that both program duration and the boom effect need to be considered in the statistical analysis. That might be done simply by including both separately. Doing so could be a problem, because the longer the duration of an MDAP in the sample, the greater the odds it entered a boom funding climate. Program duration is then a rough-and-ready surrogate for the boom effect, and if it is a sufficiently good surrogate, it is impossible to estimate the separate effects of duration and the boom effect. In this event, it would be best to exclude the separate marker for the boom effect and use just program duration.

An alternative to these two approaches takes off from the observation that boom effects are simply duration effects during a boom period. This suggests splitting program duration into two parts—time in bust periods and time in boom periods. The time a program spends in bust climates is expected to capture duration effects; time spent in boom climates captures boom effects that—in a boom climate—subsume duration effects. This is the approach adopted.

E. Uncontrolled Factors in the Natural Experiments

This section briefly considers some factors, in addition to the four discussed above, that some might argue need to be considered in an analysis of clustering of PAUC growth.

Those who approach cost growth in terms of previous statistical studies may instinctively reach for program characteristics at this juncture. These probably should not be included in addition to acquisition policy, however. A change in policy on contract types between the McNamara-Clifford years and the 1969 Packard reforms provides an excellent example of why this is so. McNamara required the use of TPP whenever it was judged to be feasible. As was noted above, in almost all cases, TPP contracts were associated with high cost growth and schedule slips. For this reason, Packard's new policy on contract types ruled out their use.

The point of this example is that there is a causal relationship between acquisition policy and program features that are the proximate causes of cost growth. Consequently, a statistical analysis can use either (1) acquisition policy bins or (2) program characteristics such as the use of TPP. It is not advisable for statistical reasons to employ in the analysis both acquisition policy bins and the program characteristics that they presumably influence.[32] This report uses acquisition policy and funding climate in place of various program features. Correspondingly, the structure of the statistical analysis assumes that program features (such as contract type and concurrency) reflect decision makers' risk tolerance and that these respond to acquisition policy and funding climate.

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[32] This conclusion rests on consideration of the top-to-bottom flow of causal influences on PAUC growth. A complete (conceptual) model of PAUC growth would fall into three blocks. The top-level block would characterize the determination of the degree of tolerance for risk in MS B baselines in terms of acquisition policy and funding climate. The second block—which would be extremely challenging to specify—would model the connection between risk tolerance and decisions on particular program features. The third block would relate PAUC growth and probably also schedule slips to program characteristics and also causes of cost growth that occur after MS B and increases beyond the MS B baseline in the capabilities to be acquired. This report explores a reduced form relationship derived from such a model. In this context, a relationship that included both acquisition policy bins and program characteristics would be the sum of a reduced form equation (found by substituting the first block into the second) and the third (structural) block. This is roughly analogous to adding a supply function to a demand function. Such a relationship probably should not be estimated by ordinary least squares (OLS) (because some of the right-hand-side variables are necessarily correlated with the error terms). The estimation problem is secondary, however. The real issue is what inferences (if any) could be drawn from an estimate of such a relationship.

A second set of factors that some would nominate are trends over time such as increases in system complexity and increases in the size of software suites. These do tend to increase the unit ***costs*** from one generation to the next for a given system type (see Section 1.B, p. 3. Many also assume that more recent MDAPs show more PAUC ***growth*** than do earlier MDAPs and point to trends over time in such program features as system complexity and software as the explanation. The underlying assumption is not accurate, however. If anything, after taking account of funding climate, PAUC growth for annual cohorts passing MS B has tended to decrease over time (see Chapter 3, Table 18, on page 40). Moreover, such features of the MS B baselines as complexity and projected software size are not obviously more important to PAUC growth than other features (for example, the maturity of critical technologies at MS B and whether the MS B PAUC estimate is realistic.)

A third set of factors are those suggested by previous quantitative studies, in particular:[33]

- PAUC growth tends to be lower for larger programs than it is for smaller programs.
- Some types of MDAPs (satellites and helicopters in particular) tend to have an average PAUC growth above the average for all MDAPs.

The second of these was explored to a limited degree and was found not to be statistically significant once account is taken of the other factors. The first was not examined because of statistical problems associated with measurements of program size.

Finally, while we consider initiatives on contract types and relaxation of acquisition regulations and statutes that arose in the Congress, this study does not include changes: (1) made by statute, (2) that fairly directly influence PAUC growth, and (3) that are not reflected in DoDD 5000.01 or DoDI 5000.02.[34] Probably the most important member of this category is the Nunn-McCurdy Act as amended in 2005. When the Nunn-McCurdy Act was initially passed in 1982, it required that the Congress be notified of unit cost growth above certain limits on an MDAP.[35] These limits were set above those in DoD regulations that required a report to the Milestone Decision Authority (MDA) of a breach in baseline cost. Clearly, the intent was that the more serious breaches be reported to the Congress. However, a baseline breach usually occurred first, and DoD could at that point

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[33] Drezner et al., *An Analysis of Weapon System Cost Growth*, 22–3, 28; and McNicol, *Cost Growth*, 40.

[34] This condition excludes several otherwise relevant congressional actions that simply put into statute acquisition policy changes DoD had already made.

[35] Department of Defense Authorization Act for FY 1983, Pub. L. No. 97-252, 96 Stat. 718 (1982), Section 1107. The two measures of unit cost used by Nunn-McCurdy were PAUC and APUC.

revise the baseline, thereby precluding a Nunn-McCurdy breach requiring a report to the Congress. It was not until 2005, when the Act was amended to require reporting against the *initial* baseline, that this loophole was closed off.[36] No attempt was made to include the effect of the 2005 change in the Nunn-McCurdy Act because this occurred late in the period considered and in a boom period when PAUC growth was so low that an attempt to tease out the factors involved did not seem worthwhile.

F. Concluding Comment

Chapter 3 picks up the discussion where this chapter leaves off. The text provides an informal statement of the proposition being considered and refers to the statistical results in terms such as: The average PAUC growth of MDAPs that passed MS B in a bust climate was significantly higher than those that passed in a boom climate. Alternatively: The average PAUC growth in the two funding climates was not significantly different. The tests used and the results of the statistical test on which the statement rests are reported in footnotes. The words “significant” and “significantly” should always be understood as being preceded by the word “statistically.”

Before turning to the statistical analyses, it also may be helpful to recall the conventions introduced above are used throughout the remainder of the report:

- **PAUC growth:** The term *PAUC growth* is used to mean PAUC growth from the MS B baseline computed using constant program year dollars and adjusted for changes in quantity acquired from that specified in the MS B baseline. The computations are described in Appendix A.
- **Acquisition Policy:** The term *acquisition policy* is used to include both changes in stated acquisition policy and changes in the acquisition process. The two typically are intertwined and the most successful changes in policy probably are those that become embedded in process.
- **Naming Convention:** Some features of the acquisition process during a particular time period were essentially the same as features from earlier periods but merely renamed; other features were newly introduced. These changes are noted only when necessary. Generally, the text adopts the names in use during the period FY 2000–FY 2009.

[36] NDAA for FY 2006, Pub. L. No. 109-163, 119 Stat. 3136 (2006), Sec. 802. For an explanation of the operation of the Nunn-McCurdy Act and an overview of its evolution see Moshe Schwartz, *The Nunn-McCurdy Act: Background, Analysis, and Issues for Congress* (Washington, DC: Congressional Research Service, 2010).

3. Statistical Analysis—Cost Growth

A. Introduction

This chapter reports the results of statistical analyses of the association between PAUC growth and the four factors identified in the preceding chapter:

- Acquisition policy
- Competition for funding
- Program duration
- Post-MS B funding climate

Section B considers only the first two topics introduced—acquisition policy and funding climate at MS B, using comparisons of average PAUC growth in various acquisition policy and funding climate bins. The advantages of this approach are, first, that the conclusions are visible in the tables and, second, that the argument is accessible to readers with little background in statistics. The statistical analysis (the details of which are placed in footnotes) tests whether the differences the eye sees are significant or, alternatively, are reasonably likely to have occurred by chance. Section C introduces what is called the baseline model, and Section D extends the analysis to the remaining two considerations—program duration and post-MS B funding climate. These sections make somewhat greater demands on readers' knowledge of modeling and statistics. Section E provides some data on cost growth due to program changes in response to an issue that emerges from the discussion in Section D.

B. Acquisition Policy and Funding Climate

Acquisition policy period and funding climate together define the two sets of natural experiments shown schematically in Figure 3. Each of the acquisition policy and funding climate pairs defines a "bin" into which will be placed average PAUC growth for MDAPs that passed MS B during the relevant period. McNamara-Clifford and AR did not include any boom years, so we have two empty bins. This array is useful because it organizes the PAUC growth data, acquisition policy periods, and funding climates in a way that bears directly on the main questions to be examined.

Acquisition Policy Configuration	Bust		Boom
McNamara-Clifford	1965–1969		none
DSARC	1970–1980	→	1981–1982
P-C DSARC	1987–1989	→	1983–1986
DAB	1990–1993 2001–2002	→	2003–2009
AR	1994–2000		none

Figure 3. Schematic Array of Natural Experiments on the Effects of Acquisition Policy and Funding Climate

Looking first at the Bust column (first vertical arrow), we have five bins, one for each of the acquisition policy configurations. Comparison of average PAUC growth in these bins might suggest that one acquisition policy configuration is particularly effective or especially ineffective or point to a trend over time in the effectiveness of acquisition policy. Similarly, (second vertical arrow) we can compare average PAUC growth for the three acquisition policies that were in effect in a boom climate. Again, this comparison has the potential to reveal something interesting about acquisition policy configuration. The three horizontal arrows call attention to the natural experiments that we have on the association of average PAUC growth and funding climate for a given acquisition policy. Do we in any of these three experiments find that average PAUC growth does not differ significantly between bust and boom climates? This result would be evidence that the acquisition policy configuration in question was reasonably effective, in that it is more difficult for the DAB to enforce realistic MS B baselines in bust climates. At the other extreme, average PAUC growth in the bust climate might be significantly higher than that of the corresponding boom climate. Such a result would indicate that the DAB process is not able to fully handle the additional stress associated with a bust climate. Finally, we might get a mixed outcome. (Average PAUC growth significantly lower in the bust climate for any of the three acquisition policy configurations that were in effect in both bust and boom climates would have sent this study back to the drawing board.)

1. Down the Columns—Changes in Acquisition Policy and PAUC Growth

As was noted in Chapter 1, Dews et al. (1979) found that the 1969 Packard reforms reduced average PAUC growth from its 1960s level. That result also appears clearly in Table 9—average PAUC growth for the McNamara-Clifford configuration (74 percent) is twice that of the bust climate portion of the DSARC period (37 percent). This difference is statistically significant.[37]

[37] K-S finds the data on PAUC growth for the DSARC to be consistent with a normal distribution and that for McNamara-Clifford to be marginally consistent with a normal distribution. For a two-tailed t-

Table 9. Average PAUC Growth for Completed Programs by Bust Periods

Acquisition Policy Configuration	Period (FY)	PAUC Growth
McNamara-Clifford	1965–1969	74% (16)
DSARC	1970–1980	37% (49)
P-C DSARC	1987–1989	34% (11)
DAB	1990–1993 2001–2002	40% (15)
AR	1994–2000	31% (19)

While a full discussion of program duration and post-MS B climate is postponed to Section D, these factors are not plausible explanations of the higher PAUC growth of the McNamara-Clifford period for this study's database. First, MDAPs in the database for the bust portion of the DSARC period had a longer average duration (15.1 yrs) than did those of the McNamara-Clifford period (13.1 yrs). Second, a higher proportion of programs that passed MS B in the bust portion of the DSARC period later entered a boom period (42 of 49); in comparison, only 4 of 16 McNamara-Clifford programs went on to enter a boom period.

The average PAUC growth for AR also is significantly less than that for McNamara-Clifford. While the averages for the P-C DSARC and DAB periods are also notably lower than McNamara-Clifford's 74 percent, these differences fall short of statistical significance. Nonetheless, there is enough evidence to suggest that the acquisition policy changes introduced by Packard in 1969 remained effective through the next four decades. This conclusion is tacked down in Section D.

These comments are about the comparison of PAUC growth in each of the four following periods to that of McNamara-Clifford. It is also useful to compare average PAUC growth in the four periods after McNamara-Clifford to each other. We find that the differences in the averages are not significantly different.[38] This is to say that changes in acquisition policy that followed the 1969 Packard reforms are not associated with any additional reductions (or in increases) in average PAUC growth.

test with unequal variances, $p = 0.072$. For the Mann-Whitney (M-W) U, $p = 0.103$, $U = 499.5$, $n_1 = 49$, $n_2 = 16$. The rationale for testing DSARC versus McNamara-Clifford without regard to PAUC growth in the other three configurations rests on the history presented in Chapter 5. The gist of that material for present purposes is that (1) the relevant features of the OSD-level oversight process in the DSARC configuration was substantially different from those of the McNamara-Clifford configuration; and (2) in comparison to the DSARC, the other three configurations do not present similarly large differences.

38 One-way Analysis of Variance (ANOVA), $p = 0.989$.

The data in Table 10 provide some insight into why the 1969 Packard reforms are associated with lower average PAUC growth. The PAUC growth of three of the 16 programs of the McNamara-Clifford years was large enough (at least 134 percent) to qualify as an outlier.[39] The striking feature of the data in Table 10 is the paucity of outliers after the introduction of the Packard reforms in 1969. Of the 94 MDAPs that passed MS B during the four post-McNamara-Clifford periods, only two had PAUC growth of at least 134 percent. This difference is statistically significant.[40] Similar differences were not found for PAUC growth of at least 50 percent and at least 100 percent.[41] It appears then that the 1969 Packard reforms worked in part by reducing the frequency of very high cost growth programs rather than by reducing cost growth on programs generally.

Table 10. Number of MDAPs in a Cohort with Average PAUC Growth for Completed Programs of at Least Three Specified Levels by Acquisition Policy Configuration during Bust Funding Climates

Acquisition Policy Configuration	Period (FY)	Average PAUC Growth	≥ 50%	≥ 100%	≥ 134%
McNamara-Clifford	1964–1969	74% (16)	9	4	3
DSARC	1970–1980	37% (49)	18	4	0
P-C DSARC	1987–1989	34% (11)	2	2	1
DAB	1990–1993 2001–2002	40% (15)	5	1	0
AR	1994–2000	31% (19)	5	1	1

The discussion now turns briefly to the association of changes in acquisition policy and PAUC growth for programs that passed MS B in boom climates. Table 11 reports average PAUC growth for MDAPs that passed MS B in the boom phase of the three policy configurations that were in effect during a boom climate—DSARC, P-C DSARC, and DAB. Average PAUC growth ranged from a low of 2 percent for DAB to a high of 20 percent for P-C DSARC. The differences across the three configurations are not statistically significant.[42] As is discussed in the following subsection, the higher average

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39 The definition of "outlier" used here is that proposed by John Tukey: observations 1.5 times the inter quartile range above the third quartile or below the first quartile. None of the outliers had exceptionally low PAUC growth.

40 Fisher's Exact Test (FET); $p = 0.021$. Application of FET to the five bins of the 134 percent column of Table 10 yields $p = 0.016$.

41 FET; $p = 0.297$ and $p = 0.271$ for 50 percent and 100 percent, respectively.

42 For one-way ANOVA, $p = 0.465$. K-S rejected the hypothesis that the data for the boom portion of P-C DSARC are normally distributed. The non-parametric Kruskal-Wallis (K-W) H test gives $H = 1.21$, $p = 0.546$. This conclusion does not change if the three TPP contracts are excluded. When this is done,

PAUC growth for the P-C DSARC configuration reflects cost growth on the three MDAPs that passed MS B in that period and were acquired with a TPP contract.

Table 11. Average PAUC Growth for Completed Programs in Boom Periods

Acquisition Policy Configuration	Period (FY)	PAUC Growth
McNamara-Clifford	**none**	n/a
DSARC	1981–1982	13% (6)
P-C DSARC	1983–1986	20% (29)
DAB	**none**	n/a
AR	**none**	n/a
DAB Post-AR	2003–2009	2% (11)

These results are not surprising. The expectation is that the baselines of MDAPs that pass MS B in boom climates will not be under as much pressure from tight funding and hence will be more realistic. If acquisition oversight is effective at preventing cost growth primarily by avoiding unrealistic cost baselines, there is no reason to expect that there will be an association between changes in acquisition policy configuration and PAUC growth for programs that passed MS B in boom climates.

2. Across the Rows—Change in Funding Climate within an Acquisition Policy Period

Table 12 presents the relevant data on the three natural experiments on funding climate. Acquisition policy configurations that do not enter into this section's analysis are marked in gray.

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p = 0.721 for one-way ANOVA; K-S continues to reject the hypothesis that the data for the boom portion of P-C DSARC excluding TPP programs are normally distributed; and K-W H, H = 0.8, p = 0.670.

Table 12. Average PAUC Growth for Completed Programs by Acquisition Policy Configuration and Funding Climate

Acquisition Policy Configuration	Bust		Boom	
	Period (FY)	PAUC Growth	Period (FY)	PAUC Growth
McNamara-Clifford	1965–1969	74% (16)	**none**	n/a
DSARC	1970–1980	37% (49)	1981–1982	13% (6)
P-C DSARC	1987–1989	34% (11)	1983–1986	20% (29)
DAB	1990–1993 2001–2002	40% (15)	2003–2009	2% (11)
AR	1994–2000	31% (19)	**none**	n/a

Average PAUC growth in each of the DSARC, P-C DSARC, and DAB configurations was noticeably higher in the bust climate. The differences for the DSARC and DAB are statistically significant, but the difference for the P-C DSARC is not.[43] If the evidence is taken at face value, P-C DSARC, in contrast to DSARC and DAB, seems to have been a relatively effective configuration. The obstacle to accepting this conclusion is the comparatively high average PAUC growth for programs initiated in the boom climate of P-C DSARC, which suggests that it was not so much successful in coping with a bust climate as not entirely successful in establishing realistic baselines in the boom climate.

An explanation for this is provided by programs acquired with TPP contracts. As was noted in Chapter 2, in almost all cases, TPP contracts were associated with high cost growth and schedule slips.[44] For this reason, Packard's 1969 acquisition reforms ruled out TPP contracts, the use of which McNamara had required when feasible. The prohibition on TPP was dropped in 1977 and an additional three programs that passed MS B in the Reagan boom years were acquired using TPP contracts.[45] If these three programs are excluded, average PAUC growth for the P-C DSARC period decreases to

43 For the DSARC period, $p = 0.088$ for a two-tailed t test with equal variances. K-S and A-D, respectively, find the data for each of the two climates of the DSARC years to be consistent with a normal distribution; an F test finds no significant difference between the two variances. The difference between average PAUC growth of programs that passed MS B in the two funding climates of the P-C DSARC years was not significant (M-W U, $p = 0.184$, $U = 204$, $n_1 = 29$, $n_2 = 11$). For the DAB period, $p < 0.001$ for a two-tailed t-test with unequal variances. K-S finds the data for each of the two climates of the DAB years to be consistent with a normal distribution; an F test finds a significant difference between the two variances.

44 See Chapter 7, pages 89–90, especially Table 31.

45 For FY 1970–FY 1980: FIM-92 Stinger, SURTASS/T-AGOS, and AGM-84A Harpoon. For FY 1983–FY 1986: T-45 Goshawk, JSTARS (USAF), and C-17A. The identifications are based on Tyson et al., "The Effects of Management Initiatives," Ch. X and Appendix A, Table A-10; and McNicol, *Cost Growth*, 53, 57–59.

12 percent, which is significantly less than the bust average of 34 percent[46] (see Table 13). Overall, the evidence suggests that the DAB process under each of the three policy configurations was not fully successful in establishing realistic MS B baselines in bust climates.

Table 13. Average PAUC Growth for Completed Programs by Acquisition Policy Configuration and Funding Climate excluding MDAPs Acquired using TPP Contracts Post-McNamara-Clifford

Acquisition Policy Configuration	Bust		Boom	
	Period (FY)	PAUC Growth	Period (FY)	PAUC Growth
McNamara-Clifford	1965–1969	74% (16)	**none**	n/a
DSARC	1970–1980	**37% (49)**	1981–1982	13% (6)
P-C DSARC	1987–1989	**34% (11)**	1983–1986	**12% (26)**
DAB	1990–1993 2001–2002	40% (15)	2003–2009	2% (11)
AR	1994–2000	**31% (19)**	**none**	n/a

Note: Three programs from the boom climate of P-C DSARC acquired using TPP are excluded.

3. Summary of Conclusions so Far

Table 14 summarizes the conclusions stated in the preceding subsections. These are provisional in that they do not fully consider post MS B funding climate and program duration, which are taken up in Section D. The remainder of the study is largely shaped by the first four conclusions (under Bust Periods) plus the association of PAUC growth and funding climate.

46 The bust climate of the P-C DSARC does not satisfy the K-S criterion for normality even with the TPP programs removed. M-W U rejects the hypothesis that average PAUC growth in the two climates is the same ($p = 0.037$, $U = 199$, $n_1 = 25$, $n_2 = 11$).

Table 14. Provisional Conclusions from Analysis of Acquisition Policy and Funding Climate

Down the Columns—Changes in Acquisition Policy and PAUC Growth	
Bust Periods	• The 1969 Packard reforms are associated with a reduction in average PAUC from its level for the McNamara-Clifford period. • Average PAUC growth remained well below its level in the McNamara-Clifford period for the bust climates of the succeeding acquisition policy periods (DSARC, P-C DSARC, DAB, and AR). • Reforms after the 1969 Packard reforms did not result in significantly lower (or higher) average PAUC growth. • The 1969 Packard reforms reduced average PAUC growth in part because they significantly reduced the frequency of very high PAUC growth programs.
Boom Periods	• Average PAUC growth of the three acquisition policy configurations that were in place during boom climates do not differ significantly from one another.
Across the Rows—Change in Funding Climate within an Acquisition Policy Period	
DSARC	• Average PAUC growth is significantly lower in the boom climate.
P-C DSARC	• Average PAUC growth is significantly lower in the boom climate if the three programs acquired using TP are excluded.
DAB	• Average PAUC growth is significantly lower in the boom climate.

C. The Baseline Model

This section revisits the results of the preceding section using a model-based approach. The "baseline model" is introduced at this point not because it yields different results—it does not—but to permit comparison with results for extensions of the model developed in the next section.

The baseline model is the following assumed relationship:

$$PAUC_i = a_0 + a_1Climate_i + a_2DSARC_i + a_3P\text{-}CDSARC_i + a_4DAB_i + a_5AR_i + e_i$$

The subscript i denotes the ith MDAP in the sample; $PAUC_i$ is the PAUC growth (as defined in Chapter 1) for the ith program. This model provides a baseline in that it includes as independent variables only funding climate and acquisition policy configuration.

Climate is a categorical variable; it takes on a value of zero for MDAPs that passed MS B in bust climates and 1 for those that passed in boom climates. The term a_0 is then the expected average PAUC growth for MDAPs that passed MS B in bust climates.[47] For MDAPs that passed MS B in a boom climate, the expected average PAUC growth is $a_0 + a_1$. The estimate of a_1 should be negative, that is, MDAPs that passed MS B in a boom climate should on average have lower PAUC growth. The model includes a categorical variable for each of four acquisition policy configurations, but not for the McNamara-Clifford configuration. For technical reasons, one of a set of categorical variables always must be omitted (or the constant term constrained to zero). The selection of the omitted variable is arbitrary insofar as the statistics are concerned; the McNamara-Clifford configuration was chosen because that is convenient for the exposition. The categorical variables for acquisition policy configurations have a value of 1 for the years of the configuration in question (e.g., FY 1994–FY 2000 for AR), and zero for other years. Finally, the error term e_i represents myriad unpredictable factors that influence PAUC growth; it is assumed to be a normally distributed random variable with a mean of zero and constant variance.

The results are presented in Table 15. The coefficients are estimated using ordinary least squares (OLS) (also known as multiple regression, linear regression, and least squares regression).[48] Three programs from the early 1980s boom period that were acquired using variants of TPP and—for reasons stated in the following section—the four programs of Bust2 are omitted.

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[47] The estimate of a_0 also includes the average net effect of any relevant variables not included in this model, and the effect on the estimated intercept of any non-linearity in the response of PAUC growth to the model's explanatory variables.

[48] Readers unfamiliar with this technique can find an explanation in any introductory econometrics text, in many introductory statistics texts, or on the internet. For example, see "How to Find Relationship between Variables, Multiple Regression," TIBCO Statistica, http://www.statsoft.com/Textbook /Multiple-Regression; "STAT 501: Regression Methods, Lesson 5: Multiple Linear Regression," Penn State Eberly College of Science, https://onlinecourses.science.psu.edu/stat501/node/283; John H. McDonald, *Handbook of Biological Statistics*, http://www.biostathandbook.com /multipleregression.html; and Online Statistics Education: An Interactive Multimedia Course of Study, David M. Lane, Chapter 14, "Introduction to Multiple Regression," http://onlinestatbook.com/2 /regression/multiple_regression.html.

Table 15. Estimated Parameters of the Baseline Model of PAUC Growth

	Coefficient	p-value
Intercept	86.8%***	< 0.001
Funding Climate		
Climate	-28.0%***	0.006
Acquisition Policy		
DSARC	-48.2%***	< 0.001
P-C DSARC	-48.3%***	0.001
DAB	-51.0%***	< 0.001
AR	-65.4%***	< 0.001

*** Statistically significant at less than the 1 percent level.

R-Square = 0.22 F = 8.00 (P < 0.001) N= 149. Estimated by Ordinary Least Squares (OLS). Bust2 programs and the three mid-1980s MDAPs acquired using TPP-like contracts omitted. Wald's F with the Bonferroni correction[49] is used to test for the equality of the estimated coefficients of the categorical variables for acquisition policy periods. The result is F = 0.71, p > 0.999.

The p-value characterizes statistical significance; any estimate with a p-value of no more than 0.10 is referred to as "statistically significant." A p-value of 0.10 means that there is an (estimated) one chance in ten that the observed estimate would occur by chance even if the true value of the coefficient were zero. Lower p-values imply that a spurious indication of significance ("false positive") is even less likely; i.e., the result is even more compelling.

Criteria typically used to judge regression equations readily accept the results in Table 15:

- The estimated coefficient of each of the independent variables has the expected sign.
- Their magnitudes are reasonable (as is that of the intercept).
- The intercept and the estimated coefficients of the independent variables are highly significant.
- The estimated equation as a whole is highly significant.

[49] The Bonferroni correction effectively increases the critical value used to judge statistical significance to recognize that in multiple comparisons there is a considerable chance of a significant difference arising randomly even if the underlying population values are identical. With four configurations, six pair-wise comparisons can be made. Under the null hypothesis that PAUC growth has the same distribution for each of the four configurations, the probability is 0.47 that at least one of the six comparisons would purely by chance be significant at the 10 percent level. If it is not corrected for this fact, the p-value associated with Wald's F-statistic overstates the probability that there are differences among the PAUC distributions in the four configurations.

- The proportion of the variation in PAUC growth within the sample that is captured by the estimated equation is towards the upper end of what can be reasonably expected for panel data.

The estimated coefficient of each of the acquisition policy categorical variables is the expected difference between average PAUC growth in that bin and average PAUC growth in McNamara-Clifford. That difference is statistically significant if the estimated coefficient of the acquisition policy categorical variable is statistically significant.[50] The estimates in Table 15 then imply:

- The 1969 Packard reforms of acquisition policy (which defines the DSARC bin) resulted in a significant reduction in average PAUC growth compared to that of the preceding McNamara-Clifford configuration.
- The other three acquisition policy configurations (P-C DSARC, DAB, and AR) also had average PAUC growth significantly lower than that of McNamara-Clifford.

We also tested for differences in average PAUC growth across the four post-McNamara-Clifford periods, with the following result: average PAUC growth in the four post-McNamara-Clifford acquisition policy bins did not differ significantly from one another.[51] Finally, average PAUC growth in the boom climate is significantly less than that for bust periods for the three acquisition policy configurations that operated in both.[52]

In brief:

- Funding climates have the expected association with PAUC growth.
- The 1969 Packard reforms reduced average PAUC growth.
- The reduction persisted through the end of the study period (FY 2009).

