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Root Causes of Cost Growth in Major Defense Acquisition Programs

David L. McNicol

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Root Causes of Cost Growth in Major Defense Acquisition Programs

David L. McNicol

Executive Summary

Introduction

Growth in the cost of Major Defense Acquisition Programs (MDAPs) usually is not the most important concern about acquisition confronting senior Department of Defense (DoD) officials, but it frequently is the most visible to the public. Moreover, many believe, with good justification, that cost growth has continued apace through the many changes made in DoD acquisition policy and processes over the past half century.

Why cost growth has been so persistent is puzzling. One provision of the Weapon Systems Acquisition Reform Act of 2009 (WSARA), possibly prompted by this observation, required the Secretary of Defense to determine the root cause of any instance in which the unit cost of an MDAP grew by at least 50 percent.[1] Over the five years that followed enactment of WSARA, analyses of the causes of cost growth of 14 MDAPs were published.[2] Although useful in several ways, these studies were mainly concerned with what this study calls the immediate or, better, the proximate causes of the cost growth. One somewhat common proximate cause of the cost growth, for example, is an unrealistically optimistic development schedule. A successful root cause analysis in such a case would explain why DoD adopted an unrealistic estimate. Were the staff analyses done to support the decision flawed or incomplete? Were the applicable policies inadequate in some respect? Did the decision reflect a lapse on the part of the senior DoD official who approved the unrealistic schedule? In only a few instances, however, did it prove to be possible to trace an individual proximate cause back to its root cause, and the studies provide no general understanding of root causes of cost growth.

The central task of this paper is to develop a theory of the root causes of Errors of Inception, which is the label applied in published root cause analyses to unrealistic elements in an MDAP's initial baseline. Competition for funding among MDAPs lies at the center of the answer proposed. The idea that competition for funding is at the root of

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1 Pub. L. 111-23, May 22, 2009, Sec 206. See also Sec. 204, which imposed a similar requirement for programs at an earlier stage of development.

2 These studies were sponsored by the Office of Program Assessment and Root Cause Analysis (PARCA), now the Office of Acquisition Analytics and Policy (AAP). See Irv Blickstein et al., *Root Cause Analyses of Nunn-McCurdy Breaches*, Vol. 1, MG 1171z1 (Santa Monica, CA: The RAND Corporation, 2011); Irv Blickstein et al., *Root Cause Analyses of Nunn-McCurdy Breaches*, Vol. 2, MG 1171z1 (Santa Monica, CA: The RAND Corporation, 2011, 2012); and Richard P. Diehl et al., "Root Causes of Nunn-McCurdy Breaches—A Survey of PARCA Root Causes Analyses 2010–2011: Interim Report," IDA Paper P-4911 (Alexandria, VA: Institute for Defense Analyses, 2012).

much of cost growth is neither new nor controversial. Competition for funding, however, has been at the periphery of the conventional wisdom about cost growth, is seldom cited as a factor in discussions of acquisition reform, and has been absent from case studies of cost growth. As a practical matter, then, it needs to be treated as a new idea that requires explanation.

Foundations of the Model

The best clue we have to the root causes of cost growth lies in differences in the average cost growth of MDAPs initiated in bust and in boom funding climates. The table below presents the average cost growth for the two complete bust and boom cycles in Department of Defense (DoD) funding that occurred during the period Fiscal Year (FY) 1964–FY 2009. Cost growth was much higher for programs whose initial baseline was established in a bust period than it was for those whose initial baseline was approved in a boom period, when funds were more readily available. Of course, it is appropriate to be wary of these data because other variables in addition to funding climate presumably are relevant, but for now they are offered as a clue. That clue points towards competition for funding.

Average Program Acquisition Unit Cost Growth for 156 Completed MDAPs

	Bust Phase	Boom Phase
1st Bust-Boom Cycle FY 1965–FY 1986	46%	18%
2nd Bust-Boom Cycle FY 1987–FY 2009	37%	2%

The acquisition process does not impose a binding funding constraint on programs approved. DoD's resource allocation process—the Planning, Programming, and Budgeting System (PPBS)—does, and it is in the PPBS that the competition for acquisition funding occurs. Further, before they begin full rate production, almost all MDAPs face their main competition for funding at the Service level in the context of the Programming phase of the PPBS.

Competition for funds provides the Program Manager (PM) with a sufficient motive for adopting an unrealistically optimistic cost estimate if the funding constraint is sufficiently tight. For this incentive to become cost growth, two other conditions must be satisfied:

- The PM must be able to manipulate the assumptions of an initial MDAP baseline prior to its approval.

- The unrealistic baseline must be accepted by the Milestone Decision Authority (MDA).