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50 Note that for the observations of the McNamara-Clifford configuration, $PAUC_j = a_0 + e_j$, and since it is assumed that $E(e_j) = 0$, $E(PAUC_j) = a_0$. If the underlying model is correct and the assumptions of OLS are satisfied, the estimated value of the intercept (denoted $\hat{a}_0$) is an unbiased estimate of a_0 and of the sample value of the average PAUC growth of McNamara-Clifford. Similarly, the expected value of the intercept and the average PAUC growth for the ith acquisition policy bin is $a_0 + a_i$ and the difference between that and the average for the reference group is $a_0 - (a_0 + a_i) = -a_i$. Hence, if $\hat{a}_i$ is statistically significantly different from zero, the average PAUC growth for acquisition policy configuration i is significantly different from average PAUC growth for McNamara-Clifford. The burden of the assumptions is lightened by the fact that, in this context, "just about" counts. For example, no great harm is done if $E(e_j)$ is small rather than zero.

51 This statement rests on the results of Wald's test with the Bonferroni correction. Wald's test, as used here, tests whether, considered jointly, any of $\hat{a}_1$, $\hat{a}_2$, $\hat{a}_3$, and $\hat{a}_4$ is significantly different from the others.

52 Evaluations of the reasonableness of the estimated coefficient of Climate must weight by the proportion of the acquisition policy configuration spent in bust and boom climates.

- Changes to acquisition policy after the 1969 Packard reforms through FY 2009 were not associated with further reductions in average PAUC growth.

The results in Table 15, in addition, provide an indication that the Packard reforms reduced the frequency of programs with extremely high cost growth. Ordinarily, when outliers (of the dependent variable) are removed from the dataset, the test statistics of the regression improve. This is not the case for the baseline model. If PAUC and duration outliers and programs procured with TPP are removed from the data set, three of the four estimated coefficients of acquisition policy bins (including that for DSARC) are not statistically different from zero. The point is that the results are driven by the extreme values of PAUC growth. That is to say, the 1969 Packard reforms were effective in part because they reduced the frequency of MDAPs with extremely high PAUC growth.

D. Extension of the Model to Include Duration and Boom Effects

Figure 4 is drawn from data presented in Table 5 and Table 6 (pages 18 and 19). It is a reminder that program duration and boom effects are entangled and that boom effects appear to be larger for programs that passed MS B during a bust period.

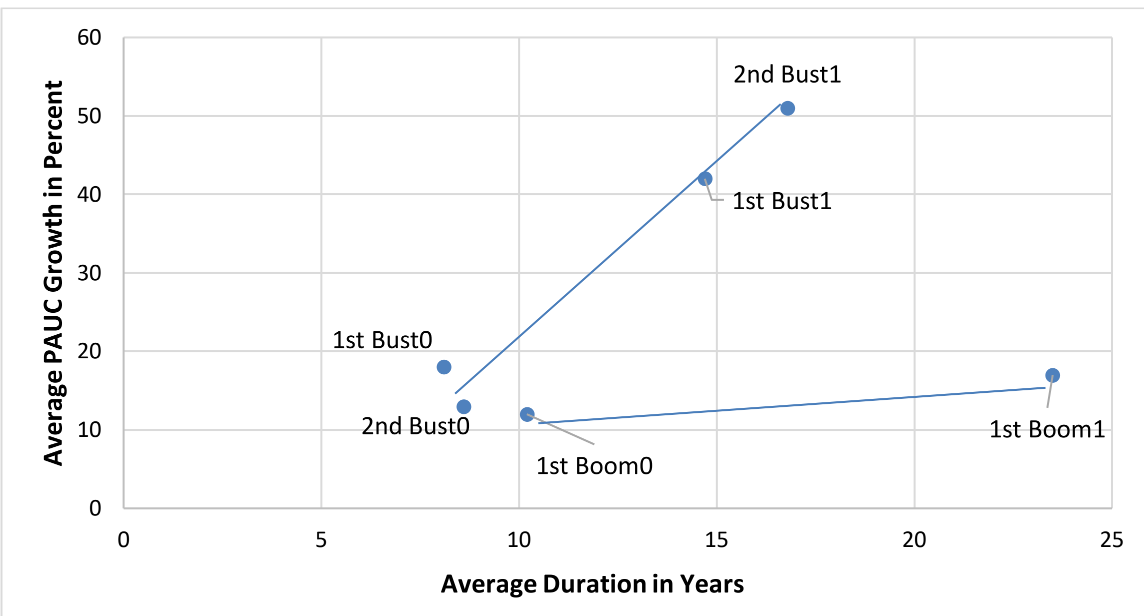

Figure 4. Average PAUC Growth and Average Program Duration for Boom and Bust Climates

Section 2.D.2 argued that a reasonable way to separate the boom effect from a duration effect is to enter into the model a variable defined as the number of years spent in boom climates (T_{boom}) and another variable that is the number of years spent in bust climates (T_{bust}). Very simple definitions of T_{boom} and T_{bust} were adopted:

- T_{boom} = number of years in boom climates post-MS B
- T_{bust} = number of years in bust climates post-MS B

Note that this counts a year during which the program was in EMD the same as a year in which the program was in production. There are several alternatives to this definition. For example, the duration variables might be defined as the years in boom and bust climates, respectively, after the program enters low-rate initial production (LRIP).

Setting aside for the moment the categorical variables for the acquisition policy configurations, the core model considered is:

$$PAUC_i = a + bClimate + cT_{boomi} + dT_{busti} + v_i ,$$

where again $PAUC_i$ is PAUC growth of the ith program and v_i is the error term. Note that c and d are measured in units of percentage points per year; they are the rates at which programs' PAUC growth increases per year in boom and bust climates, respectively. We expect the estimated coefficient of Climate to be negative, implying that programs that passed MS B in boom climates have lower PAUC growth than those that passed in bust climates. This specification also allows for climate effects in that the estimates of c and d may be different. In particular, we would expect the estimate of c to be larger than that of d—that is, that PAUC growth accumulates more rapidly in boom than in bust years.

Table 16 presents the estimated parameters of this model expanded to include the categorical variables for the acquisition policy configurations.[53] The estimated coefficient for T_{boom} (which is statistically significant) implies that MDAPs add about 3.8 percentage points of PAUC growth for each year spent in a boom climate. The corresponding figure for bust climates (which is not significant) is 0.59 percentage points per year. The pattern of results for the coefficient of the climate variable and the coefficients of the categorical variables for the four acquisition policy configurations is by now familiar: the 1969 Packard reforms resulted in lower PAUC growth and that effect persisted.

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[53] The use of OLS assumes that T_{boom} and T_{bust} are independent of PAUC growth. If this assumption fails, the OLS coefficient estimates are biased. Loosely, the magnitude of the bias depends on the extent to which the two duration terms are related to PAUC growth. If the correlation is small, which is a reasonable assumption, then so is the bias in the OLS estimates. See Franklin M. Fisher, *The Identification Problem in Econometrics* (New York, McGraw-Hill, 1966), 85–7.

Table 16. Estimated Coefficients and p-values for a Model that Includes the Effects of Post-MS B Funding Climate and Duration

	Coefficients	p-value
Intercept	73.1%***	< 0.001
Funding Climate		
Climate	-28.7%***	0.009
T_{boom}	3.8%/yr***	0.021
T_{bust}	0.59%/yr	0.515
Acquisition Policy		
DSARC	-56.7%***	< 0.001
P-C DSARC	-50.3%***	0.001
DAB	-59.5%***	< 0.001
AR	-80.2%***	< 0.001

*** Statistically significant at less than the 1 percent level.

R-Squared = 0.26, F = 7.02 (P < 0.001), N= 149. Estimated using OLS. Bust2 programs and the three mid-1980s MDAPs acquired using TPP-like contracts omitted. Wald's test for the equality of the estimated coefficients of the categorical variables for acquisition policy periods with the Bonferroni correction yields F= 1.43, p = 0.0.946.

An alternative to the climate variable as a way to incorporate climate effects into the model uses what are called slope categorical (or indicator) variables, one for boom years (T_{boom} × Climate) and one for bust years (T_{bust} × Climate). (Recall that Climate takes on a value of zero for MDAPs that passed MS B in bust climates and 1 for those that passed in boom climates.) In this approach, climate effects are captured in the estimated coefficients of T_{boom}, T_{bust}, and the slope categorical variables. As is explained below, introduction of these variables allows the regression to pick different rates of cost accumulation for MDAPs that passed MS B in boom climates than for those that passed in bust climates. We expect that MDAPs that passed MS B in boom years accumulate cost at lower rates in both bust and boom years than MDAPs that passed MS B in bust years. The estimated coefficients for T_{boom} × Climate and T_{bust} × Climate are then expected to be negative.

Table 17 presents the estimated coefficients and p values for this alternative. Note that for programs that passed MS B during a bust climate, Climate = 0. The estimated rates at which PAUC growth accumulates for these programs are then 4.7%/yr. in boom climates and 0.9%/yr. in bust climates. The latter estimate is not statistically significant. For programs that passed MS B in a boom climate, Climate = 1. The accumulation rates for MDAPs that passed MS B in a boom climate are then -1.0%/yr. in a boom climate (=4.7%/yr -5.7%/yr), which is statistically significant, and 0.3%/yr (=0.9%/yr.-0.6%/yr) in a bust climate, which is not.

Table 17. Estimated Coefficients and p-values for a Model that Includes the Effects of Post-MS B Funding Climate and Duration (Alternative 1)

	Coefficients	p-value
Intercept	67.9%***	< 0.001
Funding Climate		
T_{boom}	4.7%/yr***	0.008
T_{boom} × Climate	-5.7%/yr*	0.057
T_{bust}	0.9%/yr	0.384
T_{bust} × Climate	-0.6%/yr*	0.698
Acquisition Policy		
DSARC	-57.8%***	< 0.001
P-C DSARC	-53.5%***	< 0.001
DAB	-61.8%***	< 0.001
AR	-83.5%***	< 0.001

* Statistically significant at less than the 10 percent level.

** Statistically significant at less than the 5 percent level.

*** Statistically significant at less than the 1 percent level.

R-Squared = 0.27, F = 6.475 (P < 0.001), N= 149. Estimated using OLS. Bust2 programs and the three mid-1980s MDAPs acquired using TPP-like contracts omitted. Wald's test for the equality of the estimated coefficients of the categorical variables for acquisition configurations with the Bonferroni correction yields F= 0.191, p = 0.762.

Finally, it is worth considering a version of the model in which the four categorical variables for the acquisition policy configurations are replaced by a time trend. The coefficient estimates obtained are reported in Table 18.

Table 18. Estimated Coefficients and p-values for a Model that Includes the Effects of Post-MS B Funding Climate and Duration (Alternative 2)

	Coefficients	p-value
Intercept	10.0%	0.222
Funding Climate		
T_{boom}	2.7%/yr**	0.008
T_{boom} × Climate	-1.6%/yr	0.360
T_{bust}	2.0%/yr***	0.004
T_{bust} × Climate	-1.8%/yr**	0.037
Time Trend		
Time	-0.4%/yr*	0.089

* Statistically significant at less than the 10 percent level.

** Statistically significant at less than the 5 percent level.

*** Statistically significant at less than the 1 percent level.

R-Squared = 0.28, F = 10.246 (P < 0.001), N= 137. Estimated using OLS. Omitted Bust2 programs, all MDAPs acquired using TPP-like contracts, and MDAPs with PAUC growth that is an outlier by Tukey's definition (1.5 times the inter quartile range above the third quartile or below the first quartile).

Because MDAPs with very high or very low PAUC growth can dominate the estimated coefficient of a time trend, for this model the estimates were computed excluding outliers and all MDAPs acquired using TPP, including those in the McNamara-Clifford period. The estimated coefficient of Time is -0.4 percentage points per year; that is, average PAUC growth for MDAPs that passed MS B in a given year has decreased by about 0.4 percent per year over the period covered by this study. This estimate is statistically significant. Some may assume that the time trend is a rough surrogate for ongoing changes in acquisition policy. We do not know what the Time variable picks up, however. The significant negative estimate is an intriguing result but not one that we can clearly relate to the myriad changes in acquisition policy over the past half-century.

E. Cost Growth Due to Program Changes

The point of departure for this section is the finding that programs that pass MS B in bust climates accumulate cost growth in both subsequent boom and bust climates at greater rates than do programs that passed MS B in a boom climate. This could occur because programs were expanded when they entered a favorable funding climate. Alternatively, the finding might indicate that programs with unrealistic MS B baselines took advantage of a boom funding climate to "get well."

The Global Broadcast System (GBS) provides an example of a program whose content was increased early in the post-9/11 boom:

> The current GBS architecture is based on Asynchronous Transfer Mode (ATM) technology…. In December 2002, DoD directed GBS's migration

> to a more sustainable commercial and standards-based open architecture, based upon the Internet Protocol (IP). Also, the GBS program received FY03 Iraqi Freedom Funds (IFF) supplemental funding for IP Acceleration of production units to replace deployed ATM units. Based upon extensive warfighter inputs, the accelerated IP production effort included design and development of a new, single case version of the Receive Suite (88XR) for the Army, Navy, and Marine Corps.[54]

Space Based Infrared Satellite-High (SBIRS-High) is a convenient and useful contrast to GBS. As of the December 2015 SARs, funding for the Baseline SBIRS-High program was expected to end in FY 2018. A large portion of the growth in SBIRS-High unit procurement cost for the baseline program—roughly one-third—occurred before FY 2003, while most of the other two-thirds occurred during FY 2003–FY 2009. This increase was not driven by increased capability, however, but by the unrealistic cost estimate in the MS B SBIRS-High baseline.[55]

In the GBS example, it seems clear that capabilities beyond those in the MS B baseline were added to the program. While unit cost did increase, that was a matter of paying more for more. For SBIRS-High, in contrast, it appears that the advent of a boom funding climate provided a program experiencing severe problems an opportunity to "get well." In effect, what otherwise would have been capability shortfalls were converted into cost growth and, relative to MS B, DoD eventually paid more for the MS B capability than had been anticipated. The boom effect includes both of these cases. So does accretion of PAUC growth during bust years.

During a period of nearly 20 years starting in 1989, The OSD Office of Program Analysis and Evaluation (PA&E) funded development of a database that separated cost growth due to program changes[56] from cost growth due to what PA&E called "mistakes." (The successor to PA&E is the Office of Cost Assessment and Program Evaluation, CAPE.) As defined by PA&E, "mistakes" were composed of three parts: (1) cost growth due to unrealistic aspects of the MS B baselines, (2) cost growth from problems that arose post-MS B (e.g., management lapses),[57] and the costs of adjustments due to events

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[54] *Selected Acquisition Report: Global Broadcast System*, December 2003, 7.

[55] See Porter et al., "The Major Causes of Cost Growth in Defense Acquisition," especially ES-29. See also Obaid Younossi et al., *Improving the Cost Estimation of Space Systems*, MG-690-AF (Santa Monica, CA: The RAND Corporation, 2008), 26–7; and Yool Kim et al., *Acquisition of Space Systems, Volume 7: Past Problems and Future Challenges*, MG-1171/7-OSD (Santa Monica, CA: The RAND Corporation, 2015), 7.

[56] A major difficulty in separating program changes from errors of inception is ambiguity in statements of capabilities to be acquired. Those responsible for compiling the PA&E database were well aware of this problem.

[57] In the terminology used by the Office of Program Assessments and Root Cause Analyses (PARCA) there are respectively errors of inception and errors of execution.

external to the program. The term does not include cost growth due to decisions to acquire more (or less) capability than that specified in the MS B baseline. A CD included with this report contains a briefing that describes the PA&E database. The data in Table 19 are drawn from the version of the PA&E database updated through the December 2002 SARs.[58]

Table 19. PAUC Growth Due to Errors and Program Changes

Cycle	Period (FY)	Number of MDAPs that Passed MS B	Errors†	Program Changes‡	Total	Program Changes as a Percent of Total
Boom	1981–1986	35	4%	11%	14%#	79%
	1970–1980	42	24%	14%	38%	37%
Bust	1987–1997	46	21%	10%	31%	32%
	Combined bust	88	22%	12%	34%	35%

† The category is the sum of PAUC growth due to unrealistic MS B baselines, management errors, and events external to the program.

‡ Changes made as a result of decisions to alter from the MS B baseline the capabilities the program is to acquire.

Components do not add to the total because of rounding error.

In the boom climate FY 1981–FY 1986, program changes were almost 80 percent of the total PAUC growth. In the bust periods, however, PAUC growth due to program changes was about one-third of the total. These data imply that the higher PAUC growth of programs that passed MS B in bust climates is primarily due to errors. Errors due to unrealistic baselines are expected to be small in MDAPs that pass MS B in boom climates. Consequently, the PAUC growth due to Errors in the 1981–1986 bin is mainly due to causes that arise after MS B. If this is accepted, the data in Table 10 imply that the average PAUC growth of MDAPs that passed MS B in bust climates due to unrealistic MS B baselines is about 17 to 20 percentage points.

F. Concluding Comment

This concludes the statistical analysis of PAUC growth. The next chapter presents a broadly similar statistical analysis of cancellations of MDAPs. The question addressed there is whether we can discern intelligible clusters of cancellations that shed some light on the roles of acquisition policy and other factors, particularly funding climate, in cancellations.

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58 This is the database used in McNicol, *Cost Growth,* 2004.

4. Statistical Analysis—Cancellations and Truncations

A. Introduction

Cancellation of an MDAP happens relatively infrequently; therefore, they do not get the day-by-day attention afforded to programs with high cost growth. They are, however, frequently cited as an important criticism of the DoD acquisition program and for that reason deserve attention in this study. Truncations—that is, procurement of far fewer units of a system than originally intended—also need to be considered, because they can amount to a partial cancellation.

This chapter provides an analysis of cancellations and truncations of MDAPs along the lines of that provided in Chapter 3 for PAUC growth. Section B presents some background information on cancellations and truncations. Sections C and D in turn take up questions that parallel those of Chapter 3:

- Is there a statistical association between changes in acquisition policy (given funding climate) and the frequency of cancellations and truncations?
- Are changes in DoD procurement funding associated with cancellations and truncations (given acquisition policy)?

Conclusions reached are summarized in Section E.

B. Background on Cancellations and Truncations

Apart from case studies, we found no studies of cancellations or truncations. This section partially fills that gap with a brief survey of cancellations and truncations followed by an examination of the conventional wisdom that most cancellations are due in considerable part to high cost growth.

1. A Brief Census of Cancellations and Truncations

An MDAP was classified as cancelled if:

- The program did not result in production of any fully configured end items, or
- Any fully configured end items produced were used only for testing and development.

Application of this definition was not clear-cut for six programs that passed MS B at the Service level, later filed SARs, and subsequently were cancelled. The five that had been designated as an ACAT I program were included in the database as cancelled programs and the one that had not become an ACAT I program was excluded.[59] In addition, four MDAPs that fit the definition more closely than not were counted as cancelled.[60] Altogether, 58 of the 311 MDAPs in the database that entered EMD during FY 1965–FY 2009 were classified as cancelled. Twelve programs that filed at least one SAR during the period FY 1965–FY 2015 but were not designated as ACAT I and/or did not pass MS B also were cancelled. These programs are not in the database or included in the list of cancelled programs.

Table 20 presents data on cancellations. The cancellation rate for Joint programs (28 percent) is somewhat higher than the average for Service-managed programs (about 17 percent). Among Service-managed programs, the Department of the Navy has the lowest cancellation rate (13 percent) and the Army the highest (25 percent).

Table 20. Cancellations, Total Programs, and Cancellation Ratios by Military Department and Joint Programs

	No. of Cancellations	No. of Programs	Cancellation Rate
Army	19	77	25%
Navy	14	110	13%
Air Force	12	78	15%
Joint	13	46	28%
Total	**58**	**311**	**19%**

The final SAR for an MDAP that has been cancelled usually identifies (with varying degrees of clarity) who initiated the cancellation. A relatively clear example is: "President Bush ordered the termination of [SRAM II] on 27 Sept. [19]91."[61] An example from the "less clear" end of the scale is provided by the Joint Ground Launched Tacit Rainbow. The final SAR for the program states that its funding was not included in the "FY92–FY93 President's Budget" and that the program was cancelled by the Secretary of Defense.[62] This statement is ambiguous because it might be nothing more than a *pro forma* recognition that the Secretary of Defense approved the entire DoD

59 The five included as cancelled were AN/WQR-Advanced Deployable System, AQM-127A Supersonic Low Altitude Target, Advanced Seal Delivery System, ASM-135A Air-Launched Anti-Satellite System, and Land Warrior. Extended Range Munition was cancelled before it was designated an ACAT I program. This is an instance—of which there is a considerable number—of a program that filed one or more SARs before it became an ACAT I program.

60 The four were Roland, Safeguard, WIN-T Increment 3, and C-27J.

61 *SAR for SRAM II*, December 31, 1991, 7.

62 *SAR for the BGM-136 Joint Ground Launched (JGL) Tacit Rainbow*, December 31, 1990, 4.

budget request. Using what is available in the SARs supplemented by materials found on limited searches on the internet, the initiative for each cancellation was attributed to a Military Department (MilDep), OSD, the White House, or the Congress. In those cases in which the SAR provided no evidence that the cancellation was initiated by the Congress, the White House, or one of the MilDeps, responsibility was assigned to OSD on the theory that the cancellation most likely occurred during the fall OSD Budget Review.

The results are reported in Table 21. A little more than one-third of cancellations are attributed to MilDeps. A cancellation, however, may actually be initiated by an organization other than the one formally responsible for it. There are cases in which, for example, a MilDep cancels a program because it appears highly likely that if it does not do so, OSD or the Congress will—in which case, OSD or the Congress probably will decide how to reallocate the funding.

Table 21. Number and Proportion of Cancellations Initiated by Different Levels of Government

Government Entity	No. of Cancellations	Proportion of Cancellations
Military Department	21	36%
OSD	23	40%
White House	4	7%
Congress	10	17%
Total	**58**	**100%**

The definition of cancellation used here ensures that all cancelled programs were in EMD or in the early stages of LRIP. In fact, all but 12 were in EMD and only one, the C-27J, was in Full Rate Production (FRP). The average time from MS B to cancellation was 5.5 years, and half of all cancellations occurred when the program was no more than 4.8 years beyond MS B, as shown in Figure 5. The distribution has a fairly long tail, however. One program was cancelled over 19 years after it passed MS B and two others were cancelled after more than 12 years.

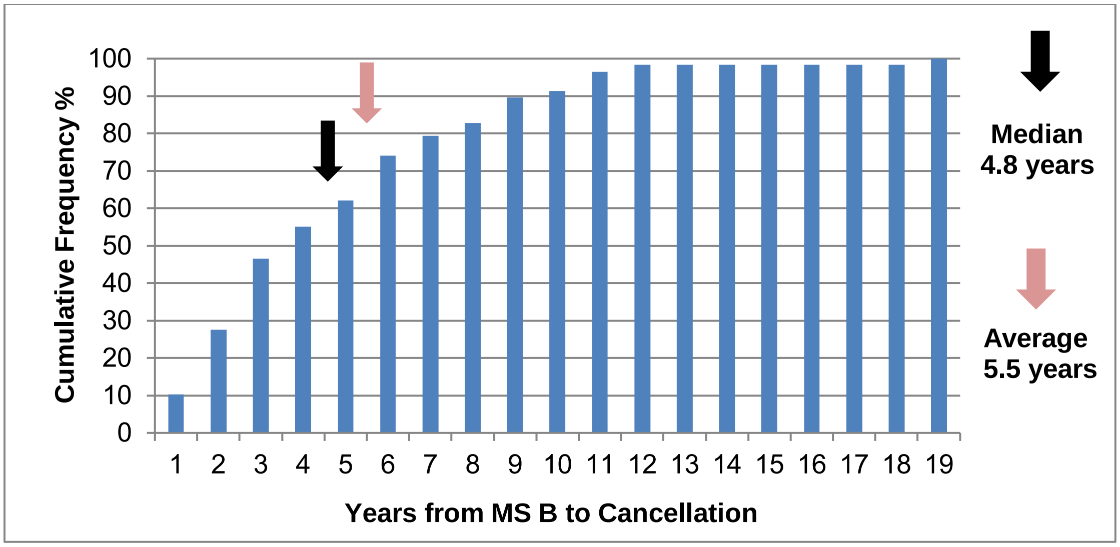

Figure 5. Cumulative Distribution of Time between MS B and Cancellation

The discussion now turns from cancellations to truncations. In most cases, the MS B baseline includes a statement of the total number of fully configured end items to be acquired. The final SAR for a program should report the total number of units actually acquired. Because programs that acquire more than the MS B baseline quantity have a negative truncation ratio, it is preferable to refer to completion ratios. The completion ratio for a program is simply the total number of end items acquired divided by the anticipated number in the MS B baseline.[63]

The extent to which a program has acquired less or more than its MS B baseline quantity can be gauged reliably only after the program has ended, because the size of the planned buy can be cut one year, the cut restored the next year, and the quantity increased beyond the MS B baseline the year after that. For this reason, the completion ratios used in the analysis are for completed programs only.

The database used in this report contains the MS B baseline quantity and the quantity actually acquired for 162 completed MDAPs that began EMD during the period FY 1965–FY 2009. Figure 6 is a histogram of the percentage of the respective MS B quantities acquired by these programs. The median program acquired 100 percent and the average program acquired 118 percent of the MS B baseline quantity. About 60 percent of the MDAPs in the sample acquired at least 90 percent of their MS B baseline quantity.

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63 The total number of units acquired includes both those purchased with procurement funds and those purchased with RDT&E funds. Care must be taken with regard to the SAR definition of the number of fully configured end items acquired. That definition sometimes is changed during the course of a program.

These figures are somewhat higher than is commonly appreciated and serve to limit the extent to which truncations reasonably can be viewed as a major problem.

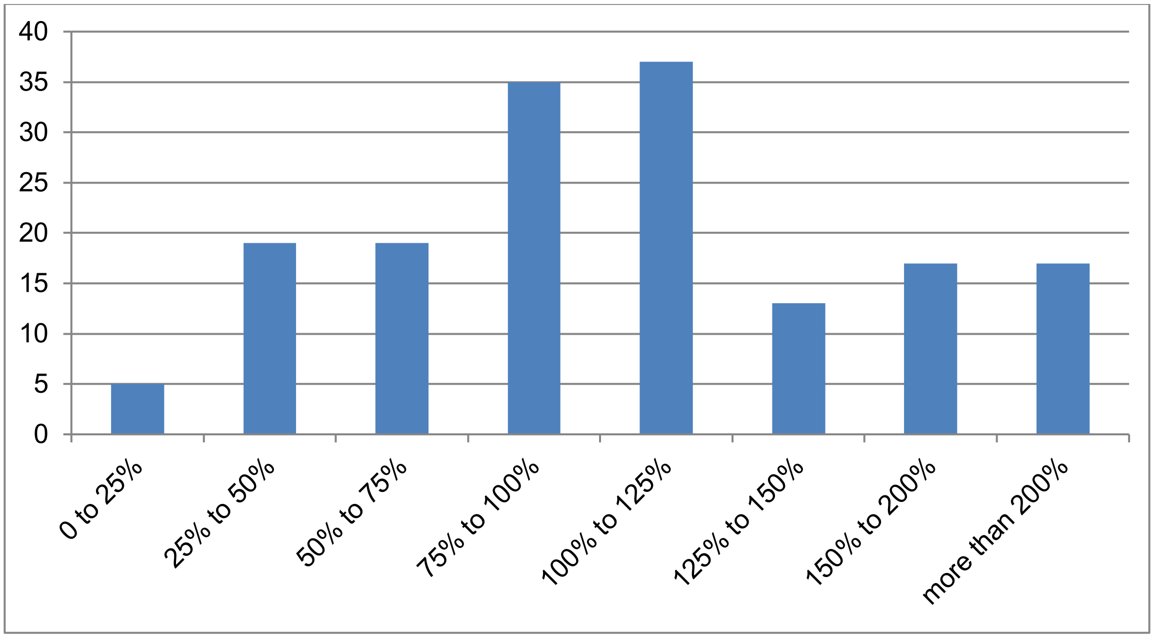

Figure 6. Histogram of the Percentage of the MS B Baseline Quantity Acquired by 162 Completed MDAPs that Passed MS B FY 1965–FY 2009

Twenty-three of the 162 completed programs (about one in seven) acquired less than 50 percent of their MS B baseline quantity. Some of these would fit comfortably on a list of cancelled programs; others would not. The F-22, for example, acquired only 29 percent of its MS B quantity, and the F-14D, only 18 percent. In short, there does not seem to be any bright line that separates truncations into those that are essentially cancellations and those that are not.

2. Cost Growth and Cancellations and Truncations

High unit cost growth commonly is thought to be a major factor in MDAP cancellation decisions. This supposition is plausible because substantial growth in unit cost not only raises a question about affordability but also tends to call into question the relevance of the Analysis of Alternatives (AoA) that informed the decision to acquire the system: at some point, the increase in unit cost presumably would tip the balance in favor of another alternative.