There are three ways for the PM to manipulate the assumptions of an initial MDAP baseline prior to its approval. First, an unrealistically optimistic estimate can be made for some feature of the system that is important to its costing. A classic example is the weight of an aircraft (which is used as a predictor of cost). Second, an unrealistic assumption can be made for some aspect of the acquisition strategy; e.g., the cost estimate may assume a larger annual lot size at full rate production than future budgets are likely to accommodate. Third, unrealistically optimistic costing assumptions, data, or methods may be used. The cost estimate may, for example, assume unrealistically large savings from the adoption of some innovation such as computer aided design.

The second condition—that the unrealistic baseline must be accepted by the Milestone Decision Authority (MDA), the senior official with the authority to approve the baseline—presents a puzzle: Why would an MDA ever accept an element of a proposed baseline in the face of creditable evidence that it was unrealistic? Part of the answer is that some, particularly in the Services, do not regard the likelihood of future growth in a program's cost as very damaging. Another part of the answer lies in the context in which an unrealistic baseline is relatively likely to be presented—bust funding climates. During bust periods, there is a mismatch between force structure, the capabilities that DoD is expected to provide, and funding. To reconcile the MDAP acquisition portfolio with anticipated funding, some new starts have to be delayed, some programs cancelled, others stretched, and still others designed to have less capability than was desirable. Each of these options was problematic. Within such constraints, starting some programs with extremely optimistic baselines may seem to be, and in fact may be, reasonable.

Empirical Analysis

The empirical analysis presented in this paper is developed through three sections. The first of these (Section C) draws the qualitative material into a sketch of a theory of the optimal choice of program features that influence a program's apparent cost but not the capabilities that it is to acquire. The theory assumes that the program faces competition for funding. This analysis leads to a relationship between cost growth, a measure of the intensity of the competition for funds, program priority, and the stringency of program oversight. The next section (D) provides operational definitions of the variables that appear in the model and identifies the prior expectations of the model's coefficients. Section 5 presents and discusses the statistical results.

The table on the following page presents the main statistical results obtained. The dependent variable is growth in Program Acquisition Unit Cost (PAUC), which includes both development cost and procurement cost (the cost of buying the system once it has been developed). The most important coefficient estimates, from the perspective of the theory developed in this paper, are those of funding climate (W) and program priority (P). It would be a blow to the theory to find that either of these estimates had a positive sign. In fact, both estimated coefficients are negative and statistically significant. Put in positive terms, the hallmarks of the theory of cost growth offered here is that, because of competition for funding, MDAPs that passed Milestone (MS) B in boom periods will tend to have lower cost growth than those that pass in bust periods and high priority programs will tend to have lower cost growth than low priority programs. This is what is found.

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

	Coefficients	p-value
Intercept	78.3%***	< 0.001
Errors of Inception—Intensity of Competition for Funds		
W (Funding Climate)	-22.7%*	0.070
P (High Priority)	-16.2%*	0.070
Errors of Inception—Acquisition Policy		
DSARC1	-58.5%***	< 0.001
DSARC2	-54.2%***	0.001
DAB1	-56.9%***	0.001
AR	-83.7%***	< 0.001
DAB2	-69.4%***	< 0.001
Errors of Execution and Program Changes		
T_{boom}	3.7%/yr**	0.020
T_{bust}	0.6%/yr	0.492

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

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

* Statistically significant at less than the 10 percent level.

R-Squared = 0.25, F = 5.383 (P < 0.001), N= 156. Estimated using Ordinary Least Squares (OLS). Wald's test for the equality of the estimated coefficients of the categorical variables for acquisition policy periods fails to reject the hypothesis that they are equal. F= 1.27, p = 0.285. In addition, Wald's F finds each of the estimated coefficients of the acquisition policy variables to be significantly different from the estimated constant term at p < 0.001. I am indebted to Dr. David Tate of IDA for suggesting the use of Wald's F and to Dr. Sarah John, also of IDA, for supervising the computations. The database used to compute this regression can be obtained by ordering David L. McNicol, *Acquisition Policy, Cost Growth, and Cancellations of Major Defense Acquisition Programs*, IDA Report R-8396 (Alexandria, VA: Institute for Defense Analyses, September 2018) (hereafter referred to as *Acquisition Policy*) with the CD from the IDA library. Alternatively, it can be found on ResearchGate at https://www.researchgate.net/publication/328202587_MDB_V54_CDxlsx. (Accessed June 6, 2020.)