For the purposes of this discussion, high unit cost growth is defined as quantity-adjusted PAUC growth of at least 50 percent against the MS B baseline.[64] A first interpretation of the conventional wisdom on unit cost and cancellations is that all programs with high PAUC growth are cancelled. The data provided in the "Completed" column of Table 22 bear on this possibility. Of the 156 completed MDAPs with a PAUC growth estimate, 43 had PAUC growth of at least 50 percent. The average PAUC growth of these programs was 93 percent, and PAUC at least doubled for nine of the 43. Clearly, then, not all MDAPs with high cost growth were cancelled.

Table 22. Distribution of PAUC Growth for Completed and Selected Cancelled MDAPs

PAUCH Growth Categories	Completed	Cancelled
At least 50%	43	10
Between 30% and 50%†	19	0
Between 0% and 30%	66	10
Less than 0%	28	5
Total	**156**	**25‡**

† These limits are motivated by those of the Nunn-McCurdy Act—PAUC growth of at least 50 percent against the original baseline for a critical breach and 30 percent for a significant breach. Note, however, that Nunn-McCurdy reporting is based on PAUC growth (and APUC), not quantity-adjusted PAUC or APUC.

‡ A quantity-adjusted PAUC growth estimate could be computed for only 25 of the 58 cancelled programs.

A second possible interpretation of the conventional wisdom is that substantially all MDAPs that were cancelled had high unit cost growth. For many cancelled programs there is no estimate of what it would have cost to complete the program and hence no relevant estimate of PAUC growth.[65] For some cancelled programs, however, SARs filed before the program was cancelled provide a good indication of the PAUC growth that occurred prior to cancellation. Actual PAUC growth was at least this large. Proceeding in this way, we were able to estimate PAUC growth for 25 of the 58 MDAPs that were cancelled.

64 The Nunn-McCurdy Act in its current form defines a "critical" PAUC breach as one of 50 percent or more against the program's original baseline (typically the MS B baseline); a "significant" breach is one of at least 30 percent against the original baseline. These limits, however, are for PAUC growth, not quantity-adjusted PAUC growth. Quantity-adjusted PAUC growth is higher than PAUC growth for programs that bought more than their MS B baseline quantities and lower for those that bought fewer.

65 SARs for the programs report the RDT&E funding and any procurement funding that will actually have been expended when all effort on the program has ended. Usually these expenditures do not result in the production of any fully configured end items, and the SAR does not report what it would cost to complete the development program and procure some quantity of the system.

The right column of Table 22 presents PAUC growth data for these 25 programs. Ten of the 25 cancelled programs showed high cost growth. Another 10 had PAUC growth of between 0 and 30 percent, and five showed negative PAUC growth. These estimates imply that not all cancelled programs had high cost growth.

The PAUC growth estimates in Table 22 for cancelled MDAPs, unfortunately, understate the true PAUC growth, in that they do not capture the cost growth between the date of the SAR used and the termination of the program. In addition, there tends to be some delay in reporting cost growth that can be expected to occur based on the evidence to date but which has not yet in fact materialized, and this might be especially the case for programs that were cancelled. The data in Table 22, then, are indicative but not conclusive.

Finally, a minimalist interpretation of the conventional wisdom is that the proportion of cancelled programs with PAUC growth of at least 50 percent is higher than it is for programs that went into production. This is the case for the sample used here, although the difference is not statistically significant.[66] The difference for a PAUC growth of at least 30 percent also is not statistically significant.[67]

In summary, the data provide very little support to the conventional wisdom that cost growth typically is a major factor in the decision to cancel an MDAP. The least that can be said is that there clearly is much more going on with cancellations than PAUC increases.

In contrast to cancellation, completion ratios are a matter of degree. We look here at MDAPs that purchased 75 percent or less of the units that the program intended to purchase at the time of MS B. This line is arbitrary but not unreasonable. Table 23 provides data on PAUC growth for programs with completion rates of less than 75 percent versus those with completion rates of at least 75 percent. A higher proportion of MDAPs with completion rates of less than 75 percent had PAUC growth of at least 50 percent, but the difference is not statistically significant.[68] There also was not a significant difference between the two groups in the proportion with PAUC growth of at least 30 percent.[69]

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66 Chi-square, p = 0.204.

67 Chi-square, p = 1.000.

68 Chi-square, p = 0.397.

69 Chi-square, p = 0.888.

Table 23. Distribution of PAUC Growth for Different Completion Rates

PAUC Growth	Completion Rate Less than 75%	Completion Rate at Least 75%
At least 50%	12	28
Between 30% and 50%	2	16
Between 0% and 30%	14	51
Less than 0%	9	17
Total	**37**	**112**

There are sufficient data on completion rates to consider a more ambitious question: are higher completion rates associated with lower PAUC growth? As a point of departure, Figure 7 is a scatter of 95 MDAPs with a completion rate of less than 125 percent of the MS B baseline quantity.

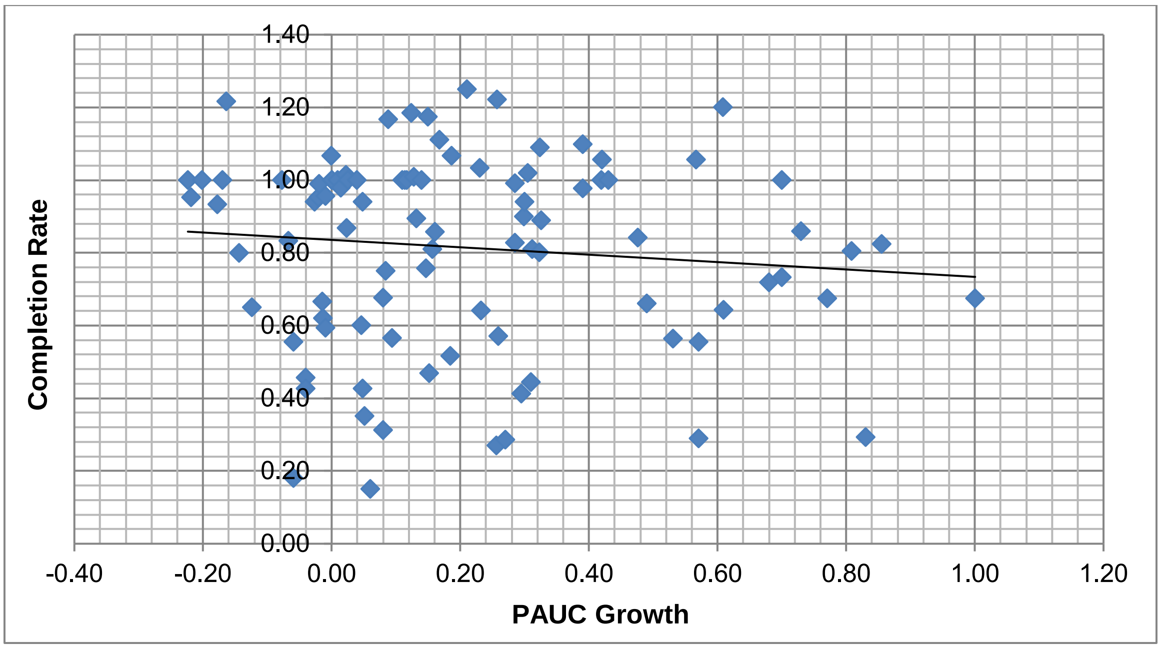

Figure 7. Scatter of Completion Ratios and PAUC Growth of 95 MDAPs

This scatter was constructed as a "best case" in support of a presumption that as PAUC growth increases, the completion rate falls. It omits eight programs for which PAUC growth was an outlier by a conventional statistical definition.[70] In addition, the scatter is limited to programs with completion rates of less than 125 percent because higher completion rates are positively associated with quantity-adjusted PAUC growth,

70 John Tukey defined an outlier as an observation that is at least 1.5 times the inter quartile range above the third quartile or below the first.

which is perverse. This implausible result is not statistically significant and may, in fact, be spurious. In particular, it may be that the very high completion rates are largely due to either (1) instances in which successive generations of a system are left on the same SAR; or (2) an ill-considered MS B quantity baseline.

The best fit line through the scatter in Figure 7 has the expected negative slope—completion rates tend to become smaller as PAUC growth increases—but the slope is not statistically significantly different from zero.[71] More important, the data in Figure 7 do not support a clear conclusion about the association of completion ratio and PAUC growth because they do not consider (1) technical performance; (2) the relative importance of the program; (3) the total size of the program; and (4) major changes in threats, especially those that came with the end of the Cold War. These factors presumably were given major weight in truncation decisions. Including a categorical variable for post-Cold War adjustments does not substantially alter the results.[72] Within the resource limit of this research there was no prospect of obtaining data on performance or relative importance for a substantial number of programs. We could not, then, untangle the effects of PAUC growth from the effects of these factors.

C. Acquisition Policy, Funding Climate, Cancellations, and Truncations

This section continues the thread of the previous section: given that cancellations and truncations involve more than PAUC growth, are they associated with acquisition policy and funding climate? To the extent that both reflected unrealistic MS B baselines, we would expect cancellations to show the same patterns as PAUC growth with respect to acquisition policy and funding climate. The results obtained so far suggest otherwise because cancellations and truncations are not tightly linked to PAUC growth. This is simply a suggestion, however, and it makes sense to check for associations of cancellations and truncations with acquisition policy and funding climate.

1. Cancellation Ratios

Table 24 provides the basic data on cancellations. In this table, cancellations are binned by the year in which the program passed MS B, not the year of the cancellation. P-C DSARC clearly differs from the other two periods that were in effect in both a bust

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71 The relationship was estimated with OLS; the estimated slope was -10.2 percent (p = 0.312).

72 The adjustment was assumed to have begun in FY 1991 and continued through FY 2000. The Berlin Wall fell in the first quarter of FY 1990 (November 9, 1989). The Soviet Union was formally dissolved in April 1991. With the categorical variable for the post-Cold War adjustment included, the estimated slope was -10.1 percent (p = 0.319).

and a boom funding climate. It is shaded for that reason and to help the eye focus on the other periods.

Table 24. Cancellation Ratios by Acquisition Policy Configuration and Funding Climate

Acquisition Policy Configuration	Bust		Boom	
	Period (FY)	Cancellations	Period (FY)	Cancellations
McNamara-Clifford	1965–1969	12.5% (3 of 24)	**none**	n/a
DSARC	1970–1980	15.1% (11 of 73)	1981–1982	22.2% (4 of 18)
P-C DSARC	1987–1989	40.7% (11 of 27)	1983–1986	10.0% (5 of 50)
DAB	1990–1993 2001–2002	12.9% (6 of 31)	2003-2009	27.9% (12 of 43)
AR	1994–2000	13.0% (6 of 46)	**none**	n/a

Setting P-C DSARC aside for a moment, in neither the bust nor the boom funding climate is the cancellation ratio significantly higher or lower for any one acquisition policy bin than for the others. This is consistent with the finding for PAUC growth for the post McNamara-Clifford periods. That is, given funding climate (and ignoring P-C DSARC) the proportion of MDAPs in a cohort that are eventually cancelled does not appear to be associated with acquisition policy.

Still setting aside the P-C DSARC period, the pattern of results found in Chapter 3 for PAUC growth does not appear for cancellations in two important respects:[73]

- The 1969 Packard reforms are not associated with a significant reduction in the cancellation ratio; that is, the cancellation ratio of the DSARC period is not significantly different from that of McNamara-Clifford.
- For DSARC and DAB periods, there is no significant association of the cancellation ratio with the funding climate that prevailed when the program passed MS B.[74]

It is interesting to note that the cancellation ratios for the DSARC and DAB bins are lower, although not significantly lower, for MDAPs that passed MS B in the bust climate than in the boom climate. For reasons brought out in the next subsection, this probably reflects historical happenstance.

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[73] For the bust climate excluding P-C DSARC: p = 0.896 for FET; for the boom climate excluding P-C DSARC: p = 0.757 for FET.

[74] DSARC: p = 0.486 for FET; DAB: p = 0.427 for FET.

The discussion now returns to the P-C DSARC period. This period stands out from the others in three respects:

- P-C DSARC has the highest bust climate cancellation ratio (40.7 percent).
- It has the lowest boom climate cancellation ratio (10 percent).
- P-C DSARC's bust climate cancellation ratio is greater than its boom climate ratio.

The relevant difference in each of these comparisons is statistically significant.[75]

The low cancellation ratio of programs that passed MS B during the boom phase of P-C DSARC (FY 1983–FY 1986) may well be an acquisition policy success. It is consistent with the character of the acquisition policy changes (the Carlucci Initiatives, after then-Deputy Secretary of Defense Frank Carlucci) that mark the P-C DSARC period. Among other things, the Carlucci Initiatives were intended to help ensure that DoD did not start more programs than reasonably anticipated funding would support.

The Carlucci Initiatives, of course, also nominally applied to programs that passed MS B during the bust phase, so the high cancellation ratio of the FY 1987–FY 1989 cohort requires explanation. It appears to be in part attributable to the Administration not following its own policy on new starts. The amount appropriated for DoD acquisition fell by about 30 percent from FY 1986 to FY 1989, and with the passage of GRH and developments in Eastern Europe, there was no reason to expect an increase in funding over the then foreseeable future. In the years FY 1987–FY 1989, however, on average nine programs passed MS B annually. This was well above the average for other bust periods (in particular, 6.7/year for FY 1970–FY 1980, 4/year for FY 1990–FY 1993, and 6.6/year for FY 1994–FY 2000). The relatively large number of program initiations suggests a decreased emphasis on the Carlucci Initiatives' goal of not starting more MDAPs than likely future budgets could sustain.

Eight of the 11 cancellations from the new starts in the FY 1987–FY 1989 cohort occurred during FY 1990–FY 1993. Sharp declines in DoD funding during those years probably account for some of these cancellations, but changes in the threat with the end of the Cold War in about 1990 also played a role. While the SARs do not spell out the fact, there is little doubt that changes in the threat were a major factor in the cancellations of SRAM II, the Small ICBM, Peacekeeper Rail Garrison, and possibly some other programs from this cohort. To some extent, then, the high cancellation ratio of the

[75] For bust climates, $p = 0.081$ for FET; for boom climates $p = 0.077$ for FET; for comparison of the bust and boom climates for P-C DSARC, $p = 0.003$ for FET. The first two of these results indicate that at least one of the periods has a ratio significantly different from the others. It did not seem necessary to go on to test that the period in question was P-C DSARC.

FY 1987–FY 1989 cohort is attributable to a singular historical event—the end of the Cold War.

2. Completion Ratios

As was noted earlier, the very high completion ratios reported by some MDAPs probably are spurious. For that reason, instead of the average completion ratio, we use the proportion of MDAPs with completion ratios less than a specific cutoff. We arbitrarily chose the cutoff to be 75 percent. The relevant data for completion ratios using the 75 percent cutoff are provided in Table 25. As with cancellations, the data reflected in this table were binned by the year in which the program passed MS B.

Table 25. Percentage of MDAPs with Completion Ratios of Less than 75 Percent by Acquisition Policy Configuration and Funding Climate

	Bust		Boom	
Acquisition Policy Configuration	**Period (FY)**	**Completion Ratio ≤ 75%**	**Period (FY)**	**Completion Ratio ≤ 75%**
McNamara-Clifford	1965–1969	30.0% (6 0f 20)	**none**	n/a
DSARC	1970–1980	28.1% (10 of 48)	1981–1982	42.9% (3 of 7)
P-C DSARC	1987–1989	53.9% (7 of 13)	1983–1986	28.6% (8 of 28)
DAB	1990–1993 2001–2002	26.7% (4 of 15)	2003-2009	7.6% (1 of 13)
AR	1994–2000	16.7% (3 of 18)	**none**	n/a

The statistical analysis finds no significant differences between the bust and boom climates for the three acquisition policy regimes that operated in each.[76] It also finds no significant differences among acquisition policy configurations for the boom climate or the bust climate.[77] It is surprising to find that bust funding climates are not associated with a larger proportion of MDAPs with less than a 75 percent completion ratio. The additional examination this result requires is postponed to the following section after additional evidence is introduced.

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76 For DSARC, p = 0.337 for FET; for P-C DSARC, p = 0.168 for FET; for DAB, p = 0.333 for FET.

77 For the boom climate, p = 0.183 for FET; for the bust climate, p = 0.170 for FET.

D. Sharp Declines in Procurement Funding and Cancellations and Truncations

This section examines the possibility that cancellations and truncations are associated with sharp reductions in procurement funding. Pushed to its limit, the possibility raised is that in many instances, programs are cancelled not because they have failed, but to close a gap between the funding requirements of the entire MDAP portfolio and available funding.

Figure 8 shows the number of cancellations recorded in the database in each fiscal year over the period FY 1965–FY 2016. Two clusters of cancellations are evident in this figure, FY 1988–FY 1992 and FY 2009–FY 2012.

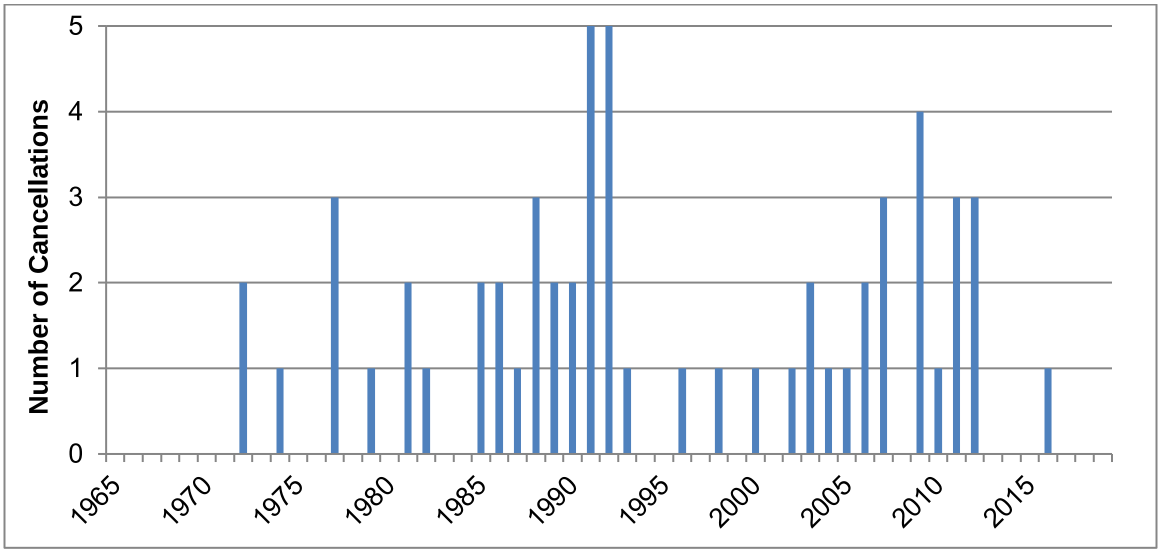

Figure 8. Number of MDAPs Cancelled Each Year, FY 1965–FY 2016

Except perhaps for FY 2009, there were large decreases in the DoD procurement appropriation from one year to the next during these periods. The first is in the bust phase following the Carter-Reagan boom in defense budgets. From peak procurement Budget Authority of $183.9 billion (FY 2017 dollars) in FY 1985, procurement fell to $64.8 billion in FY 1994, about 35 percent of its FY 1985 level.[78] The second period of declining funding was FY 2010–FY 2013. The financial crisis that sparked the Great Recession occurred towards the end of Calendar Year (CY) 2007, or approximately during the first quarter of FY 2008. The withdrawal of US troops from Iraq began in FY 2009 and the Budget Control Act was signed into law late in FY 2011. FY 2013 DoD

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78 These data, as well as similar funding data cited later, are in billions of constant FY 2017 dollars of Budget Authority. They are from Table 6-8 (p. 133ff) of the Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2017*.

procurement funding in constant 2017 dollars stood at about 55 percent of its FY 2008 level.

Thirty-four MDAPs were cancelled during the 14 years FY 1986–FY 1994 and FY 2009–FY 2013, an average of nearly 2.3 cancellations each year; during the other 38 years (through FY 2016), the average cancellation rate was about 0.66 cancellations per year. A simple model was used to compute the probabilities of the observed cancellations for these two periods.[79] Using that model, the probability of observing 21 or more cancellations during the nine years FY 1986–FY 1994 is 0.003. The corresponding probability of observing 11 or more cancellations for the FY 2009–FY 2013 period is 0.04.

DoD total Procurement Budget Authority decreased from FY 2008 to FY 2009.[80] Some of the cancellations may have been made to accommodate the decrease. The only other readily visible reason that helps to explain this is Secretary of Defense Robert Gates' comparatively high willingness to cancel programs. Two of the four cancellations in FY 2009 are attributed to Gates (who was Secretary from December 2006 until July 2011).

The absence of a cluster of cancellations during the early to mid-1970s may be surprising because this apparently was the bust phase of a boom-bust cycle associated with US involvement in the War in Vietnam. Withdrawal of US forces from Vietnam began in 1969. Virtually all US combat forces had been withdrawn by the end of 1972, but US material support for South Vietnam continued into 1975. In FY 1969, procurement funding in constant FY 2017 dollars was $116.8 billion. Using FY 2017 constant dollars, real procurement funding was down by 15.5 percent in FY 1970, and by FY 1975 it was just over half what it had been in 1969. A likely explanation for the comparatively low cancellation rate during FY 1970–FY 1975 can be found in changes over the relevant period in the composition of procurement funding. A large part of the increase in procurement funding during FY 1962–FY 1969 was for munitions and procurement to replace systems lost in combat, particularly aircraft. Insofar as

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[79] The model effectively treats each program as identical insofar as cancellation is concerned. There is a period of years (L) starting at MS B during which a program can be cancelled. The probability of cancellation during the relevant period is p. It is also assumed that the probability of cancellation is the same in each year of L; in particular, $p' = p/L$. There are assumed to be N programs at the start of each year, and any programs cancelled during the year are replaced at the start of the next year. In a given year, the probability that there will be k cancellations out of N programs is given by the binomial distribution $B(N, k, p)$. The probability of k cancellations over s years is $B(sN, k, p')$.

[80] The Budget Authority appropriated for Procurement declined by nearly 20 percent in constant FY 2017 dollars. This was not offset by increases for the Global War on Terror or the Oversea Contingency Operations account, which came into use in FY 2009.

procurement of MDAPs for modernization is concerned, the Vietnam War period was a bust climate.[81]

Figure 9 is a display of truncations that parallels that in Figure 8 for cancellations. Of the 162 MDAPs for which we have a completion ratio, all but 43 acquired at least 75 percent of their MS B baseline quantity. The 43 MDAPs that did not are plotted in Figure 9 by their last year of production (or, in cases for which that is not available, the year of their final SAR).

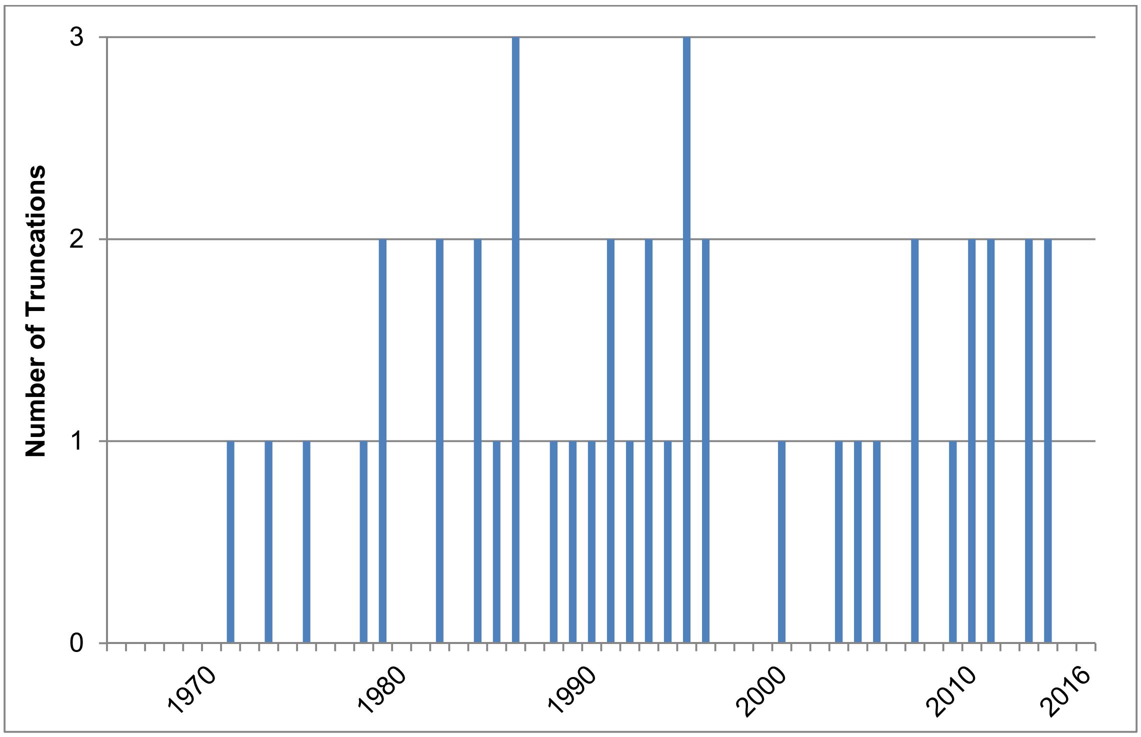

Figure 9. Number of MDAPs with a Completion Ratio of Less than 75 Percent, FY 1965–FY 2016 for Completed Programs

Figure 9 does not convey a strong impression that truncations clustered in the periods when the procurement budget was sharply decreasing. The simple model described earlier also does not point to clustering.[82] During the period FY 1986–FY 1994,

81 These comments are based on an unpublished IDA working database drawn from various US government sources. We are indebted to Dr. Daniel Cuda of IDA for providing these data.

82 It was assumed that 70 MDAPs were in production—that is, producing units that were fielded—and that 50 of these had not yet acquired 75 percent of their MS B baseline quantity. It was also assumed that programs did not reach 75 percent of MS B baseline quantity until their eighth year of production. Of the 263 programs in the database that were not cancelled, 43 acquired less than 75 percent of their MS B baseline quantity, for an overall rate of 0.163. The annual probability over the seven years during which a program was liable for truncation was then 0.023 (= 0.163/7).

12 MDAPs in the sample were concluded before having procured at least 75 percent of their MS B quantity. For reasonable assumptions, the model finds the probability of this observation to be about 30 percent; that is, not improbable. The corresponding probability for the period FY 2009–FY 2013 is 31 percent.

This is a surprising and not entirely plausible result, because we would expect truncations of ongoing programs to be one of the tools used to respond to large, unexpected decreases in procurement funding. One part of the explanation may lie in the distinction between when a decision to truncate a program was made and when the program actually ended. It is possible that in some cases the decision to truncate a program was made (say) two years before the program ended. If so, there may in fact be more clustering than Figure 9 indicates. Another and probably more important explanation lies in the fact that truncations can be reversed. A program may then be truncated during a period when procurement funding is rapidly declining only to be increased in later years. Such transient truncations are not picked up in the data used here. On the evidence at hand, however, truncations do not appear to be associated with sharp decreases in procurement funding.

Finally, this discussion raises the question of whether the conclusions of Section C (on acquisition policy effects) change if the two funding climates (bust and boom) are replaced by three (stable, boom, bust). Using the same approach as that used in Section C but distinguishing three climates (Bust-Stable, Bust-Declining, and Boom) provided only limited evidence that any of the acquisition policy bins had a cancellation ratio significantly different from that of the climate mean.[83]

E. Conclusions

The clearest conclusion offered by this chapter is that cancellations of MDAPs are concentrated in the two periods during which DoD procurement funding declined sharply. This is not a surprising conclusion, but it is useful to know that cancellation of major programs is in fact one of the ways that DoD responded to large funding reductions. Truncations, in contrast, are not clustered in periods of declining procurement funding, which is surprising.

[83] FET provides an indication that the DAB may have had a significantly higher cancellation ratio in both Bust-Declining and Boom climates than the other configurations. Furthermore, for the DAB period, the cancellation rate for the Bust-Declining period is significantly higher than that for the Bust-Stable period. Chi-square, $p = 0.024$.

Apart from the association of cancellations and decreases in procurement funding, the conclusions offered are about what appears not to matter—or to matter much—in cancellation and truncation decisions:

- Excepting P-C DSARC, within a funding climate there is no statistical association between cancellations or completion ratios of less than 75 percent and the acquisition policy prevailing when a program passes MS B.
- Given acquisition policy configuration, there is no consistent association of funding climate with cancellations or completion ratios of less than 75 percent.
- Most programs with high PAUC growth were not cancelled.
- The evidence permits those so inclined to accept that higher PAUC growth tends to result in lower completion rates.

Is it reasonable to infer from the evidence that large decreases in DoD funding such as those of FY 1986–FY 1993 and FY 2010–FY 2013 caused the cancellation of MDAPs that otherwise would have been completed? To be clear about this, it is necessary to distinguish between decisions to reduce the overall DoD acquisition portfolio and decisions about which programs to cancel. The latter involve a range of considerations—how well the programs are doing, how important they are, and the continued salience of the threats to which they respond, among others. The decision on the extent to which cancellations should be used to close a funding gap involves choices among bad alternatives—cancellations, delays in new starts, stretches of existing programs, acceptance of less costly alternatives in some cases, and adoption of very optimistic costing and programmatic decisions for both new starts and—to the extent possible—ongoing programs. Viewed from this angle, the root cause of many cancellations seems to be a mismatch between DoD's missions and functions, its force structure, and its funding.

5. How Did the 1969 Packard Reforms Reduce PAUC Growth?

A. Introduction

The preceding chapters were concerned with reporting statistical analyses. Little attempt was made to interpret the results in terms of changes in acquisition policy. In this chapter and the two that follow, the roles of statistical results and historical interpretation are reversed. We largely take as given the statistical results reported earlier and ask whether they make sense in the light of the changes that occurred in acquisition policy.

This chapter is concerned with the significant reduction in average PAUC growth during the 1970s and compared to FY 1965–FY 1969. While the 1969 Packard reforms clearly were the proximate cause of the lower PAUC growth, this conclusion is only a starting point. The 1969 Packard reforms:

- Added before MS B a substantial phase for the maturation of key technologies and separated MS B and MS C,
- Established the DSARC,
- Prohibited the use of TPP and discouraged the use of fixed price (FP) development contracts,
- Enhanced the role of test and evaluation in the acquisition process,[84]
- Adopted the policies of realistic costing and full funding and established independent costing as part of the milestone review process,[85]
- Encouraged the use of design to unit production cost, and
- Stressed the importance of Program Manager (PM) tenure and especially of short reporting chains between PMs and the MDA.

The task then is to consider which of these reforms were directly responsible for the reduction in PAUC growth.

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84 Steven J. Hutchison, "The Original Director for Test and Evaluation," *Defense AT&L* (January–February 2014): 30–3.

85 Donald Srull, ed., *The Cost Analysis Improvement Group: A History* (McLean, VA: LMI, 1998).

Doing this is a matter of a "before-and-after" comparison. Accordingly, Section B briefly describes the OSD-level MDAP oversight process installed by McNamara in February 1964. Section C takes up changes made by Packard to the milestone review process and acquisition policy. Section D presents the conclusions suggested by the comparison.

B. McNamara—DoDD 3200.9

In 1961, McNamara installed a new process to make major DoD policy and resource allocation decisions. One part of McNamara's intent was that major acquisition programs would be initiated by the Secretary of Defense through a process managed by the Office of Systems Analysis (OSA). (OSA was the precursor to the Office of Program Analysis, then the Office of Program Analysis and Evaluation and, in turn, the Office of Cost Assessment and Program Evaluation.) Under McNamara, the portions of the newly established Five Year Defense Plan (FYDP) concerned with force structure, major RDT&E programs, and major procurement programs were developed through multi-month studies that OSA led. Each of these studies concerned a broad national security objective—for example, strategic deterrence. For a given objective, they included policy objectives, force structure and system requirements, options for systems acquisitions, and funding.[86]

Studies culminated in a Draft Presidential Memorandum (DPM). In some instances, the decisions were in fact made by the President; in others, by the Secretary of Defense.[87] Programs initiated through a DPM apparently did not require further OSD-level approval to proceed into EMD and procurement. There was, however, a second track for initiation of a major system acquisition, through what was called a Program Change Proposal (PCP). There was an expectation that programs that entered the FYDP via DPM decisions would remain stable over time. The FYDP was updated annually, however, and during the fall Budget Review, the

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[86] The standard references for McNamara's resource allocation initiatives are Alain C. Enthoven and K. V. Smith, *How Much Is Enough? Shaping the Defense Program, 1961-1969* (New York: Harper and Row, 1971, reissued by the RAND Corporation in 2005), and Charles J. Hitch, *Decision-Making for Defense* (Berkeley, CA: University of California Press, 1966).

[87] In terms used in the 1980s and 1990s, the DPM took the place of Defense Planning Guidance, Joint Requirements Oversight Council approval of requirements, the Program Decision Memorandum (PDM), a Program/Budget Decision to provide funding, and parts of Acquisition Decision Memoranda. The costing for major acquisition programs that entered the FYDP via the DPM route was done by the cost group within OSA, which was the predecessor of the Cost Analysis Improvement Group, and current Cost Assessment deputate of the Office of Cost Assessment and Program Evaluation (CAPE CA).

Services could seek changes to the FYDP, including initiation of a major acquisition program, through PCPs.[88]

It was this second track that apparently led to the MDAP oversight process used during the period covered by this study. In February 1964, McNamara issued Department of Defense Directive (DoDD) 3200.9, Project Definition Phase,[89] which established an OSD-level milestone decision process for major acquisitions that originated in a Service or, more accurately, a Component. The process had only a single milestone. A revision of DoDD 3200.9 issued in July 1965 established a second milestone.

Understanding the DoDD 3200.9 process is challenging because the directive is dense and its context is not part of the historical memory of the acquisition community. For explanatory purposes, it is useful to refer to the first milestone as MS B_{con}, because it provided only "conditional" authority to begin EMD. The second milestone will be called MS M, for McNamara, because it has no close analog in the OSD-level oversight processes of subsequent periods.

MS B_{con} was preceded by the "Concept Formulation Phase." No OSD approval was required for a Service to enter this phase; that is, there was no MS A. DoDD 3200.9 stated six "prerequisites" that a program was required to satisfy to get MS B_{con} authority,[90] and the purpose of the MS B_{con} review was to evaluate whether the proposed program met these conditions. The review was initiated by a PCP or, if the program were already in the FYDP, by a memorandum from the Component head to the Secretary of Defense.

The review process under DoDD 3200.9 was administered by DDR&E.[91] Initially, reviews were based on information in the PCP and a Technical

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88 Acquisition programs initiated using a PCP with development funding or total acquisition cost of more than certain amounts required approval by the Secretary of Defense. See Clark A. Murdock, *Defense Policy Formation* (Albany, NY: State University of New York Press, 1974), 112. A PCP probably involved comparatively limited OSD review because the fall Budget Review did not allow for much more than that. Requirements for these programs seem to have been developed within the Service's requirements process. McNamara took an active role in the top-level management of some acquisition programs, most famously the F-111. See Coulam, *Illusions of Choice*. It is not clear how typical this level of secretarial involvement was.

89 For a discussion of DoDD 3200.9, see Thomas K. Glennan, Jr., *Policies for Military Research and Development*, P-3253 (Santa Monica, CA: The RAND Corporation, January 1966), 12.

90 DoDD 3200.9 (July 1, 1965), Paragraph VI.C, p. 4.

91 William D. O'Neil and Gene H. Porter, "What to Buy? The Role of Director of Defense Research and Engineering (DDR&E): Lessons from the 1970s," IDA Paper P-4675 (Alexandria, VA: Institute for Defense Analyses, January 2011), 25-47. Fox, *Defense Acquisition Reform, 1969 to 2009*. Chapter 2, especially 35–58, provides a sketch of how the process evolved during the

Development Plan (TDP), along with other materials referenced in the TDP. What was called Format B of the PCP was the document used to record the results of the review, including any changes in the TDP.[92] In 1968, DDR&E substituted a new document called the Development Concept Paper (DCP) for the TDP.[93] The DCP became the source of summary information about the proposed program. It is a reasonable guess that overall the process had the same shape seen subsequently: the Services provided information on the proposed acquisition, and OSD staff—then primarily from OSA and DDR&E—reviewed the materials and could raise issues and make recommendations for changes. MS B_{con} (and also MS M) authority required the approval of the Secretary of Defense.

MS B_{con} authority permitted the Service to begin the Contract Definition phase. The rationale of this phase rested on McNamara's policy that TPP be used in all cases in which it was practicable to do so.[94] An FP development contract was strongly preferred in cases in which TPP was judged to be infeasible. Recall that a TPP contract covered EMD, procurement, and usually some aspects of operations and maintenance, each on a fixed price basis. These contracts were awarded after a competition. The purpose of the Contract Definition Phase, then, was to define the project at a level of detail that permitted the contractors (usually at least two) to write TPP contracts for EMD, procurement, and—often—aspects of Operations and Maintenance (O&M) as well.

The Contract Definition Phase was to last at most six months.[95] With the proposals then in hand, the Service would seek MS M authority. MS M authority authorized the Service to select one of the competing contractors and make the contract award. DoDD 3200.9 did not provide for any milestones post-MS M.

Abstracting from the details, and the fact that it was built around the use of TPP contracts, the McNamara MDAP oversight process had three central features:

- Milestones beyond which an MDAP is not to proceed without the approval of the Secretary of Defense on the recommendation of the MDA.[96] Backup

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1960s. See also C. W. Borklund, *The Department of Defense* (New York: Frederick A. Praeger, 1969), 83.

92 DoDD 3200.9 (July 1, 1965), paragraph VI.E, p. 6.

93 Murdock, *Defense Policy Formation*, 113.

94 The 1965 revision of DoDD 3200.9 stated that one of the purposes of the Contract Definition Phase was to "[p]rovide a basis for a firm fixed price or fully structured incentive contract for Engineering Development." DoDD 3200.9 (July 1, 1965), paragraph V.B(1), p. 2.

95 DoDD 3200.9 (July 1, 1965), paragraph VI.F.7, p. 9.

96 The MDA is what the title implies—the official responsible for granting milestone authority for a program. There were some categories of MDAPs over the period covered by this study (many

enforcement of the Secretary's decisions was provided by the Comptroller, who would not permit funds to be spent on the activities of a phase unless the Service had received authorization from the MDA to enter that phase.

- A review of the program at milestones by OSD staff elements on the basis of information the program submitted. Staff elements could raise issues to the MDA and offer recommendations.
- A decision by the MDA, informed by staff reviews of information provided by the Service, to allow the program to proceed—perhaps with modifications—or to delay it.

These remained the foundation of the OSD-level acquisition process throughout the period covered by this study and beyond.

C. The 1969 Packard Reforms

Two sets of reforms of the OSD-level processes were set in motion in the early months of the Nixon Administration (1969). The central issue in the first of these was the degree of initiative OSD would exercise in decisions on force structure, system requirements, and initiation of major development projects and major weapon system acquisitions. In loose terms, Nixon's Secretary of Defense, Melvin Laird, returned initiative on these matters to the Services. Subject to planning and fiscal guidance issued by the Secretary or Deputy Secretary of Defense, each of the Services prepared a POM. The Service POMs were reviewed by OSD during the annual Program Review. Although the label had come into use earlier, this was the first edition of what has since been understood as the Planning, Programming, and Budgeting System (PPBS). For present purposes, a key point to note is that under the system set up by Laird, with perhaps rare exceptions, MDAPs were no longer initiated at the OSD level.

The second set of reforms, undertaken by Deputy Secretary of Defense David Packard, concerned the oversight of MDAPs. Perhaps in consonance with the reforms of the resource allocation process being undertaken by Laird, Packard described a central element of his reforms as returning management of MDAPs to the Services. Decisions on whether an MDAP was ready to proceed to the next phase were to be made at the OSD level by the MDA, but the Service was free to execute

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space systems, in particular) for which the MDA was not the USD(AT&L). The NDAA for FY 2016, Pub. L. No. 114-92, 129 Stat. 726 (2015), Sec. 825, transfers milestone decision authority post-MS A to Component heads unless the Secretary of Defense specifically decides to retain it.

the program so long as key metrics (in particular, cost, schedule, and performance) remained at levels established at the relevant milestone review.[97]

Historical accounts of the 1969 Packard reforms emphasize the theme of a return of authority to the Services. In doing so they tend to play down, or ignore entirely, the fact that Packard built on McNamara's DoDD 3200.9 process. Although the Packard reforms changed it in some crucial ways, the basic architecture of the process was retained: Packard did not scrap the DoDD 3200.9 milestone review process for something else; he established a better milestone review process, one freed of the tie to TPP contracts and FP development contracts.

One pivotal change was in policy on contract type. Packard ruled out the use of TPP and discouraged the use of FP development contracts.[98] As a general matter, Packard's policy was to match contract terms to the riskiness of the acquisition. This policy change had consequences for the definition of the milestones. Recall that under the 1965 revision of DoDD 3200.9 there was no separate FRP milestone. Absent TPP, this no longer made sense. Packard's reforms in effect eliminated MS B_{con} and split MS M into two:

- MS II—authorization to enter EMD, and
- MS III—authorization to begin FRP.[99]

MS III typically came several years after MS II.

Packard also altered the pre-EMD milestone structure. The Concept Formulation Phase of DoDD 3200.9 was retained and continued not to require OSD-level approval to enter. Packard, however, added an additional phase between the

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97 Murdock, *Defense Policy Formation*, notes that the new Decision Coordinating Paper (successor to the Development Concept Paper) did not provide "any mechanism for ongoing managerial control" (176). This suggests that the Services were relieved of the obligation of Program Evaluation and Review Techniques (PERT) reporting. During the McNamara-Clifford period, contractors for all major programs were required to use PERT, which provided OSD staff a basis for looking into programs while they were in EMD. The 1969 Packard reforms also did not include oversight by OSD of ongoing MDAPs that were within baseline values of key metrics.

98 Fox, *Defense Acquisition Reform, 1969 to* 2009, 38, reports that McNamara "abandoned the TPP concept in 1966." The source Fox cites is for the facts stated earlier in the paragraph. There is some evidence that TPP continued to be used through the end of the McNamara-Clifford period. See Walter S. Poole, "Acquisition in the Department of Defense, 1959–1968: The McNamara Legacy," in *Providing the Means of War: Historical Perspectives on Defense Acquisition, 1945–2000*, ed. Shannon A. Brown (Washington, DC: United States Army Center of Military History and Industrial College of the Armed Forces, 2005), 83.

99 DoDI 5000.2, issued October 23, 2000, formally established MSs A, B, and C (in place of MSs I, II, and III) as the main decision points for an MDAP. The definitions are such that MS B is placed several months earlier in the process than MS II. At different times, MS C has been defined as the start of LRIP (earlier MS IIIa) or FRP (MS III).

Conceptual Phase (the new name) and EMD—the Validation Phase. Entry into the Validation Phase required MDA approval (what was then called MS I—MS A post-2000). The important point here is not the requirement for MDA approval as such, but that the purpose of the Validation Phase was to ensure the technologies that a system would use were sufficiently mature to proceed into EMD. One of Packard's signature policies was "fly before you buy." The introduction of the Validation Phase did not guarantee that a prototype would be built during the Validation Phase, but it presumably did reduce the risk of programs that came forward for MS B.

Packard clearly intended that more be done during the Validation Phase than had been typical of earlier programs. That would imply more funding and more time spent on technology development and maturation before MS B. This is an interesting point, because by the early 1980s, concerns began to arise about the time required to field an MDAP new start. Unfortunately, the SARs generally do not report the MS A date so there is no ready source of information even for fairly recent programs on the duration of the technology development phase.

Making EMD a separate phase probably incentivized firms to do a better job on it since there is generally more profit in production than in development and the firm could not begin production until it had finished EMD to the MDA's satisfaction.[100] Moreover, separating the decision to enter EMD from the decision to enter production changed the economic incentives faced by the firms that competed for the EMD contract. With Packard's changes, the firms faced two competitions—one for getting an EMD contract and then a second for a production contract, typically awarded to only one of the competitors.

Finally, Packard sought to better codify and regularize the OSD-level acquisition process. An important part of this was his establishment of the DSARC. The DSARC replaced the more ad hoc coordination process of DoDD 3200.9. DoDD 3200.9 itself was replaced with DoDD 5000.1 (July 13, 1971), issued after Packard had left DoD. In 1975, the first version of DoDI 5000.2, "The Decision Coordinating Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC)," was released. This instruction served mainly to define the process in more detail.

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[100] DDR&E was designated as the MDA at MS I and MS II; the Assistant Secretary of Defense for Installations and Logistics was the MDA for MS III. Fox, *Defense Acquisition Reform*, 57, provides a useful schematic comparison of the DoDD 3200.9 milestones and those of Packard's DoDD 5000.1/DoDI 5000.2.

D. Does the History Accept the Statistical Results?

The question is whether it is plausible to attribute the lower average PAUC growth during the 1970s to the Packard reforms. Granting the strong family resemblance, there were marked differences between OSD-level oversight in the McNamara-Clifford period and the post-Packard 1970s that can be connected to PAUC growth. The most straightforward is a difference in contract policy. As already has been noted, McNamara required the use of a TPP contract when it was feasible. This is important because TPP contracts tend to show high cost growth. Packard ruled out the use of TPP. More generally, Packard directed that contract type be adapted to the risks of the individual program. Could the explanation of the statistical results be as simple as this change in contract policy?

Table 26 provides data that bear on this question. Four of the 16 programs in the database that entered EMD during the McNamara-Clifford period were acquired with a TPP contract. In addition, three programs that passed MS B in the early 1970s were acquired with TPP contracts. These may have been grandfathered from the McNamara-Clifford period. If these seven observations are excluded, average PAUC growth in McNamara-Clifford is 65 percent and the average for the DSARC is 35 percent. This difference is notable but not statistically significant.[101] The change in contract policy, then, does provide an important part of the explanation of the lower PAUC growth of the DSARC period.

Table 26. Average PAUC Growth in the McNamara-Clifford and DSARC Configurations with and without TPP Contracts Included

Acquisition Policy Configuration	Including TPP Contracts	Excluding TPP Contracts
McNamara-Clifford	74% (16)	65% (14)
DSARC	37% (49)	35% (46)

There must be more to the story than that, however, because of the difference between the two periods in the frequency of high PAUC growth outliers. Setting aside programs acquired with TPP contracts, the PAUC growth of two of the remaining 12 McNamara-Clifford programs were outliers. There were no PAUC growth outliers in the DSARC period. This difference is statistically significant[102] and becomes more clearly apparent when a longer time period is considered. Still, setting aside programs acquired with TPP contracts, we have PAUC growth data on

[101] M-W U, $p = 0.162$ ($U = 320$, $n_1 = 42$, $n_2 = 12$).

[102] FET, $p = 0.046$.

91 programs that passed MS B in bust funding climates after the Packard reforms were introduced. Of these, only two were outliers. The Packard reforms are then associated with a significant reduction in the frequency of high PAUC growth programs. Save for several MDAPs that passed MS B during the AR period and had not been completed by the end of FY 2016, this reduction persisted over the four decades after 1969.

There is a reasonable presumption that many instances of extremely high cost growth reflect Errors of Inception. Was the post-Packard process better at establishing a minimum standard of realism in MS B baselines? Two features of the Packard reforms together plausibly had this result. First, Packard's "fly before you buy" policy required a more extensive risk reduction phase prior to entry into EMD. It was the DSARC process that enforced (at MS B) "fly before you buy" or, more generally, sought to ensure that all MDAPs had achieved at least a minimum level of technological maturity at MS B.

Second, the DSARC process was more fully specified than that of the McNamara-Clifford period, possibly more rigorous, and probably better accepted by the Services because of the care Packard took to coordinate it with them. It is hard to gauge the importance of this point. Bureaucracies are intended to produce reasonably uniform results across a class of cases. Achieving this goal requires that there be explicit criteria, a recognized process for gathering information, and—since many people are involved in the process—rules of the road. In short, to be effective, a bureaucratic process requires rules and regulations. Rules and regulations are, of course, notoriously problematic—too few and the result is confusion and wasted effort; too many and the result is rigidity and delay. Packard at the time thought a fuller set of rules for the process was required and, given his background and successes, his judgment deserves deference in a historical analysis.

6. Changes in the OSD-Level Processes Directly Affecting PAUC Growth, FY 1970–FY 2009

A. Introduction

This chapter takes up the second and third of the study's main statistical results (stated in Chapter 3, Table 14, on page 32):

- Average PAUC growth in each of the acquisition policy periods following the 1969 Packard reforms was significantly less than that of the McNamara-Clifford period.
- The four periods do not differ significantly from one another in average PAUC growth.

Broadly, the results of the 1969 Packard reforms persisted, but changes in acquisition policy after the 1969 Packard reforms did not result in further reduction in average PAUC growth.

Does it make sense in terms of the history of acquisition policy to suppose that the persistently lower average PAUC growth (normalizing for funding climate) over the following 40 years can be traced to the 1969 Packard reforms? And that further changes in acquisition policy post-1969 produced no further reductions? Someone who does not know much of the history of acquisition policy might see these as uncomplicated questions. To the extent that the reforms institute by Packard in 1969 remained in place, they would be expected to have the same effects in 1999 and 2009 as they did in 1979 and 1989. Each period would then have average PAUC growth below that of McNamara-Clifford. Moreover, it might seem reasonable to guess that processes that directly influence PAUC growth did not change much and therefore average PAUC growth in the periods following the 1969 Packard reforms did not differ statistically.

This perspective would not come easily to someone acquainted with the history, however. The 1980s and 1990s saw a succession of changes to acquisition policy—the Carlucci Initiatives (early 1980s), implementation of Packard Commission recommendations (late 1980s to early 1990s), and Acquisition Reform (1994 through about 1998). These changes were widely expected to improve the results obtained by the DoD acquisition process, including a reduction in PAUC growth. Looking ahead, the naïve explanation proves to be substantially accurate. During the four decades that followed (and for nearly a decade beyond), the 1969 Packard reforms remained substantially in place and were in some respects strengthened. The main policy initiatives undertaken (which were associated with increases, not decreases in PAUC growth) involved few MDAPs and, hence, do not show up plainly in the averages for the various periods.

This chapter is organized around the top-level proximate causes of cost growth developed by the Office of Program Assessments and Root Cause Analyses (PARCA)[103]:

- Errors of Inception—cost growth stemming from flaws "baked into" a program's MS B baseline
- Errors of Execution—cost growth due to substandard management by the government or the contractor, or management errors of judgment and some duration-linked causes of cost growth (e.g., stretches unrelated to problems internal to the program)
- Program Changes—deliberate decisions post-MS B to change the capabilities of the system that the program is to acquire

For present purposes, the important thing about these categories is that they are anchored on DoD decision processes—MS B reviews, program management, and the PPBES—and policies on realistic costing, full funding, and contract types. Consequently, they provide useful guidelines on where to look for changes and continuity in the OSD-level processes that directly affect PAUC growth.

This chapter considers declared acquisition policy; that is, acquisition policy as it is characterized by the provisions of the 5000-series documents. The following chapter takes up the more elusive matter of changes in the priorities assigned to declared policies, and policy initiatives not reflected in DoDD 5000.01 or DoDI 5000.02.

B. Errors of Inception—the Milestone B Review

The main elements of the plan for undertaking an MDAP are established at MS B. As a comprehensive and generally thorough review, MS B provides a good tool for avoiding Errors of Inception. It is, in fact, the only tool available for doing so because it is at MS B that the baseline against which program performance is measured is established. Unless the program was saved by good luck, problems embedded in the MS B baseline eventually become cost growth (and probably a schedule slip) or a performance shortfall.

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[103] PARCA was created by the Weapon Systems Acquisition Reform Act (WSARA) of 2009. One of its responsibilities is to perform a root cause analysis of the cost growth of any MDAP that has a critical Nunn-McCurdy Act breach.

Successive versions of the DoD 5000-series documents have specified policies that at least nominally are used to judge a program seeking MS B authority. For example, for much of the period covered by this study, at MS B, programs were to have realistic estimates of acquisition and Operations and Support costs, the estimates for acquisition cost for the then-current FYDP were to be fully funded, and the contract type used was to be appropriate given the riskiness of the program. The membership of the DAB (or earlier, the DSARC) is also specified, usually in DoDI 5000.02, along with the roles of the various officials involved. In addition, DoDI 5000.02 either explicitly in some editions or implicitly in others identifies the supporting activities responsible for particular elements of a DAB program review. These three elements—policy statements, constitution and operation of the DAB, and the assignment of responsibilities for elements of a program review—constitute a reasonable definition of the milestone review process.

Given this definition, the milestone review process includes on the order of two dozen distinct elements (policy on realistic costing, authority of USD(AT&L) to delegate MS approval authority, responsibility for provision of the independent cost estimate at MS B, …). It would be straightforward, although a large task, to construct a reasonable list of these elements and then trace the history of each through the 5000-series documents. For example, the initial version of DoDD 5000.1 (1971) implied, but did not say explicitly, that cost estimates should be realistic.[104] This was explicitly stated in the first version of DoDI 5000.2 (1975).[105] Successive editions of 5000-series documents continued to state that the cost estimates adopted at MS B and MS C should be realistic and, from 1980 on, usually added that estimated costs should be fully funded at MS B.[106]

Focusing attention on successive changes in elements of the milestone review process seems implicitly to assume that small, incremental changes have substantial effects. In fact, it would not be reasonable to assume that they do. A better way to approach the topic probably is to look at the statement of some element c. 1969 and then its formulation in FY 2009, at the end of the study period. Table 27 uses as an example of such a comparison the definitions of MS B from the initial version of DoDD 5000.1 (July 13, 1971) and from DoDI 5000.02 (December 8, 2008). The notable aspect of this example is not the differences in language but the essential congruity of the two definitions.

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[104] DoDD 5000.1, July 13, 1971, paragraph B.2, p. 3.

[105] DoDI 5000.2, January 21, 1975, paragraph III.B.1.b(5), p. 4.

[106] DoDD 5000.1, March 19, 1980, paragraph D.2.d, p. 3.

Table 27. Provisions on MS B from DoDD 5000.1 (July 13, 1971) and DoDI 5000.02 (December 8, 2008)

DoDD 5000.1 (July 13, 1971), III (Policy), Section B.2, p. 3
Full-Scale Development. When the DoD Component is **sufficiently confident** that program worth and readiness warrant commitment of resources to full-scale development, it will request a SecDef decision to proceed. At that time, the DSARC will normally **review** program progress and suitability to enter this phase and will forward its recommendations to the SecDef for final decision. Such review will confirm (a) the **need** for the selected defense system in consideration of threat, system alternatives, special logistics needs, estimates of development costs, preliminary estimates of life cycle costs and potential benefits in context with overall DoD strategy and fiscal guidance; (b) that **development risks** have been identified and solutions are in hand; and (c) realism of the **plan** for full- scale development. [Emphasis added.]
DoDI 5000.02, (December 8, 2008), Enclosure 2, Section 6 (Engineering and Manufacturing Development (EMD) Phase), pp. 19–25
b. Entrance into this phase depends on technology maturity (including software), approved requirements, and full funding. Unless some other factor is overriding in its impact, the maturity of the technology shall determine the path to be followed.†
c. (2) Prior to beginning EMD, users shall identify and the requirements authority shall approve a minimum set of key performance parameters (KPPs), included in the [Concept Development Document] CDD, that shall guide the efforts of this phase.
c. (3) EMD begins at Milestone B, which is normally the initiation of an acquisition program. …At Milestone B, the MDA shall approve the Acquisition Strategy and the Acquisition Program Baseline (APB). The MDA decision shall be documented in an [Acquisition Decision Memorandum] ADM.‡
c. (5) The MDA for an MDAP, without the authority to delegate, shall assess the program business case and sign a certification memorandum prior to Milestone B approval …
e. (4) …Transition into EMD also requires full funding (i.e., inclusion of the dollars and manpower needed for all current and future efforts to carry out the acquisition strategy in the budget and out-year program), which shall be programmed in anticipation of the Milestone B decision.

† The MS B review was required by Enclosure 2, 1.a.

‡ Technology risk reduction is to take place during the Technology Development Phase (between MS A and MS B). That this has occurred is to be verified in the MS B review. Note also that the 2008 MS B is to occur after Preliminary Design Review, and hence is a few months further into the program than the 1971 MS B.

Appendix B provides brief (about two pages) descriptions of five substantial changes in the milestone decision process adopted during the 1980s and 1990s. These are offered for those who want somewhat more detail than the brief examples offered above.

The first two changes described in Appendix B are of a piece with the examples already mentioned:

A. **DAB Committees and Overarching Integrated Product Teams (OIPTs).** In 1986, subordinate DAB committees were established for several areas (e.g., conventional systems). In 1994, these committees were renamed OIPTs, and Working-level Integrated Product Teams (WIPTs) were established.