The estimates of the next five variables provide some insights into the effects of changes in acquisition policy. These categorical variables are defined by changes in acquisition policy; between each period marked out and the next, at least one major change in acquisition policy occurred. There also is an important way in which acquisition policy did not change across the periods. The first period (DSARC1) marked the introduction of a set of reforms introduced by then Deputy Secretary of Defense David Packard at the start of FY 1970. These reforms remained in effect across all five of the periods. McNamara-Clifford (FY 1965–FY 1969) is used as the reference period. The coefficients then are the estimated difference between average PAUC growth in McNamara-Clifford and the period in question. Each of the estimates has the expected negative sign.

The estimates of the coefficients for the acquisition policy variables make three important points. First, compared to McNamara-Clifford, the Packard reforms (DSARC1) reduced average PAUC growth. Second, the estimated coefficients of each of the other periods is negative, implying again lower average PAUC growth than McNamara-Clifford, which suggests that the Packard reforms continued to be effective. Third, there is no statistically significant difference among the estimated coefficients of the acquisition policy variables. This implies that the many changes in acquisition policy after the Packard reforms—especially the spate of changes during the 1980s and 1990s—did not have a statistically observable effect on average PAUC growth.

Finally, the two duration variables (t_{boom} and t_{bust}) are an *ad hoc* extension of the model to include the two other main sources of cost growth present in the data, Errors of Execution and Program Changes. Although the estimated coefficient of each is positive, that for the time spent in boom periods (T_{boom}) is much larger and statistically significant.

Concluding Comments

The causal chain described in this paper begins with unrealistic features in a proposed MS B baseline for an MDAP, which are the largest source of cost growth. Unrealistic baselines are proposed almost exclusively in bust periods, during which the competition for acquisition funds is particularly intense. It is the looming competition for funds, which is intrinsic to the Program/Budget process, that provides the PMs with an incentive to propose an unrealistic baseline, and especially an unrealistically optimistic cost estimate. The unrealistic proposed baseline becomes an unrealistic actual baseline on its acceptance by the MDA and funding in the Program/Budget process. A short explanation of why this happens is: DoD has not developed policy that is clear enough and strong enough to prevail in the factually tangled situations presented by bust periods. Finally, long bust periods reflect delays at the top levels of the US government in reconciling decisions on DoD funding and force structure and missions. Ultimately, then, a large part of cost growth in MDAPs over the period considered in this study is a symptom of underlying flaws in high-level defense policy and decision making.

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A. Introduction

Growth in the cost of Major Defense Acquisition Programs (MDAPs) usually is not the most important concern about acquisition confronting senior Department of Defense (DoD) officials, but it often is the most visible to the public. Moreover, many believe—with good justification—that cost growth has continued apace through the many changes made in DoD acquisition policy and processes over the past half century. From the point of view of those predisposed to reform the DoD acquisition machinery, cost growth has been the gift that keeps on giving. It has been the object of a number of changes in acquisition policy and part of the pretext for many others.

Why cost growth has been so persistent is puzzling. In 1969, David Packard, then Deputy Secretary of Defense, installed an oversight mechanism and a set of acquisition policies that among other things were intended to curb cost growth. Over the years the oversight mechanism was strengthened and acquisition policies, including those concerned directly with cost growth, were elaborated. The fact that these measures were judged to be necessary implies a belief that there is some underlying incentive for cost growth that needs to be regulated. What this incentive is, however, is not obvious—nobody likes cost growth *per se*—nor is it obvious why the mechanisms that exist to control it have not been fully effective.

One provision of the Weapon Systems Acquisition Reform Act of 2009 (WSARA), apparently prompted by such considerations, required the Secretary of Defense to determine the root cause of any instance in which the unit cost of an MDAP grew by at least 50 percent.[1] Over the five years that followed enactment of WSARA, analyses of the causes of cost growth of 14 MDAPs were published.[2] Although useful in several ways, these studies were mainly concerned with what this study identifies as the immediate or, better, the proximate causes of the cost growth. One somewhat common proximate cause of the cost growth, for example, is an unrealistically optimistic development schedule. A successful root cause analysis of such a case would explain why DoD adopted the unrealistic schedule estimate. Were the staff analyses done to support the decision flawed or incomplete? Were the applicable policies inadequate in some respect? Did the decision reflect a lapse on the part of the senior DoD official who approved the unrealistic schedule?

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1 Pub. L. 111-23, May 22, 2009, Sec 206. See also Sec. 204, which imposed a similar requirement for programs at an earlier stage of development.

2 These studies were sponsored by the Office of Program Assessment and Root Cause Analysis (PARCA), now the Office of Acquisition Analytics and Policy (AAP). See Irv Blickstein et al., *Root Cause Analyses of Nunn-McCurdy Breaches*, Vol. 1, MG 1171z1 (Santa Monica, CA: The RAND Corporation, 2011); Irv Blickstein et al., *Root Cause Analyses of Nunn-McCurdy Breaches*, Vol. 2, MG 1171z1 (Santa Monica, CA: The RAND Corporation, 2011, 2012); and Richard P. Diehl et al., “Root Causes of Nunn-McCurdy Breaches—A Survey of PARCA Root Causes Analyses, 2010–2011: Interim Report,” IDA Paper P-4911 (Alexandria, VA: Institute for Defense Analyses, 2012).

In only a few instances did it prove to be possible to trace an individual proximate cause back to its root cause, and the studies provide no general understanding of root causes of cost growth.

The central task of this paper is to develop a theory of the root causes of Errors of Inception, which is the label applied in root cause analyses to unrealistic elements in an MDAP's initial baseline. While the term is not yet widely used, Errors of Inception are generally (and, as noted below, correctly) believed to be the proximate cause of the largest part of cost growth. They are in effect cost growth embedded in the initial baseline that will emerge as the program progresses. Baldly stated, the question asked here is: What factors led DoD to adopt a baseline with significant unrealistic elements for a considerable proportion of the MDAPs it undertook?

Competition for funding among MDAPs lies near the center of the answer proposed. The idea that competition for funding is close to the root of much of cost growth is neither new—it first appeared in the literature 40 years ago—nor is it controversial.[3] Competition for funding, however, has largely been absent from statistical and case studies of cost growth, has been at the periphery of the conventional wisdom within the acquisition community about cost growth, and is seldom cited as a factor in discussions of acquisition reform.[4] As a practical matter, then, it needs to be treated as a new idea that requires explanation.

For the explanation to be convincing, it must be anchored on the relevant DoD bureaucratic processes and a clear connection must be established between the incentives inherent in the competition for funding and cost growth. This is the objective of the following section. It isolates where in the DoD acquisition and resource allocation processes the competition for funding among MDAPs occurs, and then goes on to explain, first, how a program's cost estimate can be adjusted in response to competitive pressures and, second, that oversight mechanisms can fail to disallow an unrealistic cost estimate.

3 See 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, p. 9 of the revised paper.

4 Evidence on this point is implicit 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. Only two of the 31 contributors to this Compendium mention competition for funding as an important factor in the acquisition process. See also Defense Acquisition Issues Related to Tactical Aviation and Army Programs: Hearing Before the Subcommittee on Airland of the Committee on Armed Services, United States Senate, S. Hrg. 109-468, 109th Cong. (November 15, 2005) following Peter K. Levine, "Lessons from the Never-Ending Search for Acquisition Reform," IDA Paper NS P-8971 (Alexandria, VA: Institute for Defense Analyses, May 2018), 113–114. Levine provides a précis of the responses of the five experts who testified at this hearing and apparently draws on responses to questions for the record provided after the hearing. The late Senator John McCain had asked each of the witnesses to provide their views on the main causes of cost growth. Only one, Dr. John Hamre, former DoD Comptroller and Deputy Secretary of Defense, mentioned competition for funds.

While entirely qualitative, this material provides the underlying conceptual basis for the theory proposed. As a foundation for the empirical results presented, a formalization of the theory is sketched in Section C. Section D provides operational definitions of the variables that appear in the theory. The statistical results are presented and discussed in Section E.[5] The final section offers conjectures on why the Office of the Secretary of Defense (OSD)-level acquisition oversight mechanisms have permitted a significant proportion of MDAPs to proceed with unrealistically optimistic baselines.

Provisions of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2016 had the effect of transferring approval authority for MDAPs at a key milestone from OSD to the Military Department (MilDep) making the acquisition. (See note 13, p. 10.) These changes were implemented in FY 2018. An argument can be made that they will prove to be untenable because they overlooked the deeply rooted difference in preferences in most administrations between the Services and senior DoD leadership. In that event, this paper should prove to be useful when the time arrives for the next major revision of the DoD acquisition process. If not, it is a historical and statistical account of the root causes of cost growth in MDAPs from the mid-1960s through—because of data limitations—FY 2009. The period FY 2010–FY 2017 and the changes implemented starting in FY 2018 are not examined here.

B. Foundations of the Model

The best clue we have to the root causes of cost growth lies in differences in the average cost growth of MDAPs initiated in periods of more and of less intense competition for funding. These are referred to as bust and boom funding climates; a brief discussion of how they were delineated is provided in Section D, Subsection 2, on p. 19.

Table 1 presents the average unit cost growth for the two complete bust and boom cycles in DoD funding that occurred during the period FY1965–FY 2009. Cost growth was much higher for programs whose initial baseline was established in a bust period when competition for funding was intense than it was for those whose initial baseline was approved in a boom period when funds were more readily available. Of course, it is appropriate to be wary of these data because other variables in addition to funding climate presumably are relevant, but they are offered here as a clue not a conclusion. That clue points towards competition for funding.