B. **Documentation and Timelines.** Documentation and timelines are important because that process relies on assessments made by staff specialists, and those assessments cannot be made without adequate programmatic information and time. The top-level guidance on documentation at the end of this study's period was DoDI 5000.02, December 8, 2008. It was more detailed and explicit but substantively remarkably similar to what was required by the first DoDI 5000.2 (December 8, 1975).

These two changes clearly did not weaken the OSD-level oversight process; more likely they modestly strengthened it.

The third change described was initially an affordability process, which included important aspects of requirements determination. It later morphed into an effort to retain an involvement for OSD officials below the level of the Secretary of Defense in the changed requirements context ushered in by the Goldwater-Nicholls Act of 1986:

C. **MSs 0, IV, and V—OMB Circular A-109 and the Carlucci Initiatives.** Components were required to include a justification for new starts with their POM submissions. These were considered in the PPBS process by a group (which included the DSARC membership) chaired by the Deputy Secretary of Defense. The process apparently was used for three or four years starting in 1982.

   The need for an affordability process was inherent in changes in PPBS made by Laird in 1969. Under the Systems Analysis process of the 1960s, a decision to initiate a new major acquisition and the decision on funding were made in the same document—the DPM. This connectivity was lost when Laird disestablished the Systems Analysis process and made the Services responsible for building their POMs. The new MS 0 process responded directly to this problem. It was, however, in effect for only three or four years; MS IV and MS V (basically directed at requirements) lasted little longer.

The fourth change described in Appendix B concerned delegation of MS authority:

D. **Delegation of MS Decision Authority.** Delegation of MS decision authority is potentially of key importance because the MS B review is the main instrument USD(AT&L) has to avoid or ameliorate PAUC growth due to Errors of

Inception. By 1996, USD(AT&L) was authorized to delegate decision authority for any of the milestones.

The key consideration here is responsibility for MS B. Transfer of MS B authority to the Secretaries of the MilDeps (and other Component heads) removes from USD(AT&L) the main tool available to them for avoiding Errors of Inception. Through the end of the period considered in this study, however, the only delegations made apparently were of MS C authority for MDAPs that were considered low risk. This is not problematic.

The last of the changes described in Appendix B, and the most difficult to evaluate, concerns the reporting chain of MDAP PMs:

E. **PM/PEO/SAE/DAE Structure.** In 1986, the Congress established the position of USD(A). Under the revised organization, PMs reported to the USD(A) (as Defense Acquisition Executive (DAE)) through a drastically shortened chain of command; it had only two layers—a Program Executive Officer (PEO) and the Service Acquisition Executive (SAE). The Service chiefs were removed from the PM chain of command.

This change was intended to reduce the administrative costs of MDAPs, speed up decision making, and improve decisions. It clearly strengthened the hand of the USD(AT&L). What removal of the Service chiefs from the acquisition chain of command implied for PAUC growth is not clear, however.[107] The statistical results do not resolve this question because the categorical variable for the DAB period also marks the full implementation of the PM/PEO/SAE/DAE structure. The estimated results then do not separate the effects of the shortened reporting chain from the effects of other changes made during this and the following period.

Reflection suggests that the most important evidence is neither the record of evolutionary changes nor start-to-end comparisons. It is, rather, what we do not find in the historical record—no mention that, once established, the milestone oversight process had any of its parts amputated or displaced by some other process. There is a Darwinian "survival of the fittest" aspect to changes in OSD processes. Many changes do not survive the administration that introduces them. Those that do generally are abraded until they fit well with the other OSD processes. The DSARC/DAB process lost none of its parts, over four decades, and in fact was strengthened. At this broad brush level, then, the

[107] See Irv Blickstein, "Acquisition Policy and Requirements Process Perspective," in *Defense Acquisition Reform: Where Do We Go from Here? A Compendium of Views by Leading Experts* (Washington, DC: United States Senate Committee on Homeland Security and Governmental Affairs, Permanent Subcommittee on Investigations, October 2014), 26–33.

historical evidence is consistent with the statistical finding that average PAUC growth (within a funding climate) has remained below its level in the McNamara-Clifford period.

C. Errors of Execution—Oversight of Ongoing MDAPs

Errors of Execution are management errors whose causes arise during the course of program execution, as opposed to Errors of Inception, which are misjudgments embedded in the MS B baseline. Errors of Execution include both errors of commission—for example, insistence on an unrealistic revision of the schedule for some portion of the EMD work—and of omission—e.g., failure to do or appreciate and act on developmental test results. The cost of Errors of Execution is defined as including the costs of stretches and restructurings made to accommodate the underlying error.

Throughout the period covered by this study, the MDA has had the authority to act on problems with MDAPs as they appeared during program execution. Problems do not always announce themselves in a timely manner, however. Viewed from this angle, an OSD-level process for oversight of ongoing MDAPs is a means of identifying problems early and avoiding surprises, and “fixing” programs that encounter major problems.

Contractors for all major programs were required to use PERT during the McNamara-Clifford period. PERT reports filed by contractors provided OSD staff a basis for looking into programs while they were in EMD. Packard’s 1969 reforms dropped the PERT requirements, an action that was consonant with his declared intent to return policy for management of MDAPs to the Services. OSD, however, retained a shared responsibility for oversight of ongoing MDAPs: “The OSD and DoD Components are responsible for program monitoring…”[108]

The process under Packard had three elements:[109]

- The threshold values for reporting purposes, in particular those for cost, schedule, and performance, were those specified in the DCP.
- The Service Secretary was responsible for ensuring that the DCP was updated annually.
- The Service Secretary also was responsible for reporting any breaches or forecasted breaches to the Secretary of Defense.

108 DoDD 5000.1 (July 13, 1971), paragraph III.3, p. 2.

109 The process was formalized by DoDI 5000.2 (January 21, 1975); see Enclosure 1, paragraphs III.D-F, pp. 6–7. It is likely, however, that in this case the initial DoDI 5000.2 simply required a process that had been in use for some time.

What happened once a breach of DCP value had been reported was not specified in DoDI 5000.2. A reasonable guess is that the DSARC reviewed the program to ensure that it was still judged to be worth pursuing, technologically feasible, and affordable, and directed revisions in the DCP, that is, changes to the program. No substantial changes to this process occurred during the 1970s.

A number of changes did occur during the 1980s. First, a revision of DoDI 5000.2 issued in March 1980 dropped the requirement for the annual update of the DCP and, moreover, did not explicitly require any official to report breaches of threshold values to the MDA. This left the annual SARs as the only source that regularly reported to OSD the cost, schedule, and performance status of MDAPs. Second, in 1984, the Defense Acquisition Executive Summary (DAES) process was established. It is not clear when DAES became functional. The first mention of DAES in DoDD 5000.1/DoDI 5000.2 was not until in 1991.[110] Third, in 1987 the PM was made responsible for reporting breaches of the "program baseline," which appears to have had about the same meaning as the Acquisition Program Baseline (APB).[111]

The process that emerged from these changes, which retained a strong resemblance to that of the 1970s, was spelled out clearly in the 1996 DoD 5000-R:

- Control objectives for acquisition program cost, schedule, and performance parameters are embodied in APBs.[112]
- …PMs provide assessments of program status and risk to higher authorities and to the user or user's representative…[113]
- …the DAES is the vehicle for reporting program assessments, unit cost…, current estimates of the APB parameters, …[114]

The initial APB was approved by the MDA as part of the MS B process. It in effect took over one of the roles of the DCP. Where earlier the Service Secretary was made responsible for tracking the program against the DCP threshold values, DoD 5000-R assigned this job to the PM. The reporting venue was the DAES.

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[110] DoDI 5000.2 (February 23, 1991), table on p. 11-D-1-2. DAES was established in place of a recommendation by GAO, which had sought an improvement in the SARs.

[111] DoDI 5000.2 (September 1, 1987), paragraph F.6, p. 8. The first mention of the APB seems to have been in DoDI 5000.2 (February 23, 1991), Part 11, Section A, Attachment 1, paragraph 3, p. 11-A-1-3.

[112] DoDD 5000.1 (March 15, 1996), paragraph D.3.g, p. 8.

[113] Ibid., paragraph E.1.m, p. 10.

[114] DoDI 5000.2-R (March 15, 1996), Part 6, paragraph 6.2.2, p. 2.

The process as of FY 2009 was largely unchanged from that of 1996:

- Acquisition program baseline [APB] parameters shall serve as control objectives.[115]
- PMs shall identify deviations from approved acquisition program baseline parameters …[116]
- The PM shall immediately notify the MDA of a deviation from any parameter (cost, schedule, performance, etc.).[117]

The DAES process was in use in 2009, but the PM was directed to report a breach directly to the MDA, rather than through the DAES.

The PA&E data mentioned in Chapter 3 provide a hint about the average magnitude of Errors of Execution.[118] Table 28 summarizes the relevant data. The most interesting number in this table for present purposes is the 4 percent for errors in the boom period FY 1981–FY 1986. This number is the sum of three components—Errors of Inception, Errors of Execution, and cost growth linked to program duration and program changes (other than capabilities changes) due to events external to the program. The main example of duration-linked PAUC growth is the costs of stretches due to across-the-board funding cuts levied by OSD or the Congress. These may be small for programs that passed MS B in a boom period. It also is reasonable to assume that Errors of Inception are, on average, small for programs that passed MS B in a boom period. Pushing these assumptions to their limit, we have an estimate for Errors of Execution for the programs for the first boom period of about 4 percent. Unfortunately, comparable data for the second boom period (FY 2003–FY 2009) are not available, so we have no check on how representative this estimate is; it is the only estimate we have of the average Errors of Inception for a substantial number of programs.

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115 DoDD 5000.02 (May 12, 2003), paragraph 3.5, p. 2. See also paragraph 4.3.4, p. 5: "The PM shall be accountable for credible cost, schedule, and performance reporting to the MDA."

116 Ibid.

117 DoDI 5000.02 (December 8, 2008), Table 6, row 5, p.45.

118 Chapter 3, Table 19, on page 44. This is the database used in McNicol, *Cost Growth*, *op. cit.*, 2004.

Table 28. Estimated PAUC Growth Due to Errors

Cycle	Period (Fiscal Years)	Errors†	Program Changes	Total
Boom	1981–1986	4%	11%	14%‡ (35)
Bust	1970–1980	24%	14%	38% (42)
	1987–1997	21%	10%	31% (46)

† Sum of PAUC growth due to Errors of Inception, Errors of Execution, and the costs of adjustments due to events external to the program.

‡ Components do not add to the total because of rounding error.

It is, finally, necessary to consider program duration and boom effects. Data relevant to this topic are presented in Table 29. The proportion of program duration spent in boom years is virtually the same for programs that passed MS B in boom periods (31 percent) and those that passed in bust periods (30 percent). Program duration then, does not require a change in the conclusion offered above on the likely magnitude of Errors of Execution.

Table 29. Average Time in Boom and Bust Periods

Cycle	Period (Fiscal Years)	Number of Programs	T_{boom} (yrs.)	T_{bust} (yrs.)	Total (yrs.)
Boom	1981–1986	35	4.0	8.8	12.8
Bust	1970–1980	45	4.4	9.3	13.7
	1987–1997	34	4.0	10.8	14.8
	Combined bust	79	4.2	10.0	14.2

D. Program Changes Post-MS B

A decision to increase the capabilities to be acquired by a program usually requires significant additional funding and, hence, cannot be made entirely within the acquisition process. Such a decision would instead need to be effected through the program budget process. It is possible, then, that changes in the PPBS would influence the volume or character of Program Changes and hence the cost growth associated with them.

In the McNamara-Clifford period, funding changes for a substantial modification of an MDAP probably would have been made during the fall Budget Review via a PCP. A PCP typically involved comparatively limited OSD review because the time constraints on the fall Budget Review did not allow for more than that.[119]

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[119] A PCP with development funding or total acquisition cost of more than certain amounts had to be approved by the Secretary of Defense. See Murdock, *Defense Policy Formation*, 112.

Under the program/budget process as restructured by Laird in 1969, in most cases a decision to increase the capabilities a program was to acquire would have been reflected in the Service's POM. Such decisions would be visible in the documentation available in the OSD Program and Budget reviews, and could be examined in those reviews.[120] This aspect of the process remained unchanged through the several major alterations of the PPBS that occurred in the years after the 1969 Laird reforms. The upshot of these comments is that the PPBS has not evolved in ways that differentially affect decisions to modify MDAPs.

Acquisition policy did shift towards encouragement of upgrades to previously approved MDAPs in place of a new start of an entire system. (That could mean, for example, replacing the engines of an attack aircraft with an improved model, then upgrading the targeting radar, and then improving the avionics, instead of starting a new system with a more powerful engine and better targeting radar and avionics, in addition to a new airframe.) The first step in this direction was taken by the Carlucci Initiatives (Number 2), which encouraged including Preplanned Product Improvements (P3I) in program acquisition strategies. This direction was included in the Reagan Administration's first revision of DoDD 5000.1.[121] The preference for P3I was retained in successive editions of DoDD 5000.1/DoDI 5000.2 and, in particular, was included in DoDD 5000.1 (March 15, 1996), but called Evolutionary Acquisition.[122] The guidance in place at the end of this study stated that:

> Evolutionary acquisition is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements.[123]

One gauge of the effect of this guidance is the proportion of separate programs passing MS B that are variants or modifications of an existing MDAP or a remanufacture of a system in the inventory (VMR). Table 30 shows new starts (NS) and VMR programs by funding climate and acquisition policy period.

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[120] Substantial changes in the capabilities to be acquired also were to be brought to the attention of the MDA. They often, but not always, would be visible in the SARs.

[121] DoDD 5000.1 (March 29, 1982), paragraph C.2.c (2), p. 2.

[122] DoDD 5000.1 (March 15, 1996), paragraph D.1.h, p. 5.

[123] DoDI 5000.02 (December 8, 2008), Enclosure 2, paragraph 2.a, p. 13.

Table 30. New Starts (NS) and Variants, Modification, or Remanufacture (VMR) by Funding Climate

Acquisition Policy Configuration	Bust			Boom		
	NS	VMR	% VMR	NS	VMR	% VMR
McNamara-Clifford	10	6	38%	-	-	-
DSARC	33	16	33%	2	4	67%
P-C DSARC	8	3	27%	23	6	21%
DAB	10	5	33%	4	7	64%
AR	10	9	47%	-	-	-
Total	**71**	**39**	**35%**	**29**	**17**	**40%**

Changes in stated acquisition policy indicate that we should expect an increase in VMRs and, hence, presumably an increase in cost growth due to Program Changes. There is, however, no trend over time evident in the data in Table 30 on the proportion of VMR programs.[124] Consequently, there seems to be no reason to expect that cost growth due to Program Changes has increased over time as a proportion of total cost growth.

Finally, we turn briefly to the question of how much PAUC growth is accounted for by Program Changes. The relevant estimates were presented in Table 28 (page 80). Nearly 80 percent of the PAUC growth on MDAPs that passed MS B during the Carter-Reagan boom climate is estimated to be attributable to Program Changes. The corresponding figure for MDAPs that passed MS B during one of the bust climates is about one-third.[125] That is, PAUC growth for MDAPs that passed MS B in boom periods is due mainly to decisions post-MS B to change the capabilities acquired by the program, while PAUC growth for programs that passed MS B in bust periods is mainly due to Errors of Execution, costs incurred by programs' adjustments to external events and, especially, Errors of Inception.

E. Concluding Comments

OSD-level oversight of ongoing MDAPs probably was comparatively lax during the early to mid-1980s, although the SARs and the Program/Budget process continued to

[124] VMR is an imperfect measure because the change in the capability acquired could be reported on the same SAR as the initial program, and that is not marked in the database used in this study. For example, since the F/A-18 A/B and the F/A-18 C/D were on the same SAR, the number of VMRs shown may be understated. This problem was ameliorated by changes in guidance and statute in the 2000s. DoDI 5000.02 (December 8, 2008, Enclosure 2, paragraph 2.c, p. 13) required major upgrades of an MDAP to be managed as a separate increment. If the same SAR is used, the 2006 change in the Nunn-McCurdy Act provided a clear incentive to at least show separately the cost and funding of a major modification.

[125] These figures include the cost of discretionary stretches of programs.

provide information on program status.[126] With this possible exception, the striking fact about the OSD-level process for overseeing ongoing MDAPs is its continuity over the 40 years 1970–2009. There were no major changes in acquisition policies directly affecting PAUC growth that need to be considered as possible reasons for an increase (or decrease) in PAUC growth.

A shift in acquisition policy took place starting in the early 1980s towards what has come to be called Evolutionary Acquisition. This policy change might have had the effect of increasing cost growth due to Program Changes, but the evidence suggests that it did not.

[126] During about 1984 through 1993, the annual Program Review included an issue paper on realistic costing. This fell considerably short of complete coverage. All MDAPs received some attention during the annual Budget Review.

7. Policy on Cost Growth and Initiatives on Contracting

A. Introduction

This chapter[127] continues the discussion of the preceding chapter and is concerned with the same two statistical findings:

- Average PAUC growth in each of the acquisition policy periods following the 1969 Packard reforms was significantly less than that of the McNamara-Clifford period.
- The four periods do not differ significantly from one another in average PAUC growth.

This chapter, however, considers changes in policy priorities and policy initiatives that were not reflected in the 5000-series documents. Section B presents the limited amount this study has on changes in policy priorities. Sections C and D, respectively, examine PAUC growth associated with policy initiatives on contract types and reductions in acquisition regulations.

B. Policy Priorities on Realistic Costing and Full Funding

As the preceding chapter showed, realistic costing and full funding were (with increasing clarity) declared policy starting with the 1969 Packard reforms, although some administrations placed a higher priority on avoiding cost growth than did others. Unfortunately, we have no objective indicators of priority of these policies in various administrations. Each of five breakpoints between the acquisition policy bins coincided with a change in administration or came fairly early in a new administration. This is to say that changes in process and any changes in the priority assigned to avoiding cost growth and other acquisition policies happened at about the same time. It is unlikely, then, that their effects can be disentangled.

The most promising case for disentangling them is provided by the Nixon-Ford years (1969–1977) and the Carter years (1977–1981). All of these were a bust funding

[127] The raw material for such an analysis is presented in Fox, *Defense Acquisition Reform*, and Christopher H. Hanks et al., *Reexamining Military Acquisition Reform: Are We There Yet?*, MG-291 (Santa Monica, CA: The RAND Corporation, 2005), especially Appendix C, 97ff.

climate and the acquisition process did not change significantly during 1969–1981. Policy may have, however. Therefore, comparison of the Carter years to the Nixon-Ford years might be illuminating.

Thirty-three MDAPs for which we have PAUC growth estimates passed MS B during the Nixon-Ford years. The 16 MDAPs for which we have PAUC growth estimates that passed MS B during the Carter years had a slightly higher average PAUC growth—40 percent. They also had a slightly shorter average duration—14.0 years compared with 15.6 years for the Nixon-Ford programs. We cannot, however, conclude from this that the Carter Administration had a more permissive policy on cost growth because all 16 of the Carter programs continued into the 1981–1986 boom climate, while only 26 of the 33 Nixon-Ford MDAPs did.[128] We do not know, then, whether, after accounting for duration and boom effects, PAUC growth for MDAPs that passed MS B under Carter's Secretary of Defense (Harold Brown) was in fact higher than the average of that for the MDAPs that passed MS B during the Nixon-Ford years.

Comment on the AR years also is required because an inconsistency seems to exist between the priority placed on avoiding cost growth during that period and average PAUC growth. The conventional wisdom is that during the AR years, the senior OSD leadership had a comparatively permissive policy on cost growth or, perhaps better, was more prepared to accept unconventional and risky acquisition approaches. The PAUC growth data are not entirely consistent with this perception. Average PAUC growth for the 19 MDAPs that passed MS B during that period and were completed by the end of FY 2016 was 31 percent, which is not significantly different from the averages for the other post-McNamara-Clifford periods.[129]

There are four ways of rationalizing this inconsistency between expectations and results. First, it could be discounted on the grounds that the effect is statistically insignificant. Second, the conventional wisdom may overstate the extent to which—in the context of DAB milestone reviews—policy during the AR years was more tolerant of cost growth. Third, the OSD-level milestone review process might have improved over time independent of any specific priorities with regard to cost growth. Fourth, the 11 MDAPs that passed MS B during the AR years and had not yet completed as of the December 2015 SARs show an average PAUC growth of 110 percent as of the December 2015 SARs. Of the 11, seven had PAUC growth of over 50 percent and four had a PAUC growth of more than 100 percent. Such a cluster of high PAUC growth programs had not been seen since the 1960s. As is discussed in the two sections that follow, the explanation

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[128] Programs that extend into boom climates tend to have higher PAUC growth. On this, see Chapter 2, Section D.

[129] Chapter 3, Table 9 and note 38, p. 29.

for these instances of high cost growth involves initiatives on contracting and relaxation of acquisition regulations, but a greater tolerance for cost growth cannot be excluded as part of the explanation.

The upshot of these comments is that this study did not identify any association of PAUC growth with changes in the priority placed on avoiding cost growth.

C. Initiatives on Contract Types

Initiatives on contract types need to be discussed because some contract types are strongly associated with high PAUC growth.

As previously noted (Chapter 5, Section C), one of the major elements of the 1969 Packard reforms was a change in policy on contract types used for MDAPs. The new policy was composed of three elements. First, "[New complex defense] systems will not be procured using the total package procurement concept or production options that are contractually priced in the development contract." This was a reversal of the policy in force during the McNamara-Clifford period. Second, "Cost type prime and subcontracts are preferred where substantial development effort is involved." This, too, was a reversal of a McNamara-Clifford-era policy, which encouraged the use of FP development contracts in cases in which TPP was judged to be infeasible. Third, "Contract type shall be consistent with all program characteristics including risk." This was the general policy position that implied the specific policies on TPP and FP development contracts.[130]

Contract policy during the early DSARC period (particularly as stated in DoDD 5000.1 of December 22, 1975) provides a good baseline for viewing the changes that followed. This directive spelled out the policy of the initial version of DoDD 5000.1 and incorporated one change: "When risk is reduced to the extent that realistic pricing can occur, fixed price type contracts should be issued."[131] Probably the main intent of this provision was to clarify that FP contracts could be used for successive lots of a program in FRP. The language used to describe contract policy varied considerably from one edition of DoDD 5000.1/DoDI 5000.2 to the next, but insofar as PAUC growth is concerned, only three different contract types need to be considered.

The first of these is TPP, which included EMD, procurement, and usually some aspects of O&M, each typically on a FP or not-to-exceed basis. Table 31 lists the MS B year and the PAUC growth for the completed MDAPs in the database that were acquired with TPP. Four of these programs are from the McNamara-Clifford period. Probably because they were grandfathered, three programs in the sample for the early 1970s used a

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[130] DoDD 5000.1, July 13, 1971, paragraph C.7, p. 5.

[131] DoDD 5000.1, December 22, 1975, paragraph C.7(d), p. 6.

TPP contract. The prohibition on TPP did not appear in the next update of DoDD 5000.1, dated January 18, 1977, and three additional programs in the sample that passed MS B in the Reagan boom years also used a competitively awarded TPP contract.

Only one of the 10 MDAPs acquired using a TPP contract (AGM-65A Maverick (TV)) had a quantity-adjusted PAUC growth of less than 50 percent. The average PAUC growth of the 10 programs is 86.2 percent, and median PAUC growth is 68 percent. This is among the clearest and strongest results to come out of the literature on cost growth of MDAPs and one for which the underlying causes are reasonably well understood.[132]

Table 31. MS B and PAUC Growth for 10 MDAPs Procured with TPP Contracts

MDAP	MS B (FY)	PAUC Growth
C-5A Galaxy	1966	77%
AGM-65A Maverick (TV)	1968	1%
Landing Ship Assault (LHA) Tarawa class	1969	57%
SRAM	1967	263%
FIM-92 Stinger Missile	1973	110%
AGM-84A Harpoon	1973	56%
SURTASS/T-AGOS	1975	68%
T-45 Goshawk	1984	70%
JSTARS USAF	1985	123%
C-17A Globemaster	1985	57%

Note: The identifications are based on Tyson et al., "The Effects of Management Initiatives," Ch. X and Appendix A, Table A-10; and McNicol, *Cost Growth*, 53, 57–59. Tyson et al. includes the Spruance Class destroyer among the TPP programs. The lead ship of the class may have been acquired on a TPP contract, but the class as a whole seems not to have been.

The second type is an FP development contract, which the conventional wisdom also associates with high PAUC growth.[133] This conclusion is not supported by the data used in this study (see Table 32). Note, however, that five of the six MDAPs identified as using an FP development contract passed MS B during a boom climate, which may account for their low PAUC growth.

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132 See Tyson et al., "The Effects of Management Initiatives," Chapter X; McNicol, *Cost Growth*, 53, 57–59; and O'Neil and Porter, "What to Buy?," 9–31.

133 Tyson et al., "The Effects of Management Initiatives," Chapter X.

Table 32. MS B and PAUC Growth for 10 MDAPs Procured with FP Development Contracts

MDAP	MS B (FY)	PAUC Growth	EMD Growth
F-14A	1969	29%	45%
E-6A	1983	0%	9%
JTIDS	1982	not available	not available
Stinger RMP	1983	not available	not available
T-AO 187	1984	-3%	24%
F-14D	1986	-6%	-2%

Note: The identifications are based on Tyson et al., "The Effects of Management Initiatives," Ch. X and Appendix A, Table A-10.

The third problematic contracting approach is Total System Performance Responsibility (TSPR), which was used primarily during the AR period and is one of the signature experiments of that period.[134] TSPR was a clause included in contracts; it was a way of structuring contracts but not a type of contract and could be used with different contractual forms. Some TSPR contracts were FP but others used incentive fee provisions. The term *Performance* in TSPR was understood in a specialized way. It referred to metrics that characterized the ability of the system to accomplish certain missions. For example, one aspect of performance of a cargo aircraft might be the tons of cargo of a specified type that a given number of the aircraft could deliver in 24 hours under specified conditions. The idea was to cast contracts in terms of such performance metrics, rather than the usual statements of work and technical specifications. The contractor would be responsible for delivering a system that met the performance specifications, while the government would do only a limited number of "inherently governmental" functions (primarily contract management, specification of the performance metrics, budgeting and financial management, and acceptance testing). Table 33 lists the TSPR programs identified. The list probably is not complete—it can be hard to tell whether any particular TSPR was used to acquire any particular system. For

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134 Hanks et al., *Reexamining Military Acquisition Reform*, provides a useful listing of AR initiatives between 1991 and 2001 at least nominally accepted by DoD. In addition to endorsing multi-year contracts and TSPR, AR encouraged the use of three other contracting initiatives: Alpha contracting, Price-Based Acquisition (PBA), and Best Value contracting. Contrary to what might be inferred from some descriptions of PBA, none of these was problematical insofar as PAUC growth is concerned. See Angel Y. Quander and Jillian N. Woppert, "Analysis of Alpha Contracting from Three Perspectives: Government Contracting, the Government Program Office, and Industry," (master's diss., Naval Postgraduate School, 2010); Timothy G. Hawkins and Jeffrey R. Cuskey, "Do the Baby and the Bathwater Deserve the Same Fate? An Exploratory Study of Collaborative Pricing in the U.S. Department of Defense," *Journal of Public Procurement* 11, no. 2 (Summer 2011): 240–74; and Ronald J. Rapka et al., "A Successful Alpha Contracting Experience," *Army AT&L* (January–March 2006): 34–7. On PBA, see Mark A. Lorell, Robert S. Leonard, and Abby Doll, *Extreme Cost Growth: Themes from Six U.S. Air Force Major Defense Acquisition Programs*, RR-630-AF (Santa Monica, CA: The RAND Corporation, 2015), especially Chapter 2.

example, the Advanced Extremely High Frequency (AEHF) satellite is sometimes discussed with TSPR programs. Note that all but one of the MDAPs in Table 33 (AGM-158) is a satellite system and all had high PAUC growth or were cancelled.

Table 33. MDAPS Acquired Using a TSPR Strategy

MDAP	MS B	PAUC Growth
Global Positioning System IIF (GPS-IIF)[a]	1996	high[b]
Space Based Infrared Sensor-High (SBIRS-High) (baseline)[a]	1997	299%
AGM-158 Joint Air-to-Surface Standoff Missile (JASSM)[c]	1998	73%
Evolved Expendable Launch Vehicle (EELV)[a]	1998	251%
National Polar-orbiting Operational Environmental Satellite System (NPOESS)[a]	2002	Cancelled

[a] Government Accountability Office (GAO), "SPACE ACQUISITIONS: DOD Needs to Take More Action to Address Unrealistic Initial Cost Estimates of Space Systems," GAO-07-96 (Washington, DC: November 2006), 8.