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5 This paper draws on the author's earlier work, especially David L. McNicol, *Acquisition Policy, Cost Growth, and Cancellations of Major Defense Acquisition Programs*, IDA Report R-8396 (Alexandria, VA: Institute for Defense Analyses, September 2018), (hereafter referred to as *Acquisition Policy*).

Table 1. Average Program Acquisition Unit Cost (PAUC) Growth for 156 Completed MDAPs

	Bust Phase	Boom Phase
1st Bust-Boom Cycle FY 1965–FY 1986	46%	18%
2nd Bust-Boom Cycle FY 1987–FY 2009	37%	2%

Source: This study uses the database released with *Acquisition Policy* and accessible at https://www.researchgate.net/publication/328202587_MDB_V54_CDxlsx. (Accessed June 6, 2020.). For a description of these data, see Appendix A of *Acquisition Policy*. Alternatively, it can be obtained by ordering *Acquisition Policy* with the accompanying CD from the Institute for Defense Analyses (IDA) library.

Note: The measure of cost used is defined in Section D, Subsection 1; it includes development and procurement funding (that is, the costs of buying the system once it has been developed); procurement typically is four to five times as much as that for development. The definition of the bust-boom phases and their break points are discussed in Section D, Subsection 2. Each of the programs used in Table 1 had completed its acquisition phase by the end of FY 2015.

Competition for funding takes place within DoD's resource allocation process, which since the late 1960s has been called one or another variant of the Planning, Programming, and Budgeting System (PPBS).[6] Attention cannot be limited to the PPBS, because it is within the acquisition process that funding requests are prepared and later reviewed for their "reasonableness."

1. Terminology

It is necessary to begin with a sketch of some top-level features of the acquisition process. The terminology used and specific statements about policy are characteristic of the period FY 2000–FY 2009.

MDAPs are carried out by program offices headed by a program manager (PM). Program offices vary widely in the number of staff directly assigned to the office, from perhaps two dozen to nearly 1000. These differences do not mainly reflect the size of the program, but rather the funding source used to pay the staff and the extent to which they are under the direction of the PM for administrative purposes. All MDAP PMs have access to various functional specialties required to put together and execute a major acquisition program, e.g., engineering disciplines, cost and budget, testing (operational and developmental), and contracting, among others.

[6] It is often said that the PPBS was introduced to DoD by Robert McNamara in 1961. This statement is inaccurate. While the label *PPBS* began to be applied in the late 1960s, the first version of what came to be understood as the PPBS was due to changes introduced by then Secretary of Defense Melvin Laird in 1969.

For the past half century, the acquisition cycle for MDAPs has been divided into three phases, denoted since 2000 by Milestone (MS) A, B, and C. These are:

- **MS A: Technology Development**. By the end of this phase, which ordinarily lasts from one to four years, the prototypes of the technologies judged to be critical to the system are to have been demonstrated in a relevant environment.[7]
- **MS B: Engineering and Manufacturing Development (EMD)**. The main purpose of EMD is to refine the design that resulted from Technology Development to the point that it can be released (now ordinarily as computer code) to the people on the factory floor who build the system. In addition, during EMD the jigs, fixtures, and tooling used to build the system; test and training equipment for it; specialized machines used in the manufacture of the system; and logistics systems for it are developed. Moreover, a substantial part of EMD ordinarily is the production of some number of systems for use in testing. Annual funding during EMD, which typically takes four to eight years, usually is several times that of the Technology Development phase.
- **MS C: Production**. Production is subdivided into two parts: low-rate initial production (LRIP) and full rate production. During LRIP, problems with the manufacturing process are worked out and fixes are designed for problems with the system revealed in testing. In addition, any infrastructure and tooling needed to support higher-rate production is developed and installed. Once this is accomplished, the system can move into full-rate production. The Production phase usually lasts 5 to 15 years, and total funding for the Production phase typically is four to five times that for EMD.

For the 156 MDAPs available for this study, the median duration of the acquisition cycle (from EMD through the end of Production) was 13 years.

Entry into each successive phase of the acquisition cycle requires approval of the senior OSD or MilDep official who has been designated by statute or DoD regulations as the Milestone Decision Authority (MDA). (It is in some instances necessary to refer to MilDeps rather than Services because the Department of the Navy includes two Services, the Navy and the Marine Corps, and oversees MDAPs for both.) The MS B review usually is broader in scope and more intensive than the other reviews. (The typical MS B review extends over more than six months, covers all aspects of the program, and involves hundreds of people.) Moreover, MS B approval is regarded as particularly important because it conveys MDAP status, and in most cases the program then becomes a budget line item. Moreover, the baseline established at MS B serves as the point of reference for

[7] An MDAP is defined for the first time in preparation for the MS A decision point. Prior to MS A the critical technologies that will go into the system have been under development separately in the DoD Science and Technology Program or as commercial products.

computing cost growth, schedule slips, and performance shortfalls. While a program's baseline is updated as the program proceeds, cost growth, in particular, is computed with reference to the original MS B baseline.