[b] GPS-IIF was not an MDAP; it was part of the NAVSTAR GPS program. GAO reported a program office estimate—apparently from about 2009—that implied a cost growth from the MS B baseline of 119 percent. See GAO, "GLOBAL POSITIONING SYSTEM: Significant Challenges in Sustaining and Upgrading Widely Used Capabilities," GAO-09-325 (Washington, DC: GAO, April 2009), 13. It is not clear that the program office estimate cited by GAO was adjusted for quantity changes.

[c] GAO, "DEFENSE ACQUISITIONS: DOD Needs to Reassess Joint Cruise Missile Costs before Starting New Production Phase," GAO-11-112 (Washington, DC: GAO, October 2010), 4.

The data in Table 33 are sufficient to convict TSPR programs only of loitering in the vicinity of programs with known high PAUC growth, and use of a TSPR approach was not the only cause of cost growth in any of these cases.[135] The first question that needs to be asked of the published studies is then, "What clear links are there between the use of TSPR and cost growth?"

One such link is that it was assumed that TSPR would reduce cost. One source of cost reduction was expected to be a decrease in the number of people employed in government program offices. Government salaries are a small part of MDAP cost, however, and the larger source of cost reductions was expected to stem from the freedom TSPR gave contractors to make trades that reduced cost while maintaining performance. Those expected reductions were built into the MS B baselines, apparently in at least some

[135] On this point see the following: Defense Science Board/Air Force Scientific Advisory Board Joint Task Force, *Acquisition of National Security Space Programs* (Washington, DC: Office of the Under Secretary of Defense (AT&L), May 2003); Lorell, Leonard, and Doll, *Extreme Cost Growth*; Kim et al., *Acquisition of Space Systems*; GAO, "SPACE ACQUISITIONS," 8; and Hanks et al., *Reexamining Military Acquisition Reform*.

cases over the objections of the independent cost analysts in OSD and the Air Force.[136] In at least some cases, government staff, particularly systems engineering staff, was reduced to a point that compromised the programs' ability to establish baseline requirements and monitor progress.[137] Moreover, the government in some instances did not require the provision of the data needed to understand the state of a program. As a result, the anticipated savings failed to materialize and the result was cost growth.

Beyond a poor record on PAUC growth of the TSPR programs in the database, the main rationale of TSPR arrangements is not solid. A TSPR contract will provide a contractor an incentive to make changes that preserved or improved the performance provided while reducing cost if it specifies that the government will pay only for the initially specified performance or, at a minimum, must approve any change that increases cost and capability. This observation points to a dilemma in the TSPR concept. On one hand, limiting the performance the government will pay for probably is not sensible for many systems and seems to require an FP contract, and there is no reason to think that an FP TSPR contract for a major EMD effort would not have the same flaws as an ordinary FP development contract.[138] On the other hand, to avoid a cost-capability spiral under a TSPR arrangement with a cost plus fixed fee or cost plus incentive fee and no limit on performance, the government probably would need to exercise a degree of oversight that obviates the advantages sought by a TSPR arrangement.

The language of DoDI 5000.2-R and DoDI 5000.2 continued to encourage casting contracts in terms of desired performance, but early in 2002 then-USD(AT&L) Edward C. "Pete" Aldridge stated that TSPR would no longer be used.[139] More generally, during 2001–2009, there were no further major experiments with different contracting approaches.

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136 See, in particular, GAO, "GLOBAL POSITIONING SYSTEM," and Defense Science Board, *Acquisition of National Security Space Programs*.

137 Defense Science Board, *Acquisition of National Security Space Programs*, 3, 10; Lorell, Leonard, and Doll, *Extreme Cost Growth*, 31; Kim et al., *Acquisition of Space Systems*, 33–4; and GAO, "SPACE ACQUISITIONS," 10. L. Parker Temple III, *Implosion* (New York: Wiley, 2013), 269–71, provides a critique of TSPR that stresses the importance of strong engineering expertise in both government and industry to the success of space programs, indicating that its lack was a major reason for the failure of the TSPR programs.

138 On the limitations of FP development contracts in space programs, see Scot A Arnold et al., "Lessons from Literature on the Effects of Contract Type on Satellite Acquisition," IDA Document NS D-4859 (Alexandria, VA: Institute for Defense Analyses, April 2013). Lorell, Leonard, and Doll, *Extreme Cost Growth*, 7, seems to equate TSPR with TPP. TPP does not imply a "hands off" stance, but the government probably did generally place total system responsibility on the contractor. TSPR, however, amounts to TPP only if it uses an FP contract and extends beyond EMD to production.

139 Hanks et al., *Reexamining Military Acquisition Reform*.

D. Relaxation of Regulations and Statutes

The Packard Commission's analysis of acquisition and Secretary of Defense William Perry's acquisition reform agenda[140] seemed to assume that a significant fraction of the funding of an MDAP typically is for costs largely driven by regulations, some required by statute and some imposed by DoD. In addition, it seemed to be tacitly assumed that many of these regulations were unduly complex and served little useful purpose. Accordingly, both Packard and Perry placed a high priority on comprehensive reform of acquisition regulations. Along with statutory changes, this goal was explored through the Defense Acquisition Pilot Program (DAPP), which was similar to the earlier Defense Enterprise Program (DEP).

The Congress established DEP in the FY 1987 NDAA.[141] Programs designated as DEPs were not subject to DoD regulations other than those specified by the SAE, but were subject to the Federal Acquisition Regulation (FAR), the Defense FAR Supplement (DFARS), and statute. We do not know what DoD regulations, if any, the SAEs elected to retain. In addition, DEP programs could be nominated for Milestone Authorization—that is, for authorization of funding through completion of the acquisition phase they were in at the time of their nomination.[142] DoD nominated 10 MDAPs as DEPs; all of these were accepted by the Congress. Milestone authorization was granted for four of the DEP programs.[143] No other programs were added to the DEP after the initial tranche.

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140 The Packard Commission's Acquisition Task Force was directed by William Perry. See President's Blue Ribbon Commission on Defense Management, *A Formula for Action: A Report to the President on Defense Acquisition* (Washington, DC: The Commission, April 1986), 1. See also Secretary of Defense William J. Perry, *Acquisition Reform: A Mandate for Change* (Washington, DC: Department of Defense, February 9, 1994).

141 NDAA for FY 1987, Pub. L. No. 99-661, 100 Stat. 3816 (1986), Section 905.

142 Some accounts of the DEP state that its establishment was a recommendation of the Packard Commission. This is not accurate, in that the Packard Commission reports did not specifically include such a recommendation. The Packard Commission, however, did recommend the use of milestone authorizations. See President's Blue Ribbon Commission on Defense Management, *A Quest for Excellence: Final Report to the President* (Washington, DC: The Commission, June 1986), xxiv–xxvii, xix.

143 The requests were made in a letter from Deputy Secretary of Defense William H. Taft, IV to the Honorable Les Aspin, Chairman of the Committee on Armed Services of the House of Representatives, March 30, 1987. Following Mark R. Radice, *The Defense Enterprise Program: A Managerial Assessment* (master's diss., Naval Postgraduate School, 1992), the Army Mobile Subscriber Equipment, Army Tactical Missile System, Navy's Trident II Missile, and the Navy's T-45 TS also were granted milestone authorization. See NDAA for FY 1988 and 1989, Pub. L. No. 100-180, 101 Stat. 1019 (1987), Sec. 106.

DoD found that the DEP programs "were more trouble than they were worth… and …allowed it [DEP] to lapse by 1990."[144]

DAPP was established in the NDAA for FY 1991.[145] From DoD's perspective, the key difference between the DEP and the DAPP probably was that the latter permitted the Secretary of Defense to waive not only DoD regulations but also acquisition statutes and regulations that implemented them. The Federal Acquisition Streamlining Act of 1994 authorized five programs to participate in the DAPP.[146] Of these, four were MDAPs, but two of these did not continue as MDAPs after 1994.[147] Another MDAP was included in the DAPP in 1995.[148] Just when the DAPP ended is not clear, but no indication was found that any additional programs were added after 1995.

In addition to the DEP and the DAPP, MDAPs whose development was funded under Other Transactions Authority (OTA) are included in this subsection because some procurement statutes do not apply to such arrangements and they typically are not required to comply with DoD procurement regulations. An Other Transaction (OT) is:

> a special vehicle used by federal agencies for obtaining or advancing research and development (R&D) or prototypes. An OT is not a contract, grant, or cooperative agreement… Only those agencies that have been provided OT authority may engage in other transactions.[149]

OTA was first granted in 1958, to the National Aeronautics and Space Administration (NASA), in the statute that created the agency.[150] DoD interest in OTA arose in the 1980s from perceived advantages of obtaining advanced technology from firms that had no experience doing development work for, or in cooperation with, DoD. Like other

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144 Fox, *Defense Acquisition Reform*, 159. The DEP is not mentioned in the NDAA for FY 1990, Pub. L. No. 101-189, 103 Stat. 1352 (1989).

145 NDAA for FY 1991, Pub. L. No. 101-510, 104 Stat. 1485 (1990), Section 809.

146 Federal Acquisition Streamlining Act of 1994, Pub. L. No. 103-355, 108 Stat. 3243 (1994), Section 5064.

147 The Fire Support Combined Arms Tactical Trainer seems to have been an ACAT II or ACAT III program. The Commercial Derivative Engine and the Commercial Derivative Aircraft appear to have been part of the 1994 competition between the C-17 and commercial derivative aircraft and probably did not continue after that competition was concluded.

148 Raymond W. Reig, "Baselining Acquisition Reform," *Acquisition Review Quarterly* 7, no. 1 (Winter 2000), Appendix A, 43. Hanks et al., *Reexamining Military Acquisition Reform*, 25, note 41, indicates that regulations were only waived for the C-130J.

149 L. Elaine Halchin, "Other Transaction (OT) Authority," RL34760 (Washington, DC: Congressional Research Service, 2011), Summary.

150 Surya Gablin Gunasekara, "'Other Transaction' Authority: NASA's Dynamic Acquisition Instrument for Commercialization of Manned Space Flight or Cold War Relic?" *Public Contract Law Journal* 40, no. 4 (Summer 2011), 894.

government agencies, DoD found that "some companies (and other entities) are unwilling or unable to comply with the government's procurement regulations."[151] The Defense Advanced Research Projects Agency (DARPA) was granted OTA in 1989.[152] DoD as a whole received OTA in 1994.[153]

According to a RAND study, DoD entered into 72 OTs during 1994–1998. Nearly 60 percent of these OTs had total funding of less than $10 million, and only six had funding greater than $100 million. The study entailed a detailed assessment of 21 of the 72 OTs. Based on this assessment, it offered a favorable assessment of OTAs, which were found to have limited risks and to provide broad benefits.[154]

Table 34 shows, for the DEP, DAPP, and OTA programs identified, the fiscal year in which the program passed MS B and its PAUC growth adjusted to the MS B baseline quantity. It is crucial to recognize that the MS B baselines were established before the initiatives were built into the programs. Consequently, PAUC growth is equal to the growth in the acquisition cost of the programs (in program base year dollars and adjusted for quantity change). If the expectations evidently behind the program were met, the DEP programs should have below average PAUC growth. A skeptic who believed that the regulations waived served a good purpose would expect above average PAUC growth.[155]

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[151] Halchin, "Other Transaction (OT) Authority," Summary; see also Gunasekara, "'Other Transaction' Authority," 893–908.

[152] NDAA for FY 1990, Pub. L. No. 101-189, 103 Stat. 1352 (1989), Section 251.

[153] Federal Acquisition Streamlining Act of 1994, Pub. L. No. 103-355, 108 Stat. 3243.

[154] Giles Smith, Jeffrey Drezner, and Irving Lachow, *Assessing the Use of "Other Transactions" Authority for Prototype Projects*, DB-375-OSD (Santa Monica, CA: The RAND Corporation, 2002), iii, 7, and 31.

[155] Note that the designations of DEP MDAPs (in January 1987) came after these programs had passed MS B. (The one exception to this statement is Medium Launch Vehicle, for which we do not have a PAUC growth estimate.) This is important because it implies that the MS B baseline cost estimates would not have made any allowance for cost reductions due to relaxation of regulations.

Table 34. Fiscal Year in which the Program Passed MS B and Quantity-Adjusted PAUC Growth for DEP, DAPP, and OTA Programs

MDAPs by Category	MS B (FY)	% PAUC Growth
DEP Programs[a]		
TOW II	1984	13%
Trident D-5 Missile	1984	15%
SSN-21 †	1985	8%
Mobile Subscriber Equipment †	1986	1%
Army Tactical Missile System †	1986	13%
Medium Launch Vehicle	1990	N/A
SRAM II	1987	cancelled
T45-TS † ‡	1984	70%
C-17 ‡	1985	57%
Titan IV	1985	212%
DAPP Programs[b]		
JDAM	1995	12%
JPATS	1995	42%
C-130J §	1996	83%
OTA Programs		
UCAV	*	n/a
RQ-3 DarkStar	*	n/a
Arsenal Ship	*	n/a
Evolved Expendable Launch Vehicle (EELV) #	1998	251%
Global Hawk	2001	n/a^
Future Combat Systems (FCS)	2003	cancelled
DDG-1000	2006	truncated

[a] See note 143, p. 92, for references that identify the DEP MDAPs.

[b] Federal Acquisition Streamlining Act of 1994, Pub. L. No. 103-355, 108 Stat. 3243 (1994), Section 5064.

† Milestone funding authorized. NDAA for FY 1988 and 1989, Pub. L. No. 100-180, 101 Stat. 1019 (1987), Section 106.

‡ TPP program.

§ Only DoD regulations waived.

* Did not pass MS B.

TSPR program.

^ The database does not include a cost growth estimate for Global Hawk that is quantity-adjusted and in common base-year dollars. It is clear from the SARs, however, that cost growth for Global Hawk was high.

Five of the DEP programs show the low PAUC growth expected of programs that pass MS B in a boom climate, as each of the DEP programs did. The average PAUC growth for these five programs is 10 percent; the average for MDAPs that passed MS B in a boom climate excluding TPP programs and Titan IV (which is an outlier) is 5 percent, so there is no evidence that relieving the DEP programs from DoD regulations is associated with lower PAUC growth. The difference is not statistically significant.[156] The milestone authorizations also did not prove to be successful, as each of the four programs breached its cost or schedule limits within two years.[157] Nor is there any need to refer to relaxation of regulations to explain the high cost growth shown by three of the other DEP programs. Two of these (T45-TS and C-17) were acquired with TPP-like contracts and have PAUC growth similar to that of other TPP programs.

There also does not seem to be anything to be made of the data for three DAPP programs. PAUC growth for JDAM is notably low for a program that passed MS B during a bust climate, but PAUC growth figures for the JPATS and C-130J programs are somewhat high even for programs that passed during a bust climate. Consequently, any claim made for JPATS and the C-130J would need to be along the lines of "cost growth would have been even higher but for regulatory relief."

Finally, Table 34 includes only the seven OTs with funding greater than $100 million because these programs were MDAPs or, perhaps with one exception, intended to become MDAPs. In contrast to the OTs that Smith, Drezner, and Lachow (2002) judged to work well, these seven projects had little or no commercial potential and to a substantial extent used technology developed by the companies involved under previous DoD contracts. They do not make a good surface case for OTs for projects with those characteristics—two high cost growth programs, one cancellation, one truncation, and four programs that never went to MS B.

The conclusion implied by the data reported in this section is that the regulatory relief provided by DEP, DAPP, and OTA programs for which data were found do not show lower PAUC growth.

E. Concluding Comment

The context of the results presented in this chapter is a study of the clustering of PAUC growth. One such cluster is provided by MDAPs that were acquired with TPP or TSPR arrangements or enjoyed some regulatory relief under DEP, DAPP, or OTA. The database for this study includes 156 MDAPs that were completed by the end of FY 2016 and for which we have a PAUC growth estimate. Forty-three of these had a PAUC growth of at least 50 percent; of these, 14 were acquired using a TPP or TSPR contract or

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[156] Two-tailed t-test with unequal variances, $p = 0.265$. A-D found the PAUC growth for the five DEP programs to be consistent with a normal distribution. K-S found the distribution of PAUC growth for the other 26 non-DEP programs that passed MS B FY 1981–FY 1986 to be consistent with a normal distribution.

[157] Radice, "The Defense Enterprise Program," 62.

under the DEP or DAPP programs. Whatever other advantages these initiatives presented, they are not associated with reduced PAUC growth.

8. Some Properties of the OSD Oversight Process

A. Introduction

Medicine in seventeenth century Europe "was a matter of trial and error, typically in that order."[158] It could not have been otherwise, because so much of the science that underpins modern medicine had not yet been discovered. Harvey's work on circulation, for example, did not appear in English until about 1650, and the germ theory of disease "was developed, proved, and popularized in Europe and North America between about 1850 and 1920."[159] Until then, many physicians mainly attributed diseases to imbalances of bodily fluids called "humors."

These comments suggest the ambition of the conclusions gathered here. This chapter points to five features of the DoD acquisition process that ought to be understood by researchers and by anyone proposing improvements in acquisition policy. The first two points offered are summaries of the conclusions reached on the main issues examined in this study:

- Is OSD-level oversight of MDAPs responsible for a sustained reduction in the level of cost growth in bust climates?
- How successful has the oversight process been in containing the tendency to higher cost growth of MDAPs that pass MS B in bust periods?

The next three topics considered are spin-offs from the main threads of the analysis:

- Are the cultures of acquisition organizations a significant cause of cost growth?
- What are the more and the less important aspects of cost growth?
- What are the purposes of OSD-level oversight of MDAPs?

The conclusions on these last three topics fall into the gray area between conjectures suggested by data and conclusions that are reasonably well grounded on the results of statistical and historical analysis.

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[158] The language in quotation marks is the author's synopsis of a longer passage in Gale E. Christianson, *In the Presence of the Creator: Isaac Newton and His Times* (New York and London: Macmillan, The Free Press, 1984), 174.

[159] "Germ Theory," Harvard University Library Open Collections Program/Contagion: Historical Views of Disease, accessed December 27, 2017.

B. Success of the Milestone Review Process

The historical analysis of the OSD-level milestone review process provides a conclusion that plays a pivotal role in the interpretation of the statistical results. The nub of the conclusion, reduced to a length suitable for printing on a t-shirt, is: Packard lives!

As was shown in Chapter 3, in comparison to the McNamara-Clifford period, this package of reforms was associated with a statistically significant reduction in PAUC growth.

The data indicate that one important reason for this reduction was Packard's prohibition on the use of TPP. Beyond that, the 1969 Packard reforms significantly reduced the proportion of MDAPs that showed very high PAUC growth. The assignment of reasons for the decrease is a matter of historical judgment. The judgment offered here is that the main factor was Packard's introduction of a more extensive technology development and risk reduction phase before the EMD decision at MS B. This phase embedded in the milestone review process Packard's policy of "fly before you buy," thereby presumably on average reducing the risks remaining in MDAPs that sought MS B authority and, at a minimum, providing the MDA at the MS B review with a better sense of the risks remaining in the proposed program.

Average PAUC growth during the bust periods of the 1980s, 1990s, and early 2000s remained lower, and among completed programs instances of extremely high cost growth remained uncommon. That is, the success of the 1969 Packard reforms on PAUC growth persisted. The question is: Why? Is the lower PAUC growth we see decades later still the result of the 1969 Packard reforms?

The answer to this question offered here is "Yes." For the period covered by this study, none of the Packard reforms was reversed or reduced to a dead letter or overtaken by other changes. To the contrary, item by item the elements of the 1969 reforms have been at least retained and most have been strengthened. To mention three examples, the version of DoDI 5000.02 in force in FY 2009 required (1) a robust Technology Development phase, (2) realistic costing of the program proposed at MS B and provided for an independent cost estimate by what is now CAPE-CA, and (3) full funding at MS B of the cost estimate adopted by the MDA. Other examples could be provided. On a historical basis, then, it is not at all farfetched to conclude that the effects of the Packard reforms persisted because the reforms themselves continued in force.

An exception to this statement is provided by initiatives on contract types and relaxation of acquisition regulations undertaken during the 1980s and 1990s. Programs directly involved in those initiatives generally had PAUC growth substantially above the average, normalized for funding climate. We did not, however, find statistically significant differences in cost growth among DSARC, P-C DSARC, DAB, and AR periods.[160] This finding is disconcerting because it suggests that, whatever other benefits they provided, successive changes in acquisition policy during the 1980s, 1990s, and 2000s did not significantly reduce PAUC growth.[161]

This conclusion may well be correct, but the statistical analysis also provides some counter evidence. When the acquisition policy bins (DSARC, P-C DSARC, DAB, and AR) are dropped from the analysis, we find a statistically significant decreasing trend (of about four-tenths of a percentage point annually) in PAUC growth.[162] Taking all of the evidence together, the safe conclusion is that for a given funding climate, PAUC growth did not increase over the period FY 1970–FY 2009 and may have shown a modestly decreasing trend.

C. Evidence of a Limitation of the Milestone Review Process

The second major question asked in this report was required by the strong association of PAUC growth and funding climate. As a reminder, Table 35 provides a summary of average PAUC growth of MDAPs that passed MS B in the bust and the boom phases of each of the two bust-boom cycles in the database. Average PAUC growth of MDAPs that passed MS B during the bust phase of the first cycle was about twice that of MDAPs that passed during the boom phase; the difference was nearly a factor of 10 for the second cycle.[163] More intense competition for funding in bust climates is a major part of the explanation for these facts, as it would provide the Services with a stronger incentive to propose programs with relatively greater risk in their MS B baselines. It is not a sufficient explanation, however. DoDD 5000.1 and DoDI 5000.2 do not permit MDAPs that passed MS B in bust periods to be riskier, and therefore have higher PAUC growth on average than those that passed in boom periods. Accordingly, it is necessary to ask why the DSARC/DAB process did not prevent the higher PAUC growth.

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[160] Several other studies have reached this same conclusion, including the first paper in the series behind this report. See David L. McNicol and Linda Wu, "Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs," IDA Paper P-5126 (Alexandria, VA: Institute for Defense Analyses, September 2014). It is important to note that these studies take the DSARC period or some later period as the baseline; they do not make any comparison to PAUC growth in the McNamara-Clifford period.

[161] This report did not consider the Weapon Systems Acquisition Reform Act of 2009, which was not signed into law until May 22, 2009.

[162] See Chapter 3, Table 18, p. 42.

[163] See Chapter 2, Section C for more detail.

Table 35. Average PAUC Growth in Boom and Bust Phases for Completed Programs

Cycle	Period (FY)	Bust Climates	Period (FY)	Boom Climates
First Bust-Boom Cycle‡	1970–1980	37% (49)	1981–1986	18% (35)
Second Bust-Boom Cycle	1987–2002	37% (45)	2003–2009	2% (11)

‡ Excluding McNamara-Clifford.

One possible explanation is that in bust periods, the greater frequency and severity of problems with programs that came to an MS B review pushed the OSD-level oversight process to what was effectively a capacity constraint. If the workload involved in milestone reviews increases significantly in bust periods, the constraint could be at the staff level. That is, the staff could be stretched to the point that it fails to identify to the MDA significant problems in the proposed baseline.[164] A possibly more important constraint is the greater intensity of Service opposition to any changes in proposed programs that would delay programs or add to funding requirements.

Another approach challenges the premise that the DSARC/DAB process failed to check the PAUC growth of MDAPs that passed MS B in bust climates. This challenge is prompted by the statistical finding that MDAPs that passed MS B in bust periods and later went into boom periods had significantly higher PAUC growth than those completed in a bust period. Stripped of all qualifications, the challenge is: In bust periods, program ambitions are scaled back so as to be consistent with the tighter funding constraint and their PAUC growth is attributable to the costs of program changes—that is, enhancements—adopted in a later boom period. In this case, the DSARC/DAB process would be judged to be a success in that programs that passed MS B in bust climates had relatively modest ambitions and were structured as evolutionary acquisitions. In short, given the way the SARs and some statutes are structured, it is possible to have significant PAUC growth without failures in the acquisition process. This possibility is only a partial explanation, however, since only about one-third of PAUC growth of MDAPs that passed MS B in bust periods was due to program changes.

Finally, there is a more subtle challenge to the premise that the DSARC/DAB process failed to check the PAUC growth of MDAPs that passed MS B in bust climates—that the MDA deliberately, with adequate information and at least tacit support from the Secretary of Defense, decided to accept greater risks in MDAPs that came to MS B reviews in bust climates. The underlying point here is that bust climates presented senior officials in OSD and those in the Services with the same menu of unappealing

164 Fewer MDAPs tend to pass MS B annually in bust years, but they might each have a larger number of problems with their baseline.

choices on major acquisition programs. Case by case and overall, there was no option that did not have serious undesirable consequences.

Each of the Services has a portfolio of programs across mission areas and commodity types, extending from efforts in the technology base through programs nearing the end of production. When a program is completed, it opens a resource “hole” that programs emerging from EMD can occupy. In turn, programs earlier in the acquisition cycle can move forward as well. When funding for acquisition turns down, these holes get smaller, or close entirely, or require cuts in funding for ongoing programs. The alternatives available in this circumstance are cancellations of programs, delays in new starts, programs that are more austere than is cost-effective on a long-term view, stretches, and unrealistic baselines—in particular, unrealistic cost and schedule estimates. Taking the 5000-series documents at face value, one role assigned to the DAB is that of precluding one class of options—unrealistic baselines.[165] Doing so would not address the underlying problem, which is an inconsistency between force structure, the capabilities that the Department was expected to provide, and funding. These factors almost certainly were inconsistent during the 1970s and for more than a decade after the end of the Cold War. That inconsistency is the context in which high average PAUC growth and most cancellations arise and presumably is a major factor to be considered in designing proposals for improved outcomes.

The three explanations offered here are not mutually exclusive. It seems likely that each is largely accurate in some cases but that none is clearly satisfactory as an overall explanation of why the OSD-level oversight process was not fully successful in limiting cost growth of MDAPs that passed MS B in bust climates.

D. Culture as a Cause of Cost Growth

The culture of the DoD acquisition organizations often is blamed for cost growth.[166] There certainly are many distinct organizations in DoD involved in acquisition, and, as with all bureaucratic organizations, they have cultures and tend to be wary of change. That said, both the historical and statistical analyses suggest that DoD acquisition culture has little to do with cost growth of MDAPs.

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[165] USD(AT&L) also plays a role in DoD efforts to balance funding for new MDAP starts with likely future funding. The major turning points in the bust-boom cycles, however, were prompted by unanticipated events—the end of the Cold War and 9/11.

[166] Examples can be found in *Defense Acquisition Reform: Where Do We Go from Here? A Compendium of Views by Leading Experts* (Washington, DC: United States Senate Committee on Homeland Security and Governmental Affairs, Permanent Subcommittee on Investigations, October 2014).

The importance of cultural resistance might be revealed by instances of overt opposition to changes in acquisition policy. In this respect, the record is mixed. Reading between the lines, the Services were opposed to McNamara's active oversight of ongoing MDAPs. There is clear evidence of opposition from not only the Services but also from OSD to the Packard Commission's PM/PEO/SAE/DAE recommendation. In the wake of the Goldwater-Nichols Act (1986), for several years OSD sought to preserve a role for OSD below the level of the Secretary of Defense in the requirements determination process. There also was opposition among career staff to some aspects of the AR initiatives of the 1990s. While significant, none of these instances of resistance to changes in acquisition policy was ultimately successful. On the other side of the ledger, Packard's careful coordination of his 1969 reforms seems to have been rewarded with their substantial acceptance. The Carlucci Initiatives were suggested by senior DoD career officials involved in acquisition, and also apparently did not generate significant opposition within the Department.

The key statistical evidence is the much lower average PAUC growth of MDAPs that passed MS B in boom climates. Does it make sense to assert that an entrenched culture sometimes results in low cost growth and other times in high cost growth? It perhaps could be asserted that the cultures of DoD acquisition organizations provide two playbooks—one for boom climates and another for bust climates. A more straightforward explanation of the data is that DoD acquisition organizations react to a change in an external circumstance—the intensity of competition for acquisition funds. This explanation also is more informative in that it draws attention to the possibility that "unreasonably" optimistic MS B baselines perhaps were a rational response to the circumstances in which they arose. Instances of extremely high cost growth probably cannot be waved away on that basis. It is necessary, however, to be careful about the extent to which the DoD acquisition process creates problems—cost growth, schedule slips, performance shortfalls—and the extent to which it provides reasonable accommodation to inconsistencies between funding and force structure and missions.

E. More and Less Important Aspects of Cost Growth

The database used in the study includes a PAUC growth estimate for 45 MDAPs that passed MS B during the long post-Cold War bust climate (FY 1987–FY 2002) and were completed by the end of FY 2016. Average quantity-normalized PAUC growth from the MS B baseline for these 45 programs was 37 percent. The PA&E data introduced in Chapter 3 suggest that about one-third of the total—call it 12 percentage points—was cost growth due to Program Changes.[167] The remaining two-thirds—roughly

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[167] Chapter 3, Section E.

25 percentage points—was the sum of Errors of Inception, Errors of Execution, and costs of program restructures due to external events (e.g., across-the-board funding costs) and other duration-dependent sources of cost growth. A comparison of results for boom and bust years suggests that Errors of Execution were small—about 4 percentage points on average at most. If this is accepted, average Errors of Inception for the MDAPs that passed MS B during the post-Cold War bust years was about 21 percentage points.

Cost growth due to Program Changes does not have the same significance as cost growth due to Errors of Inception and Errors of Execution. First, as a broad generality, decisions to upgrade an MDAP rather than undertake a new start have been consistent with acquisition policy since at least 1981, initially as P3I and then from the mid-1990s as Evolutionary Acquisition. Second, the incremental costs of Program Changes are funded through the Program/Budget process. Some, like new starts, may not be realistically funded. They key point, however, is that Program Changes are a matter of DoD paying more for capability beyond that in the MS B baseline, while Errors of Inception and Errors of Execution are a matter of paying more for the MS B capability, or possibly even less than the MS B capability. Cost growth due to Program Changes should not be on the rap sheet of the acquisition process.

Cost growth due to Errors of Inception (about 21 percentage points) is much larger than that due to Errors of Execution (at most about 4 percentage points). Errors of Inception are not necessarily more important, however. The classic Error of Inception occurs when DoD contracts for a Cadillac and budgets for a Chevrolet. Eventually, additional funding must be added to the budget to buy the Cadillac. The 21 percent PAUC growth is a measure of the amount of funding that must be added. It does not measure the added cost of the acquisition portfolio, however, because that portfolio included the Cadillac but underpriced it. The increase in the cost of the acquisition portfolio is the cost of the adjustments that must be made to accommodate the added funding required to acquire the Cadillac. DoD must make the necessary budgetary adjustments within a given top line—usually within funding for acquisitions. These adjustments include such measures as stretches, delays, cancellations, and descoping of programs. (The adjustments made are not necessarily confined to the program that requires additional funding.)

The literature on cost growth includes only one published attempt to compute the cost adjustments associated with Errors of Inception.[168] The result was 2 to 8 percentage

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[168] McNicol. *Cost Growth*, 9–10 and Appendix B. The computation of the tax due to Errors of Inception recognizes some considerations in addition to stretches and is for that reason complex. To get the flavor of this computation, suppose for example that, in a 10-year period, 50 MDAPs passed MS B and some of these had seriously unrealistic baselines. To simplify the problem, also assume that all 50 programs were eventually completed, although because some had unrealistic baselines, many of the

points of the MS B baseline cost. Subsequent work on the effect of stretches on cost progress curve slopes suggests that the upper end of the range could be higher.[169] Still, staying with published computation of the tax, the relevant comparison between Errors of Inception and Errors of Execution is not 21 percentage points versus 4 percentage points, but 2 to 8 percentage points versus at most 4 percentage points. Thus, given the current state of knowledge, Errors of Inception and Errors of Execution may be of roughly equally quantitative importance.

This conclusion, however, may fail to recognize the real importance of Errors of Inception that result in especially high cost growth. Such MDAPs, particularly very large MDAPs, are a major impediment to rational allocation of DoD resources. As cost growth emerges, plans are to a significant extent dictated by force of circumstances rather than measured choices among available alternatives. This not only disrupts rationally formulated plans but in effect shifts authority for DoD resource allocation towards the Service acquisition organizations and away from the President, the Secretary and Deputy Secretary of Defense, the USD(AT&L), and the Congress. If it is in fact the case that an unrealistically funded program that makes reasonable technical progress will eventually be fully funded, those programs muscle their way to the head of the funding line, apart from their comparative merits.

F. Purpose of OSD-Level Oversight of MDAPs

McNamara's DoDD 3200.9 and the successive editions of DoDD 5000.1 and DoDI 5000.2 did not articulate the underlying rationale for OSD-level oversight of MDAPs. More specifically, they did not point out what circumstances make OSD-level milestone reviews necessary. This observation is important because, lacking such an understanding, proposals for change often are a proxy for debate over the need for OSD-level milestone reviews, and may through lack of understanding do more harm than good.

DoDD 3200.9 described the purpose of the second of its two milestones as follows:

> The ultimate goal of Contract Definition…. is achievable performance specifications backed by a firm fixed price or fully structured incentive proposal for Engineering Development.

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funded at MS B and on average across the portfolio Errors of Inception were zero. The reference portfolio would have a higher initial funding, would be completed sooner, and would have a lower total cost, because it avoided the added costs of stretches. Suppose that the total cost is lower by 2 percentage points. This would imply that the same funding could acquire 51 "average" MDAPs efficiently procured rather than the 50 procured with stretches. If the "tax" were 8 percentage points, it would be possible to procure 54 MDAPs rather than 50.

169 Patricia F. Bronson, "A Model for Cost Progress on Defense Department Procurement Contracts," IDA Paper NS P-4437 (Alexandria, VA: Institute for Defense Analyses, July 2009).

The Directive goes on to list "subsidiary objectives" included in the "overall objective." These include:

- Firm and realistic performance specifications,
- Verification of technical approaches,
- Identification of high risk areas, and
- Establishment of firm and realistic schedules and cost estimates.

In effect, the milestone review process established by DoDD 3200.9 was an inspection station, at which an MDAP was examined by OSD staff—in particular, the staff of DDR&E[170] and OSA.

The surface case for such an inspection facility rests on the fact that the Secretary of Defense is politically accountable to the President and the Congress for shortcomings in major acquisition programs—cost growth, schedule slips, and performance shortfalls. Particularly in light of the increased authority provided by the DoD Reorganization Act of 1958, the Secretary of Defense needed a process for ensuring that the major acquisition programs proposed to the Congress met the tests for prudent commitments of large amounts of funding ultimately provided by the nation's taxpayers. That political requirement for a quality assurance process of some form for MDAPs still exists.

Another possible rationale for the milestone review as inspection station is that OSD decision makers generally are not partisans in the competition among MDAPs for funding. As a result, OSD staff can provide professional advice without concern about running afoul of some pre-established policy position. This does not mean that OSD staff have better scientific and technical knowledge than their Service counterparts. A "superior knowledge" rationale for OSD oversight of MDAPs had some currency in the 1960s and early 1970s. For example, this perspective seems to be embodied in the name "Cost Analysis Improvement Group" for the OSD independent cost analysis group established by Packard in 1972. The language surrounding the establishment of DDR&E in 1958 also suggests that it was to provide leadership to the Department in science and technology. Whatever merit it may once have had, the superior knowledge rationale fairly quickly faded.

A third, and deeper, rationale for the OSD-level milestone review process lies in the likelihood that the Secretary of Defense often will have a different—typically lower—tolerance for risk in major weapon system acquisitions than the leaders of the Military Departments. From this perspective, the inspection station is a means for the Secretary of

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[170] DDR&E was established by the DoD Reorganization Act of 1958, Pub. L. No. 85-599, 72 Stat. 514 (Aug. 6, 1958).

Defense, or the MDA acting on behalf of the Secretary of Defense, to gauge the riskiness of a proposed MDAP and then adjust it to what the administration finds acceptable. Policy direction cannot be relied upon to achieve this goal because the riskiness of an MDAP depends on so many complicated and interrelated factors; inspection is necessary.

The process administered by DDR&E under DoDD 3200.9 and the subsequent DSARC and DAB milestone review processes had an important second function in addition to being an inspection station; they also were a repair facility or condemnation agent for "broken" MDAPs. When an MDAP encountered substantial schedule slips or cost growth or a significant performance shortfall, it would undergo a program review. The outcome of the program review could range from cancellation to a major restructuring to a stretch and the addition of the funding needed to make the program executable. These possible outcomes are much the same as those of an MS B review, and so the repair facility/condemnation agent needs to be located at the OSD level for the same reasons the MS B review does—differing perceptions of risk and the political accountability of the Secretary of Defense for major acquisition programs.

The blunt characterization of the functions of the OSD-level MDAP oversight process offered here—inspection station, repair facility/condemnation agent—appears nowhere in the DoD 5000-series documents. This characterization also is not present in the main historical accounts of the evolution of the DoD acquisition process or in discussions of how it should be changed. This is unfortunate. It is impossible to fully gauge the success, or lack thereof, of the OSD-level MDAP oversight process, or have a coherent discussion of how it might be improved, without a well-articulated statement of the context in which it operates and the problems it is intended to ameliorate—if not entirely solve.

G. Concluding Comment

Any reasonably knowledgeable person who reads this report carefully will find aspects of it that could be improved and conclusions that seem to be inadequately supported or simply wrong. These readers are directed to the compact disc (CD) in the sleeve on the back cover of this report. That CD contains a Microsoft Excel workbook with the data used in the study as well as some additional documentation. These materials are offered as a contribution to continuing efforts within the analytical community to contribute well-grounded analyses to inform discussions about acquisition policy and process.

Appendix A.
The Data

A. Cost Growth Metric and Ground Rules

The principal cost growth metric used in this paper is quantity-normalized Program Acquisition Unit Cost (PAUC) growth in program base year dollars. In most instances, the PAUC growth figure used is measured from the Milestone (MS) B baseline. PAUC includes Research, Development, Test, and Evaluation (RDT&E) funding as well as procurement funding.

Each of the programs in the database with a PAUC growth estimate completed Engineering and Manufacturing Development (EMD), went into production, and fielded at least some units to operating forces. We follow the convention of not including in the database any MDAP that was not at least five years beyond EMD, so that cost growth would have time to appear. The most recent Selected Acquisition Reports (SARs) available for this paper were those for December 2015, so the most recent programs included are those that passed MS B in FY 2010. The report covers fiscal year (FY) 1965–FY 2009. The database contains an estimate of PAUC growth for 185 of the Major Defense Acquisition Programs (MDAPs) that entered EMD for this period.

The estimates mainly are drawn from the database developed for Institute for Defense Analyses (IDA) Paper P-5330 (Revised), which in turn evolved from the database for IDA Paper P-5126.[1] The cost growth observations for FY 1965–FY 1969, however, and a few of the observations for FY 1970–FY 1989, are drawn from other studies, as is discussed below.

B. Business Rules

Almost all of the data used in this research were taken directly or indirectly from SARs. SARs filed in FY 1997 and subsequent years are available through the Defense Acquisition Management Information Retrieval (DAMIR) system. Many SARs filed before FY 1997 are available on an Office of the Under Secretary of Defense

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1 David L. McNicol et al., "Further Evidence on the Effect of Acquisition Policy on Cost Growth of Major Defense Acquisition Programs," IDA Paper P-5330-REVISED (Alexandria, VA: Institute for Defense Analyses, August 2016); David L. McNicol and Linda Wu, "Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs," IDA Paper P-5126 (Alexandria, VA: Institute for Defense Analyses, September 2014).

(Acquisition, Technology and Logistics) (OUSD(AT&L)) SIPRNet site. These two sources provided SARs under about 345 distinct labels.

Not all of these distinct labels are distinct programs. Three steps are needed to get from the list of distinct SAR labels to a list of MDAPs:

1. During the 1970s, each Component involved in a joint program sometimes filed a SAR. These SARs reported the same program data. The database used in this research includes only the data reported (for the entire program) in the SAR filed by the lead Component.
2. The program name used on the SAR often changes over the acquisition cycle for a given program. For example, the OH-58D Kiowa Warrior was first reported as the Army Helicopter Improvement Program (AHIP). In most cases the database uses the name under which the last (or, for ongoing programs, most recent) SAR was filed.
3. Multiple MDAPs that have passed MS B are sometimes combined into a single MDAP. Conversely, a single MDAP that has passed MS B is sometimes split into two or more separate MDAPs. If the data permitted (and they often did not), our rule was to maintain the program(s) as they had been defined at MS B.

For the reasons noted above, the database does not include any MDAPs that passed MS B after FY 2010. In addition, the following were excluded from the main database:

- Major Automated Information Systems (MAIS),
- Chemical Demilitarization Programs,
- Ballistic Missile Defense programs managed by the Ballistic Missile Defense Agency and its predecessors,
- Programs that filed a SAR but were never designated as an MDAP, and
- Programs cancelled before they passed MS B or before they were designated as an MDAP.

These exclusions were indicated by the purpose of the analysis, which is to gauge the effect of different Office of the Secretary of Defense (OSD)-level acquisition regimes and funding climates on MDAP outcomes. The database then should include only programs subject to OSD-level acquisition policy. To at least a significant extent, the excluded programs differed from the MDAP norm. The exclusions therefore resulted in a main database that contains 311 MDAPs that entered development during the period FY 1965–FY 2009.

Most of the MDAPs in the database passed MS B at the OSD level. Some, however, entered at MS C, obtained both MS B and Low Rate Initial Production authority in a single OSD-level review, or passed MS B at the Service level and later became

Acquisition Category (ACAT) I programs. These cases are noted in the database for programs that became MDAPs in FY 1989 or later, but not reliably noted for programs begun earlier.

Finally, it proved to be necessary to adopt a clear criterion for program cancellation. In the database, a program is classified as cancelled if:

- The program did not result in production of any fully configured end items, or
- Any fully configured end items produced were used only for testing and development.

Application of this definition was not clear-cut for six programs that passed MS B at the Service level, later filed SARs, and subsequently were cancelled. We retained on the list of cancelled programs the five that had been designated as ACAT I programs and excluded the one that had not.[2]

Two other programs were counted as cancelled, although they did not exactly satisfy the criteria stated. The C-27J was included on the list of cancelled programs because the 21 C-27Js produced were placed directly in long-term storage and later transferred to Special Operations Command and the US Coast Guard. Roland was included, although the system was produced in the United States in limited quantities and issued to a single National Guard battalion, which falls into a gray area between issue of the system to Active Duty units and its use only for development, experiment, and training.

We found 12 additional programs that filed one or more SARs during FY 1959–FY 2009 and were cancelled. These 12 were not included on the list of cancelled programs because they were either cancelled before passing MS B, were never designated an ACAT I program, or were cancelled after they fell below the ACAT I level. They appear as numbers 59–70 in "Program Notes" included on the CD in the pocket on the back cover of this report.

C. Coverage

As was noted above, the database includes 58 MDAPs that were cancelled (as an ACAT I program) after passing MS B and includes 253 programs that went into production. We have Average Procurement Unit Cost (APUC) and PAUC estimates for 185 of the MDAPs that went into production, of which 156 had been completed as of the

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[2] AN/WQR-Advanced Deployable System, AQM-127A Supersonic Low Altitude Target, Advanced Seal Delivery System, ASM-135A Air-Launched Anti-Satellite System, and Land Warrior were retained on the list of cancelled programs. Extended Range Munition was cancelled before it was designated an ACAT I program.

December 2015 SARs. Table A-1 reports the relevant data broken down by the nine time periods used in the statistical analysis. Overall, the database reports a cost growth estimate for about 70 percent of the MDAPs that went into production.

Table A-1. MDAPs in the Database Not Cancelled, with an APUC and a PAUC Estimate, by Bust/Boom Time Periods

Period (FY)	Went into Production	Number with APUC & PAUC	Percent with APUC & PAUC
1965–1969	20	16	76%
1970–1980	62	49	79%
1987–1989	16	11	69%
1990–1993	14	11	78%
1994–2000	40	30	75%
2001–2002	11	6	55%
Total	**163**	**123**	**73%**
1981–1982	14	7	50%
1983–1986	45	31	69%
2003–2009	31	24	77%
Total	**90**	**62**	**69%**
Grand Total	**253**	**185**	**73%**

D. Sources of Cost Growth Estimates

Table A-2 lists the sources of the APUC and PAUC estimates used in this paper. Nearly half of the total was taken from an MDAP cost growth database developed and maintained by the Office of Program Analysis and Evaluation (PA&E) Resource Analysis deputate. The PA&E cost growth database is documented in a briefing by John McCrillis given at the 2003 Annual Department of Defense (DoD) Cost Analysis Symposium.[3] The briefing is included on the CD provided with this paper.

3 John McCrillis, "Cost Growth of Major Defense Programs," Briefing (presented at the Department of Defense Cost Analysis Symposium, Williamsburg, VA, January 30, 2003).

Table A-2. Sources of the APUC and PAUC Growth Estimates Used in Different Periods

Period (FY)	PA&E	IDA P-2722	RAND	In-House	Total
1964–1969	0	16	0	0	16
1970–1979	36	8	2	0	46
1980–1989	45	0	4	1	50
1990–1999	7	0	0	32	39
2000–2009	0	0	0	30	30
2010	0	0	0	4	4
Total	**88**	**24**	**6**	**67**	**185**

APUC and PAUC growth estimates for an additional 24 MDAPs were taken from IDA Paper P-2722.[4] The provided CD includes the main volume of P-2722, as well as an Excel workbook with the data. The next section of this appendix describes how the IDA P-5126 cost growth estimates were made.

Communication from the RAND Corporation provided updates to the FY 2015 SARs of estimates for six MDAPs published in a 1996 study[5] of APUC and PAUC growth estimates normalized to the MS B baseline.

Fifty-eight of the MDAPs in the PA&E cost growth database were still ongoing at the time of the final PA&E update (that is, when the December 2004 SARs were filed). These were replaced with in-house estimates. In addition, APUC and PAUC growth estimates for MDAPs that passed MS B during FY 2008–FY 2010 were made, for a total of 67 in-house estimates.

The PA&E estimates were constructed through a detailed examination of the SAR variances. The IDA P-2722, IDA P-5126, and RAND estimates were made with data at a much more aggregated level. The methods used were essentially the same, but it is reasonable to assume that they differ in detailed ways not captured by the general characterization each offers of the method used. IDA P-2722 did not in all cases follow the business rules used in IDA P-5126 and this paper.

These four sources use the same definitions of the relevant cost terms and are based on SAR data. Each also, in most instances, measures cost growth from the MS B baseline when it is available and reports quantity-normalized unit cost growth. Thus, a PAUC

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4 Karen W. Tyson et al., "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs, Vol. I: Main Report," IDA Paper P-2722 (Alexandria, VA: Institute for Defense Analyses, 1992).

5 Jeanne M. Jarvaise, Jeffrey A. Drezner, and Dan Norton, *The Defense System Cost Performance Database: Cost Growth Using Selected Acquisition Reports*, MR-625-OSD (Santa Monica, CA: The RAND Corporation, 1996).

estimate from, for example, IDA P-2722 means the same thing as an APUC estimate from the other three sources.

There were several MDAPs from the 1960s and 1970s for which we had two APUC and PAUC growth estimates. The decisions on which of the alternative estimates to use was entirely rules-based. The PA&E database did not provide estimates for MDAPs that entered EMD during FY 1965–FY 1969. The unit cost growth estimates used for FY 1965–FY 1969 are from IDA P-2722. In addition to the SAR data, IDA P-2722's estimates in many cases reflected other sources of information, including material provided by the program office and contractors. For FY 1970 and beyond, we used the PA&E estimate in all cases in which the last SAR for the program had been filed by the time of the final update of the PA&E database (which used the December 2004 SARs). In a few cases, IDA P-2722 had a cost growth estimate for a program not included in the PA&E database. In these instances, we used the estimate from IDA P-2722 if the program was reported complete in the most recent SARs used; otherwise, we used the RAND estimate, if available.

E. Computation of the IDA Main Database (MDB) V 5.4 Estimates

This section briefly describes how the 67 in-house estimates were made.

1. RDT&E

The SARs report fully configured units acquired with RDT&E funds and those acquired with procurement funds. Only the former are used in computing quantity-adjusted RDT&E cost growth. Our procedure was simply to compute the ratio of the Current Estimate (CE) of RDT&E cost and the baseline RDT&E cost (both in program base year dollars) and scale that by the ratio of baseline quantity to CE quantity. Suppose, for example, that the number of fully configured units purchased with RDT&E funds has increased from four to five and that CE RDT&E cost is 50 percent larger than the baseline cost. Our computation of unit RDT&E cost growth is then (4/5) x 1.5 - 1, or 20 percent.

2. APUC

The method used to normalize APUC for quantity change depended, first, on the extent to which quantity changed between MS B and the final SAR and, second, on whether a useable estimate of the slope of the learning curve was available.

a. No Quantity Change (NQC)

The SAR CE quantity was within ±1 percent of the MS B quantity for 12 of the MDAPs for which estimates were required. No quantity normalization is needed for these programs; their APUC growth is computed by dividing the CE APUC in the final SAR (or the December 2012 SAR for an ongoing program) by the MS B APUC and subtracting 1. The APUC growth for SBIRS-High also falls into this category. The total number of SBIRS-High satellites to be acquired decreased from five (at MS B) to four (the December 2012 SAR). The decrease, however, was in a satellite purchased with RDT&E funds, and we did not put these on a learning curve. There was no change in the number of SBIRS-High satellites purchased with procurement funds. Finally, although the PAC-3 quantity change fell outside the ±1 percent boundary, data limitations made it necessary to compute the PAC-3 APUC growth as the ratio of the CE and MS II APUCs.

b. Defense Acquisition Management Information Retrieval (DAMIR) System Learning Curve (DLC)

The DoD contractor staff for DAMIR provided us with their estimates of learning curve parameters that we were able to use to compute APUC growth for 13 MDAPs that passed MS B during FY 1989–FY 2001. We refer to these as the DAMIR Learning Curve (DLC) APUC growth estimates. For each of these, we took the CE APUC growth in program base year dollars from the last SAR for the program or the December 2015 SAR (for ongoing programs). The task was to normalize this APUC estimate to the MS B quantity, which was done as follows:

- We used the learning curve to compute the recurring flyaway cost at the MS B baseline quantity.
- The CE estimates of RDT&E and non-recurring flyaway cost were taken from the final SAR for the program or from the December 2012 SAR (for ongoing programs).
- Support costs paid for with procurement dollars are, for many programs, primarily initial spares and support equipment, although other items may also fall into this category. Initial spares and support equipment normally scale with the number of units of the system purchased. For that reason, we used the CE support cost reported in the last or most recent SAR scaled to the MS B baseline quantity.

c. Calibrated Learning Curve (CLC)

Twenty-nine MDAPs did not have a PA&E estimate or estimated learning curve parameters, and their CE quantity was significantly different from the MS B quantity. The approach we used in those cases rested on a cost progress curve of the conventional form:

$$C = TQ^{\beta}. \tag{A-1}$$

In this expression, C is recurring flyaway cost, T is first unit cost, Q is cumulative production, and β is the cost progress parameter. We solved this and used the CE for recurring flyaway to get:

$$\hat{T} = CQ^{-\beta}. \tag{A-2}$$

This will be referred to as the calibrated learning curve (CLC) method. A value of β = 0.94 was used for each program. From this point, the computations were the same as those for MDAPs for which DAMIR staff provided the learning curve parameters.

3. PAUC

Quantity PAUC is simply the sum of quantity-normalized RDT&E and procurement (computed using APUC), divided by the baseline quantity. The baseline quantity includes both units bought with RDT&E funds and those bought with procurement funds.

Table A-3 provides an overview of the number of estimates in MDB V.5.4 made with each of the methods. Note that these figures include MDAPs that had not been completed by the end of FY 2016.

Table A-3. Sources of the Quantity-Normalized Unit Cost Growth Estimates Used in Different Periods

Period (FY)	NQC	DLC	CLC	Total
1989–2001	5	13	22	39
2002–2010	7	0	20	27
Total	**12**	**13**	**42**	**67**

F. Comparison of the PA&E and CLC/DLC PAUC Growth Estimates

IDA P-5126 compared the PA&E estimates for 23 MDAPs with estimates made using the CLC and DLC methods.[6] That material is repeated here without substantial changes.

The obvious approach is to compare the PA&E PAUC growth for systems that have been completed with PAUC growth for those same systems computed using the DLC and CLC methods. Unfortunately, there are no MDAPs that have been completed and for which we have both a PA&E PAUC growth estimate and the data needed to compute a DLC or CLC estimate. The best we can do is to examine the 23 MDAPs that passed

6 McNicol and Wu, "Evidence on the Effect of DoD Acquisition Policy and Process," A-7, A-9.

MS II/B during FY 1989–FY 2001 and for which we have a PA&E PAUC growth estimate, a DLC estimate, and a CLC estimate.

The PA&E estimates were most recently updated with the 2004 SARs. The DLC and CLC estimates, in contrast, incorporated more recent data—either the final SAR for the program or, for ongoing programs, the December 2012 SAR. Consequently, in most cases we would expect the DLC and CLC PAUC growth estimates to be larger than the corresponding PA&E estimate. That is the test: A method fails if it yields estimates that are "too often" and by "too much" less than the PA&E estimates. Clearly, this is a weak test.

The relevant estimates are presented in Table A-4. The comparison of the PA&E estimates and CLC estimates is on the left, and the comparison of the PA&E and DLC estimates is on the right. The CLC estimates are larger than the PA&E estimates for 17 of the 23 MDAPs—in most cases, considerably larger. They are smaller in six cases (shaded rows). In all but one of these cases (Joint Direct Attack Munition, or JDAM) the differences are absolutely or relatively small. The average of CLC PAUC growth estimates is 77 percent, in comparison to an average of 60 percent for the PA&E estimates. The DLC estimates exhibit the same pattern. The average of the DLC estimates is 73 percent, and four of them (shaded rows) are less than the PA&E estimate for the program, three by a substantial amount.

Table A-4. Comparison of PA&E, CLC, and DLC PAUC Growth Estimates for 23 MDAPs

Program	PA&E	CLC	Program	PA&E	DLC
Longbow Apache	78%	117%	Longbow Apache	78%	133%
F-22	41%	71%	F-22	41%	55%
F/A-18E/F	6%	12%	F/A-18E/F	6%	9%
Bradley Upgrade	39%	54%	Bradley Upgrade	39%	86%
MIDS	30%	72%	MIDS	30%	68%
CEC	48%	62%	CEC	48%	62%
H-1 Upgrades	124%	192%	H-1 Upgrades	124%	197%
LPD 17	43%	71%	LPD 17	43%	72%
CH-47F	147%	173%	CH-47F	147%	156%
GMLRS/GMLRS AW	125%	249%	GMLRS/GMLRS AW	125%	243%
MH-60S	62%	69%	MH-60S	62%	70%
Tactical Tomahawk	24%	28%	Tactical Tomahawk	24%	27%
GBS	10%	31%	GBS	10%	33%
Stryker	21%	25%	Stryker	21%	22%
UH-60M Black Hawk	49%	62%	UH-60M Black Hawk	49%	61%
WGS	28%	55%	WGS	28%	42%
C-130J	70%	84%	C-130J	70%	70%
JPATS	43%	40%	JPATS	43%	44%
SSN 774	35%	33%	SSN 774	35%	37%
JDAM	18%	-10%	JDAM	18%	-13%
Javelin	229%	197%	Javelin	229%	134%
MH-60R	95%	74%	MH-60R	95%	80%
NAS	25%	21%	NAS	25%	1%
Average	**60%**	**77%**		**60%**	**73%**

Note: The PA&E estimates were updated only through the 2004 SARs. The CLC and DLC estimates incorporate information from the last SAR for the program or the December 2012 SAR (for ongoing programs).

Appendix B.
Selected Major Changes Post-FY 1970 in the OSD-Level Milestone Review Process

A. DAB Committees and Overarching Integrated Product Teams (OIPTs)

The same Instruction that replaced the Defense Systems Acquisition Review Council (DSARC) with the Defense Acquisition Board (DAB) established 10 "Acquisition Committees" to support the DAB.[1] These were chaired by the Assistant Secretary (Command, Control, Communications, and Intelligence) (C3I) or the director of the relevant office within the office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)). Each of the DAB principals was represented on each committee as were DAB advisors (the officials responsible for providing the Milestone Decision Authority (MDA) with particular assessments, such as an independent cost analysis).

These committees played two formal roles in DAB milestone reviews. First, they ensured that the documentation required by the DAB had been prepared and was adequate. (A committee meeting called explicitly to review documentation often was referred to as a DAB Readiness Review.) Second, the committees provided a forum for resolving issues before they reached the DAB, and refining those that did go forward. Beyond these two formal roles, for some Office of the Secretary of Defense (OSD) staff, the pre-DAB review committee meetings were virtually the only way available to inform themselves about the programs coming up for DAB review and the issues associated with them. By providing this access to information, the committees helped to reduce the frequency with which DAB principals raised an issue for the first time at the DAB review.