2. Competition for Funding

Two aspects of the review process at MS B combine to produce an illusion that MDAPs do not compete with one another for funding. First, the MS B review includes a program cost estimate developed by the PM's office. This cost estimate effectively is the PM's recommendation for funding that should be requested for the program. A (possibly revised) cost estimate is included in the baseline approved by the MDA. Second, the acquisition oversight process as such does not include a cap on the total addition to future cost for the MDAPs that receive MS B approval during the year. Programs are reviewed one-by-one throughout the year, and programs considered later in the year are not constrained by the costs of programs approved earlier in the year. Because of this, the "affordability analysis" that is part of the current MS B review process is ineffective.[8] Taken together, these points may suggest to the unwary that acquisition funding is somehow adjusted in the background to accommodate the costs of the MDAPs approved by the MDA, presumably by finding any additional funds required elsewhere in the budget. In fact, funding limits are present, but in the PPBS, not in the acquisition process.

In what follows, the term Program/Budget will be used in place of PPBS, because it is primarily the Programming and Budgeting phases that are relevant. It is necessary at this point to distinguish "program" from "budget" in the Program/Budget context. Program in this context does not mean MDAP or, generically, acquisition program. In the language of the Program/Budget process, the "program" and the "budget" are what in ordinary terms is called a budget. The distinction lies in the taxonomy used in arraying the data. A program is arrayed in categories (strategic forces, mobility forces, and so on) intended to show what capability the funding would support. A budget is instead arrayed in terms of input categories (e.g., military pay, operations and maintenance). Each of the Services annually prepares a comprehensive program covering the upcoming budget year and the four subsequent years. The Service-level programs are commonly called Program Objective Memorandums (POMs). The intent is that the large resource allocation decisions, including

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[8] For decades acquisition policy has directed the Services to ensure that the programs brought forward for MS B approval are affordable; that is, that they fit within the Service's likely topline as reasonably projected into the future. In the mid-1990s a distinct affordability process was added to the OSD-level MS B review process, and these flowed down to the Service level. To the extent that this process involved limits at all, however, they were not a cap on additions to funding for MDAPs, but on additions to funding within a commodity type (e.g., tactical aircraft.) Moreover, the new rules are widely thought not to have been effective in achieving even the limited ends sought. Further changes were made during FY 2010–FY 2016 but they did not resolve the intrinsic problem which is that "affordability" by its nature cannot be assessed in a process that views MDAPs sequentially and without an explicit funding constraint.

those on MDAPs, will be made in the context of the POM build. After review and ordinarily some revision at the OSD level, the POMs become the basis for budgeting, which involves a range of considerations (e.g., the fraction of funds already available that have been obligated) that do not come up in programming. [9]

Each year, as the POM builds are getting underway, the Secretary or Deputy Secretary of Defense issues Fiscal Guidance (FG) to each of the MilDeps. The FG gives the maximum amount that the Service can request for the upcoming budget year and each of the four following years in what is called the Future Years Defense Plan (FYDP). Within the decision space available as a practical matter, the Secretary of each MilDep decides how much of the FG to make available for modernization, of which MDAPs typically are the largest part.

Changes in the funding requested for an MDAP can be made in either the Programming or the Budgeting phase and at either the MilDep or the OSD level. As a rule, however, the main arena for competition for funds among acquisition programs in the year that they get MS B approval is the Service-level POM process. There has been wide variation over time and among the Services in what organizations are responsible for the POM builds and how they are structured. It would not be safe, however, to suppose that acquisition programs generally have had a privileged or even a separate place in these processes. Again, as a rough generality, MDAPs compete implicitly if not explicitly with all the other claims on the funding limit set for the POM.

Nevertheless, not all of a Service's MDAPs compete for funds on an equal footing. Some programs have a higher priority than others, and in a Program/Budget context, "higher priority" means "higher priority" for funding. Laying aside until Section D the question of how priority can be measured, high priority MDAPs in some sense stand towards the front of the MDAP funding line.

3. Malleability of Program Content and Cost Estimates

The PM's cost estimate is useful as a tool of competition for funding only if the PM has leeway to adjust the degree of optimism built into it. Within limits, a PM does have this flexibility. For the purposes of this paper, it is understood that the term PM means the Program Manager in consultation as necessary with his superiors in the acquisition chain, and it should be borne in mind that the PM is supported by a program office, which commands extensive technical, analytical, and managerial resources.