In about 1994, the DAB committees were replace by OIPTs. The membership of the OIPTs was the same as that of the DAB committees and they played the same roles. As with the DAB committees, only three of the OIPTs proved to be active in DAB reviews: Strategic Systems, Conventional Systems, and C3I, which collectively covered almost all MDAPs. The Strategic Systems and Conventional Systems OIPTs were merged not long after their creation.

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[1] DoDI 5000.2, "Defense Acquisition Program Procedures" (September 1, 1987), paragraph C.2, p. 2.

The most notable change was not the establishment of OIPTs—which basically was a name change—but the introduction of Working-level Integrated Product Teams (WIPTs). The designation "Product Team" rather than "committee" or "working group" was intended to convey two points. First, the purpose of the WIPT was to produce a particular product. In the context of a development program, an IPT would be charged with developing part of the design of the product, with due regard for producibility and maintainability. In the DAB context, the "product" was some aspect of the documentation for a DAB review—such as the acquisition strategy, the cost estimate, or the Systems Engineering Report. The "team" indicated that the members of the IPT were to regard themselves not as a representative of their organization but as a producing member of the IPT. The IPT was "integrated" in that it included all of the relevant functional specialties and organizations required to produce the product. Members were to be "empowered;" that is, they were to have the authority to make decisions.

WIPTs were a mixed blessing from the perspective of the OSD functional communities. Participation in a WIPT could be awkward for any office charged with making an independent assessment or estimate, and the WIPT process imposed new obligations to consult, which required more time, more meetings, and more travel. Under the new process, however, some OSD offices involved in DAB reviews had improved access to data and obtained program information further in advance of the planned DAB review. This was, in particular, the case for the OSD-level independent cost analysts (now the Cost Assessment deputate of the Office of Cost Assessment and Program Evaluation, or CAPE-CA). Moreover, it was easier within the WIPT structure to resolve issues well in advance of an OIPT or DAB meeting.

B. Documentation and Timelines

Although not a topic that attracts much interest, documentation and timelines are the foundation of the OSD-level MDAP oversight process. This is so because that process relies on assessments made by staff specialists, and those assessments cannot be made without adequate programmatic information and time.

From the mid-1960s well into the 1970s, the Development Concept Paper/Decision Coordinating Paper (DCP) was understood to be the main source of information about the program available to the OSD staff. In the terminology used around 2009, the DCP included summaries of the relevant Capabilities Need Document, the Analysis of Alternatives (AoA), the Acquisition Strategy Report (ASR), the Technology Readiness Assessment (TRA), the Program Manager (PM)'s cost estimate, and the logistics plan, and served as both the Acquisition Decision Memorandum (ADM) and the Acquisition Program Baseline (APB). Although Department of Defense Directive (DoDD) 5000.1

provided guidelines for the material to be included, there was no fixed format for the DCP.[2] Instead, at the start of the process, the Service undertaking the acquisition worked with the staff of the MDA to establish the outline for the DCP to be submitted for the upcoming review.

Gradually, over the two decades following Packard's 1969 reforms, the DCP lost its central role in the OSD-level milestone decision process. Its place as a description of the program proposed by the acquiring Service eventually was taken by individual documents directed to particular topics—acquisition strategy, test, cost estimation, systems engineering, and others. The role of the DCP as a decision document was eventually taken over by the ADM and the APB.

The top-level guidance on documentation at the end of this study's period was DoD Instruction (DoDI) 5000.02, dated December 8, 2008. Enclosure 4 of that Instruction identifies the "Statutory and Regulatory Information and Milestone Requirements." The tables listing those requirements span 12 pages. At first glance, the difference between the December 2008 DoDI 5000.2 and the July 1971 DoDD 5000.1 is so great that characterizing it in intelligible terms is impossible, but, in fact, it is fairly straightforward. First, it is necessary to set aside information requirements for Major Automated Information Systems (MAIS) and below ACAT I-level acquisition programs, neither of which played any role in the original DoDD 5000.1. Second, it is necessary to distinguish between information that is to be supplied by the acquiring Service (almost always by the PM) and assessments to be provided by OSD staff.

The results, grouped by topic, appear in Table B-1. The first seven items under Program Description are topics that would go into a DCP. Much of a Cost Analysis Requirements Document (CARD) (item 8) also would, although as a document designed specifically for independent cost estimators, the CARD would have more detail than a DCP. Similarly, OSD staff Program Assessments, with the possible exception of the Beyond LRIP Report (item 4) had their analogs in the 1970s process. The Data Reporting Requirements have roots that go back even further, in some cases to the 1960s. The items in the fourth block, Other Statutorily Required Reports and/or Assessments, all post-date the early 1970s and reflect congressional acquisition reform efforts.

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2 The initial version of DoDD 5000.1 (July 13, 1971) provides a general description of the material that is to be included in the DCP at each milestone (section B, pp. 2–4). More detailed guidelines, but still no format, were provided by the first version of DoDI 5000.2 (January 21, 1975).

Table B-1. MS B Documentation Requirements for ACAT ID Programs in DoDD 5000.02, as of December 8, 2008

Item No.	Title
Program Description (provided by the Service acquiring the systems)	
1	Acquisition Strategy
2	AoA (subject to OSD AoA plan)
3	Capability Need
4	Component Cost Estimate
5	Manpower Estimate
6	Systems Engineering Plan
7	Test and Evaluation Master Plan (TEMP) or Test Evaluation Strategy (MS A)
8	Cost Analysis Requirements Documents (CARD)
9	Operational Test Plan
10	Information Assurance Strategy
11	Information Support Plan
12	Item Unique Identification (IUID) Implementation Plan
13	Life Cycle Signature Support Plan
Program Assessments (provided by OSD staff)	
1	Assessment of the AoA
2	Affordability Assessment
3	Assessment of the Manpower Estimate
4	Beyond Low Rate Initial Production Report/Operational Test and Evaluation Reports
5	Independent Cost Estimate (ICE)
6	Independent Technology Readiness Assessment (TRA)
Data Reporting Requirements	
1	Selected Acquisition Reports
2	Cost/Software Data Reports
3	Unit Cost Reports
4	Earned Value Reports
Other Statutorily Required Reports and/or Assessments	
1	Clinger-Cohen Act Compliance
2	Consideration of Technology Issues
3	Market Research
4	Programmatic Environmental Safety and Occupational Health Evaluation
5	Live Fire Test and Evaluation (LFT&E)
6	Survivability Test and Evaluation
7	Spectrum Usage
8	Replacement System Sustainment Plan
9	Information Technology and National Security System Interoperability Test Certification

The DCP had annexes; the guidelines permitted references to other, presumably more detailed, documents and authorized DSARC principals to issue guidelines on various functional areas. It is plausible that as the processes of the various staff specialties matured, they came to rely on versions of what had initially been "references," and the need for the DCP faded. The largest change that resulted may not be in the level of detail in the program descriptions provided by the PM but rather in the degree of flexibility in the process. As was noted above, the DCP for each particular review was decided by OSD—presumably the MDA's staff—in consultation with the acquiring Service. Thus, the topics to be covered and the amount of detail to be provided were "tailored in." By 2008, the descriptions of the material to be provided by the PM were largely specified in DoD regulations and statutes. Thus, the topics covered and level of detail had to be "tailored out."

Why the process evolved in a way that reduced flexibility is not clear. One possibility is that bureaucracies prefer clearly specified rules (which they then apply) to discretion.[3] Another possibility is that negotiating an outline for a DCP was time-consuming and required a considerable effort from both the MDA staff and the Service. While everyone might have wished to have more flexibility in some cases, overall it may have been considerably easier to simply adopt a fixed format.

C. MSs 0, IV, and V—OMB Circular A-109 and the Carlucci Initiatives

In April 1976, the Office of Management and Budget (OMB) issued Circular A-109, "Major Systems Acquisitions." DoD made two related changes (contained in the January 1977 version of DoDD 5000.1) in response to the new guidance. First, where previously the need for a new acquisition had been documented in the DCP, this was now to be done in a new, separate document, the Mission Element Need Statement (MENS). Second, a new milestone was added—MS 0: Program Initiation.[4] An MS 0 DSARC review was held in response to a Component's submissions of a MENS; a DCP was not required. After the DSARC review, the Under Secretary of Defense (Research and Engineering) (USD(R&E)) recommended a decision on the MENS to the Secretary of Defense. A favorable decision permitted the Component to enter the system exploration phase. Progression into Demonstration and Validation phases still required an MS I DSARC review based on a DCP. It is likely that the MENS and MS 0 were simply *pro forma* changes.

Moreover, the addition of MS 0 did nothing to alleviate a major problem with the OSD-level Planning, Programming, and Budgeting System (PPBS) and acquisition

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3 Steven Kelman, *Procurement and Public Management: The Fear of Discretion and the Quality of Government Performance* (Washington, DC: AEI Press, 1990).

4 It is unclear what "program initiation" meant and this language was not repeated in successive revisions of DoDD 5000.1 and DoDD 5000.2.

processes installed by Laird and Packard in 1969—limited means for reconciling decisions made in the acquisition process with those made in the PPBS. Carlucci Initiative Number 25 was directed at this problem and produced a change with clear potential importance.[5] The intent of the new process was described in the March 1982 version of DoDD 5000.1 as follows:

> The order of magnitude of resources the DoD Component is willing to commit and the relative priority of programs to satisfy the need identified in the JMSNS [Justification of Major System New Start, the new name for the MENS] will be reconciled with overall capabilities, priorities, and resources…[6]

The JMSNS then was to be the basis for an affordability process.

The need for an affordability process was inherent in changes in PPBS made by Laird in 1969. Under the Systems Analysis process of the 1960s, a decision to initiate a new major acquisition and the decision on funding were made in the same document—the Draft Presidential Memorandum (DPM). This connectivity was lost when Laird disestablished the Systems Analysis process and made the Services responsible for building their Future Years Defense Plans. Funding decisions then moved through one process—PPBS—and acquisition decisions through another—the DSARC, and the decisions made in the two processes often were inconsistent. This could itself be a cause of cost growth and seems to have been a major motivation behind the Carlucci Initiatives.

In the new process, Components were required to include JMSNSs with their Program Objective Memorandum (POM) submissions, typically made in June. The JMSNSs were gathered together into a major system new starts issue paper, which was considered by a combined Defense Resources Board and DSARC, chaired by the Deputy Secretary of Defense. Decisions on JMSNSs were included in the Program Decision Memorandum (PDM) issued by the Secretary of Defense at the end of the Programming phase and funding for concept exploration for approved JMSNSs included in a Component's Budget Estimate Submission (submitted in mid-September).

What amounted to a trial run of the Initiative 25 process was part of the Program Review in the summer of 1981.[7] The process apparently was used for the summer 1982 through 1986 Program Reviews; these were boom years during which affordability was not typically a major concern. The process was probably not used for Program Reviews

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5 Deputy Secretary of Defense Frank C. Carlucci, Memorandum, "Improving the Acquisition Process," April 30, 1981, 30. The text of the Carlucci Initiatives can be found at https://ia600504.us.archive.org/25/items/SECDEFInitiativestoImproveDOD/SECDEF%20Initiatives%20to%20Improve%20DOD.pdf

6 DoDD 5000.1 (March 29, 1982), paragraph E.7, p. 6.

7 *Final Report of the Task Force on Acquisition Improvement*, December 23, 1981, 25-1, 25-2.

in 1987 and subsequent bust years when it might have played a major role.[8] The Initiative 25 affordability process was discontinued because the Goldwater-Nichols Act, which became law in October 1986, designated the Chairman, Joint Chiefs of Staff (CJCS), as the principal advisor to the Secretary of Defense on major system requirements.[9]

The revision of DoDI 5000.2 that moved MS 0 from the PPBS back to the acquisition process also added two new milestones: (1) MS IV—Logistics Readiness and Support Review; and (2) MS V—Major Upgrade or System Replacement Decision.[10] The first of these was absent from the February 23, 1991 revision of DoDI 5000.2, but the second (renamed MS IV) formally remained part of the DSARC/DAB process through mid-FY 1996. Only limited use was made of either of these milestones.

MS IV and MS V were, at their roots, about requirements determination. During the 1960s McNamara had put in place in OSD the bureaucratic process to facilitate his routine use of his statutory authority over requirements for MDAPs. As briefly sketched in the preceding section, this process was dismantled in 1969. The Secretary and Deputy Secretary through the USD(R&E) continued to exercise some direct influence on MDAP requirements through the mid-1980s. This changed with the passage of the Goldwater-Nichols Act and enactment of some of the recommendations of the Packard Commission. The latter decisively put the new USD (Acquisition) (USD(A)) in control of the acquisition process, while Goldwater-Nichols made the CJCS the principal advisor to the Secretary of Defense. The introduction of MS IV and MS V was an attempt to maintain involvement in requirements determination of OSD at a level below the Secretary of Defense, which did not survive the second Reagan Administration.

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8 General Accounting Office, "ACQUISITION: Status of the Defense Acquisition Improvement Program's 33 Initiatives," GAO/NSIAD-86-178BR (Washington, DC: GAO, September 1986), 49, states that Initiative 25 had been implemented. That probably would not have been said had DoD not used the process in the 1986 Program Review. New versions of DoDD 5000.1 and DoDI 5000.2 issued in September 1987 retain MS 0 but make no mention of the JMSNS or MENS or any document that replaced them and do not contain language placing the decisions on major system new starts within the PPBS.

9 See DoDI 5000.2 (September 1, 1987), paragraphs D.5 and D.6, p. 4.

10 Ibid.

D. Delegation of Milestone Decision Authority

Delegation of milestone decision authority is potentially of key importance because the MS B review is the main instrument USD(AT&L) has to avoid or ameliorate PAUC growth due to Errors of Inception. Policy on delegation of milestone decision authority went through four phases during FY 1970–FY 2009:

- The versions of DoDD 5000.1 and DoDI 5000.2 issued during FY 1970–FY 1980 made no provision for delegation of milestone decision authority. The Secretary of Defense was the MDA at each milestone.
- During FY 1981–FY 1987, authority for MS C was delegated to the relevant Service Secretary unless the Secretary of Defense acted affirmatively to retain it.[11]
- The automatic delegation of the MS C decision was reversed by DoDD 5000.1 of September 1, 1987. Under this directive, the Secretary of Defense retained MS C decision authority unless the Secretary delegated it to the Service Secretary. [12]
- DoDD 5000.1/DoD 5000.2-R in 1996 permitted USD(AT&L) to delegate decision authority for any of the milestones and eliminated the requirement for Secretary of Defense approval of delegations. Future revisions through the end of the period considered continued these provisions.[13]

Delegation appears to have become common from at least 1987 (see Table B-2). Although the Army and Air Force each provide exceptions, in most instances ACAT ICs (MDAPs for which milestone authority has been delegated to the Service Secretary) made up 60 to 70 percent of the programs on each of the Military Department's MDAP list, which is about the proportion of MDAPs that would be expected to have completed EMD.

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[11] The March 29, 1982 edition of DoDD 5000.1 adopted the principle that "management responsibility for system acquisition programs shall be decentralized except for decisions specifically retained by the Secretary of Defense." Paragraph C.1.b. The Directive went on to specify that the Secretary of Defense was the MDA at MS A and MS B, implying that the Component Head had MS C authority unless the Secretary of Defense acted to retain it. DoDD 5000.1 (March 29, 1982), paragraph C.1.b, paragraph E.4.

[12] DoDD 5000.1 (September 1, 1987), paragraph C.7, p. 2.

[13] DoDI 5000.2 (Oct. 23, 2000), paragraph 4.8.2, p. 47 is particularly clear: Initially, all programs are treated as ACAT ID [DAB program] until formally designated ACAT IC [Component program] by the USD(AT&L). At any time, the USD(AT&L) may delegate milestone decision authority for an ACAT I program to the head of the DoD Component, who may redelegate to the Component Acquisition Executive.

Table B-2. Number of ACAT ID and ACAT IC Programs of Each of the Military Departments, 1988, 1996, and 2002

Department	Year	ID	IC	Total	Percent IC
Army	**1988**	20	14	34	41%
	1996	7	16	23	70%
	2002	12	9	21	43%
Navy	**1988**	19	29	48	60%
	1996	9	18	27	67%
	2002	11	14	25	67%
Air Force	**1988**	17	16	33	48%
	1996	10	18	28	64%
	2002	3	25	28	89%

Note: ACAT I programs for which milestone decision authority had been delegated are designated IC (for Component); those for which the MDA is USD(AT&L) are designated ID (for DAB).

Sources: 1988: Memorandum from Under Secretary of Defense for Acquisition Robert Costello to Secretaries of the Military Departments, "Delegation of Major Defense Acquisition Programs," May 13, 1989; Major Defense Acquisition Program List, 1996; OUSD(AT&L); Memorandum from Under Secretary of Defense (AT&L) E. C. Aldridge, Jr. to Secretaries of the Military Departments, "Fiscal Year (FY) 2002 Major Defense Acquisition Program (MDAP) Lists," May 29, 2002.

Granting the USD(AT&L) discretionary authority to delegate milestone decision authority does not as such seem problematic in terms of PAUC growth. The conventional understanding of the period was that only MS C authority was delegated and that the delegation came post-MS B when the USD(AT&L) had reasonable confidence that the program in question was low risk.[14] It also is relevant that delegation of milestone decision authority was revocable.[15]

USD(AT&L) after 1996 had the authority to delegate MS A and MS B authority as well as MS C. A crucial question is: Was in fact MS A and, especially, MS B authority delegated? We can answer that question only for 2002. On the 2002 list, a total of 16 programs across the three Military Departments were redesignated ACAT IC instead of ID. In one case, the redesignation apparently was an outcome of the MS B decision; in the other cases, MS B preceded redesignation of the program as IC.

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14 Paragraph E2.1.10 of DoDI 5000.2 (October 23, 2000) implies that USD(AT&L) had established criteria for designation of ACAT I programs as IC. We were unable to locate such criteria.

15 The source of the 2002 data in Table B-2 includes three instances in which the IC designation was revoked (and the program reverted to ID.)

E. PM/PEO/SAE/DAE Structure

President Reagan in July 1985 created a President's Blue Ribbon Commission on Defense Management,[16] which became known as the Packard Commission, after its chairman, David Packard. One of the main recommendations of the Packard Commission was a drastic simplification of the chain through which PMs reported to the Defense Acquisition Executive (DAE).[17]

The status quo at the time of the Packard Commission was for most PMs to be located in a Service system command. The PM for an MDAP (usually an Army, Air Force, or Marine Corps colonel, or Navy captain or their civilian equivalent) reported up the chain of the system command to its commander, typically a four-star. The commander of the systems command reported to the chief of staff of the Service who, for acquisition matters, reported to the Service Secretary. The Service Secretary could bring an issue raised by a PM that made it through the chain of command to the USD(R&E). A PM might be required to provide upwards from 30 briefings to get their program in front of the DAB for a milestone review.[18] The Packard Commission recommended replacing the chains of command running through the systems commands with just two layers. The first of these would be the new Program Executive Officers (PEOs). PMs (usually several PMs) would report to a PEO. The PEO would report to a Service Acquisition Executive (SAE), who would bring acquisition issues to the USD(A).[19]

The Congress accepted this recommendation, establishing the position of USD(A) in July 1986.[20] Viewed in bureaucratic terms, the creation of USD(A) entailed moving USD(R&E) one step down in the OSD hierarchy: USD(R&E) reverted to the title DDR&E and would in the future report to the new USD(A) instead of to the Secretary

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16 Executive Order (EO) 12526, President's Blue Ribbon Commission on Defense Management, July 15, 1985. Reprinted in *A Quest for Excellence: Final Report to the President, Appendix* (Washington, DC: The Commission, June 1986), 27–8.

17 The first mention of a DAE in the 5000 series seems to have been in DoDD 5000.1 (March 19, 1980), paragraph E.2, p. 6, which specified the responsibilities of the DAE. The DAE at that point probably was the USD(R&E).

18 Paul Kaminski, "Round Table Discussion on Defense Acquisition," in *Providing the Means of War: Historical Perspectives on Defense Acquisition, 1945–2000,* gen. ed. Shannon A. Brown (Washington, DC: US Army Center of Military History and Industrial College of the Armed Forces, 2005), 379.

19 President's Blue Ribbon Commission, *A Quest for Excellence*, xxiv–xxv.

20 USD(A) was established by Section 301of Title V of Pub. L. 99-348, July 1, 1986, a statute mainly concerned with the military retirement system. The Goldwater-Nichols Act (Pub. L. 99-433, October 1, 1986) mentions the USD(A). Much more extensive provisions on USD(A) and the change in USD(R&E) to DDR&E are in Sections 901, 902, and 903 of Title IX of Division A of Pub .L. 99-661. While the trail is not well marked, it seems likely that Goldwater-Nichols made only conforming amendments to Pub. L. No. 99-348 and that, insofar as the establishment of USD(A) is concerned, the substantive amendments are in Pub. L. No. 99-661.

and Deputy Secretary of Defense. Substantively, the creation of USD(A) implied a shift of emphasis from research and engineering to oversight of DoD's acquisition portfolio.

President Reagan directed the Secretary of Defense to put in place the directives necessary to establish the office of USD(A) and the PM/PEO/SAE/DAE reporting chain.[21] Insofar as OSD-level directives were concerned, this was done with a revision of DoDD 5000.1 issued September 1, 1987 and a new DoDD 5134.1, "Under Secretary of Defense (Acquisition)," issued February 10, 1987. The first USD(A), Richard Godwin, took office in September 1986.

Actually implementing the PM/PEO/SAE/DAE structure required three further feats of bureaucratic prestidigitation. First, both the Service Secretary and the Service Chief had acquisition organizations; these had to be merged. This seems largely to have been accomplished by the end of the second Reagan Administration.[22] Second, the Service Secretaries had to appoint an SAE, extract PMs from their reporting chain up to the commander of the systems command and the Service Chief, appoint PEOs, and redirect PMs to report to the SAE through a PEO. Third, strict adherence to the Packard Commission required that for issues concerning MDAPs, the SAE communicate directly with the USD(A). The second and third of these steps were not completed during the Reagan years.

The actual organization chart for oversight of MDAPs during the late 1980s is not something DoD would want to see in a *Harvard Business Review* article. On one hand, the nominal wiring diagram was that of the PM/PEO/SAE/DAE structure. On the other hand, the actual chain of command often still ran from the PM through the system command commander to the Service Chief and the Service Secretary before reaching the DAE.[23] This situation was not resolved fully until after Richard Cheney's 1989 management review.[24]

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21 National Security Decision Directive 219, "Implementation of the Recommendations of the Blue Ribbon Commission on Defense Management," Section III, Paragraphs A and B, April 1, 1986.

22 See John R. Transue, "Streamlining the Organization," in David R. Graham et al., *Defense Acquisition: Observations Two Years after the Packard Commission, Volume II: Background Papers*, IDA Report R-347-VOL-2 (Alexandria, VA: Institute for Defense Analyses, May 1989), especially 74–88.

23 See Fox, *Defense Acquisition Reform, 1969 to 2009*, 145–6, and Graham et al., *Defense Acquisition: Observations, Volume I: Main Report*, IDA Report R-347-VOL-1 (Alexandria, VA: Institute for Defense Analyses, May 1989), III-2.

24 Secretary of Defense Richard Cheney, *Defense Management: Report to the President*, July 1989.

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Abbreviations

ACAT	Acquisition Category
A-D	Anderson-Darling
ADM	Acquisition Decision Memorandum
AEHF	Advanced Extremely High Frequency
AHIP	Army Helicopter Improvement Program
AI	Automated Information
ANOVA	Analysis of Variance
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
APUC	Average Procurement Unit Cost
AR	Acquisition Reform
ASR	Acquisition Strategy Report
ATM	Asynchronous Transfer Mode
C3I	Command, Control, Communications, and Intelligence
CAPE	Office of Cost Assessment and Program Evaluation
CAPE-CA	Cost Assessment deputate of the Office of Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Document
CD	Compact Disc
CDD	Concept Development Document
CE	Current Estimate
CJCS	Chairman, Joint Chiefs of Staff
CLC	Calibrated Learning Curve
CY	Calendar Year
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DAES	Defense Acquisition Executive Summary
DAMIR	Defense Acquisition Management Information Retrieval
DAPP	Defense Acquisition Pilot Program
DARPA	Defense Advanced Research Projects Agency
DCP	Development Concept Paper/Decision Coordinating Paper

DDR&E	Director of Defense Research and Engineering
DEP	Defense Enterprise Program
DFARS	Defense FAR Supplement
DLC	DAMIR Learning Curve
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DPM	Draft Presidential Memorandum
DSARC	Defense Systems Acquisition Review Council
EELV	Evolved Expendable Launch Vehicle
EMD	Engineering and Manufacturing Development
EO	Executive Order
FAR	Federal Acquisition Regulation
FCS	Future Combat Systems
FET	Fisher's Exact Test
FG	Fiscal Guidance
FP	Fixed Price
FRP	Full Rate Production
FY	Fiscal Year
FYDP	Future Years Defense Program/Five Year Defense Plan
GAO	General Accounting Office/Government Accountability Office
GBS	Global Broadcast System
GPS	Global Positioning System
GRH	Gramm-Rudman-Hollings
ICE	Independent Cost Estimate
IDA	Institute for Defense Analyses
IFF	Iraqi Freedom Funds
IP	Internet Protocol
IUID	Item Unique Identification
JASSM	Joint Air-to-Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JGL	Joint Ground Launched
JMSNS	Justification of Major System New Start
KPP	Key Performance Parameter
K-S	Kolmogorov–Smirnov
K-W	Kruskal-Wallis

LFT&E	Live Fire Test and Evaluation
LRIP	Low-Rate Initial Production
MAIS	Major Automated Information System
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDB	Main Database
MENS	Mission Element Need Statement
MilDep	Military Department
MS	Milestone
M-W	Mann-Whitney
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorization Act
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NS	New Start
O&M	Operations and Maintenance
OIPT	Overarching Integrated Product Team
OLS	Ordinary Least Squares
OMB	Office of Management and Budget
OSA	Office of Systems Analysis
OSD	Office of the Secretary of Defense
OT	Other Transaction
OTA	Other Transactions Authority
P3I	Preplanned Product Improvements
PA&E	Program Analysis and Evaluation
PARCA	Office of Program Assessments and Root Cause Analyses
PAUC	Program Acquisition Unit Cost
PB	President's Budget
PBA	Price-Based Acquisition
P-C	Post Carlucci
PCP	Program Change Proposal
PDM	Program Decision Memorandum
PEO	Program Executive Officer
PERT	Program Evaluation and Review Techniques
PM	Program Manager
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budgeting, and Execution System

PPBS	Planning, Programming, and Budgeting System
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SAE	Service Acquisition Executive
SAR	Selected Acquisition Report
SBIRS-High	Space Based Infrared Satellite-High
TDP	Technical Development Plan
TEMP	Test and Evaluation Master Plan
TPP	Total Package Procurement
TRA	Technology Readiness Assessment
TSPR	Total System Performance Responsibility
U.S.C.	United States Code
US	United States
USD(A)	Under Secretary of Defense for Acquisition
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology and Logistics)
USD(R&E)	Under Secretary of Defense (Research and Engineering)
VMR	Variant, Modification, or Remanufacture
WIPT	Working-Level Integrated Product Team
WSARA	Weapon Systems Acquisition Reform Act

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14. ABSTRACT
This study is concerned only with major defense acquisition programs (MDAPs). It is further confined to "acquisition costs," which is a term of art defined as the sum of Research, Development, Test and Evaluation (RDT&E) funding and procurement funding (that is, the cost of buying the system once it has been developed). The main question asked is whether changes in Department of Defense (DoD) acquisition policies and oversight processes over the period fiscal year (FY) 1964–FY 2009 significantly altered cost growth on MDAPs and the proportion of MDAPs cancelled. Cost growth and cancellations are singled out for examination because they often have been used in public and congressional discussions as tests of the success (or lack thereof) of DoD acquisition of major systems. The available quantitative evidence on whether changes in acquisition policy have reduced cost growth and cancellations is mixed and inconclusive. Because it is a pivotal question and because the topic remains relevant, this study undertook a fresh and comprehensive analysis of the extent to which changes in acquisition policy over the period FY 1965–FY 2009 influenced MDAP cost growth and cancellations.

15. SUBJECT TERMS
Acquisition policy; acquisition process; acquisition reform; Defense Systems Acquisition Review Council; Defense Acquisition Board, Planning; Programming; Budgeting, and Execution System; program cancellation; program truncations; cost growth; PAUC growth; funding climate; Major Defense Acquisition Programs; milestone reviews; Defense Enterprise Program; Defense Acquisition Pilot Programs; Other Transactions Authority; Total Systems Performance Responsibility; Total Package Procurement

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