How much flexibility the PM has depends on where the program is in the acquisition process. The context assumed here is the period of about 18 months to one year before MS B. By this point most programs will have been in the Technology Development phase

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9 This clear separation was blurred somewhat starting in 2003 with the adoption by OSD of concurrent Program and Budget reviews.

for two or three years. Changing the capabilities that the program is to acquire is still possible at that stage but is difficult and must be done through a cumbersome bureaucratic process. A PM has a much more direct control over the program office's estimate of the costs of the program and some of the assumptions that lie behind it. The relevant decisions on these features are embodied in documents (such as the Program Office Cost Estimate (POE) and the Acquisition Strategy Report) that are part of the MS B review process.

Discussion of this topic requires the notion of "realism" in cost estimates and program assumptions. From the start, OSD-level acquisition regulations have specified that program cost estimates, and in fact all aspects of the program baseline, are to be "realistic" or "prudent" or "not unreasonably optimistic."[10] In the mid-1990s, efforts were made to define the realistic cost estimate as the 50th percentile of the estimate's cumulative probability distribution. This may be a conceptually satisfactory approach but one that proved to be impracticable within the limitations of time and resources available. The "reasonableness" of a cost estimate, or some feature of an MDAP baseline, is then a well-informed judgment with a factual basis but also a substantial subjective component.

It is useful to distinguish three pathways through which a POE for an MDAP can be manipulated without changing the technological features of the program.[11] First, unrealistically optimistic costing assumptions, data, or methods may be used. Some of these are commonplace: the slopes assumed for cost progress curves,[12] overhead rates, and the rate of reliability improvement (which has a large influence on procurement of initial spares). Some are less common:

- Overestimate the savings due to obtaining (post EMD) competition on subassemblies.
- Project unrealistically large savings from the adoption of some innovation, e.g., computer aided design.
- Double-count savings from cost reduction initiatives and savings from ordinary learning.

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[10] The first OSD-level milestone review process was established in 1964 by Department of Defense Directive (DoDD) 3200.9, February 1964.

[11] The material in this section is based on the author's experience at OSD overseeing reviews of Service cost estimates and preparation of independent cost estimates.

[12] Cost analysts typically understand the slopes of learning curves simply as something observed. They are that, but cost progress mainly is a rational response by defense prime contractors to the incentives and constraints of their contracts. On this, see William P. Rogerson, "Economic Incentives and the Defense Procurement Process," *Journal of Economic Perspectives* 8, no. 4 (Fall 1994), 65–90, especially 77–83; David A. Lee, *The Cost Analyst's Companion* (Tyson's Corner, VA: Logistics Management Institute, 1997), Chapter 2; and 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).

Second, an unrealistic assumption can be made for some aspect of the acquisition strategy. A few examples are:

- EMD schedule (i.e., remaining development effort required)
- Annual lot size at full-rate production
- When multiyear procurement contracts will be introduced.
- The amount of developmental testing required
- The number of test assets in the program needed to support the operational testing
- The contract type used
- The amount of computer code that will be reused (i.e., taken from a legacy system)

Third, an unrealistically optimistic estimate can be made for some feature of the system that is important to its costing. A classic example is the weight of an aircraft (which is a proxy for its size). Some other examples are:

- The maturity of the technologies to be employed
- The technical feasibility and stability of program requirements
- The amount of software that will need to be written for the system
- The reliability of the system when it is mature

It is important to emphasize that none of the steps listed above permanently change the program. As the program proceeds, and reality is revealed, MS B assumptions that prove to be unrealistic change and cost grows. The MS B assumptions do, however, yield apparent reductions in in the POE estimate at MS B, which can be substantial, and which often are somewhat hard to detect and criticize effectively.

4. MS B Reviews

The POE does not automatically become the cost estimate included in the material the Service brings to OSD for the MS B review, much less what goes into the budget request that DoD eventually submits to the Congress. The proposed MS B baseline is reviewed at both the Service and the OSD level and these reviews can, and sometimes do, result in changes, including changes to the POE.

The most searching view of an MDAP's cost estimate ordinarily occurs at MS B. The MS B review is a detailed inspection of the program that spreads over about six months, requires substantial documentation of many topics (e.g., the planned test program, the systems engineering plan, the cost estimate, the progress that has been made on the system's critical technologies, and the proposed acquisition strategy, among others). The reviews are done by OSD staff organizations that are specialists in the topic and spend a considerable fraction of their time on milestone reviews. The staff reviews, which are advisory, are communicated to the MDA, who for all of the MDAPs in this study was the Secretary of Defense, the Deputy Secretary of Defense, or the Under Secretary-level official who headed the OSD-level acquisition organization. In addition to OSD staff specialists, the milestone review process also included (informally or formally) ways in which other senior officials with responsibilities touching on a program could advise the MDA. Starting in 1986, the forum for this advice was the Defense Acquisition Board (DAB). The DAB was chaired by the Under Secretary of Defense (Acquisition, Technology, and Logistics) (USD(AT&L));[13] its vice-chair was the Vice Chairman of the Joint Chiefs of Staff.

Acquisition policy has mandated realistic baselines for MDAPs, and the MDA has had the formal mandate and the staff support necessary to enforce this policy at MS B. On this basis, we would expect to see little cost growth from Errors of Inception, that is, MS B baselines with significantly unrealistic assumptions. Perhaps surprisingly, this expectation is difficult to evaluate.

The cost growth data in Table 2 provide a useful platform for explaining why this is so. The data in Table 2 do not suggest that the milestone review process has usually resulted in realistic MS B baselines—36 of the 110 MDAPs that passed MS B during one of the two bust periods experienced cost growth of more than 50 percent. There are, however, two problems that need to be considered before accepting this impression. First, cost estimates are forecasts and, like all forecasts, are uncertain. Could it be that the data in Table 2 simply reflect the inherent uncertainty in MS B cost estimates? The best evidence on this point is the PAUC growth data in Table 1 (p. 4) for boom periods. These estimates are made in the same way, and subject to the same milestone review process, as those for bust periods, but appear to be quite accurate. The average PAUC growth for programs that passed MS B during the first boom period is 18 percent, while the average for those that passed MS B during the first bust period is 46 percent. The comparison for the second bust-

[13] Before 1986, the MDA specified in acquisition regulations was the Secretary or Deputy Secretary of Defense, although in practice the role seems in most cases to have been played by the Director, Defense Research and Engineering (DDR&E), which was later redesignated the Under Secretary of Defense (Research and Engineering). In 1986, the Congress established the position USD(Acquisition) and designated the USD(A) as the MDA for most MDAPs. In 1993, the title became USD(Acquisition and Technology), and in 1997, USD(Acquisition, Technology, and Logistics). The NDAA for FY 2017 (P. L. 114-328, Dec. 23, 2016) replaced the position of USD(AT&L) with an Under Secretary of Defense for Research and Engineering (USD(R&E)) and an Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)). See Section 901. The NDAA for FY 2016 (P. L. 114-92, Nov. 25, 2015) placed MS B decision authority in most cases with the Service Acquisition Executive, but permits the Secretary of Defense to designate the USD(A&S) as the MDA for MS B for a program if certain criteria are satisfied. See Section 825.

boom period is even starker. Consequently, it is not reasonable to explain the data in Table 2 as simply a reflection of the inherent uncertainty in MS B PAUC estimates.

Table 2. Average PAUC Growth of the MDAPs in the Sample that Passed MS B in Bust Periods

Average PAUC Growth	1st Bust Period FY 1965–FY1980	2nd Bust Period FY 1965–FY1980	Total
> 50%	24	12	36
30% to 50%	13	7	20
< 30%	28	26	54
Total	65	45	110

Note: The two break points (30 percent and 50 percent) are motivated by provisions of the Nunn-McCurdy Act. Simplifying somewhat, the Nunn-McCurdy Act generally required that PAUC growth be measured from the MS B baseline. The Act defined PAUC growth of at least 30 percent as a "substantial breach" and required that these be reported to the Congress. PAUC growth of at least 50 percent constituted a "critical breach" of the MS B baseline. In addition to the reporting requirement imposed for substantial breaches, for critical breaches Nunn-McCurdy imposed several certification requirements. In contrast to the data in this table, the PAUC growth figures used in computing whether a Nunn-McCurdy breach has occurred are not adjusted for quantity change.

Second, the figures behind Table 2 include not only cost growth due to Errors of Inception but also to the two other categories of causes used in root cause analyses: Errors of Execution and Program Changes. As the label suggests, Error of Execution are errors made by government and contractor PMs. MS B reviews guard against these errors only to the extent that they include an examination of the program's management plans. Program Changes are changes in the capabilities the program is to acquire that are not forced by problems with the program, resulting in cost growth, a schedule slip, or a performance shortfall. Substantial cost growth attributable to Program Changes typically reflects upgrades to the system initiated several years after MS B. Program Changes also contains several subcategories, including across-the-board funding cuts.

The only statistical data on the magnitudes of Errors of Execution and Program Changes come from an unpublished and obscure database assembled by OSD.[14] The amount of cost growth due to Errors of Execution seems to be small, on the order of 10 percent of the cost growth in bust periods.[15] Program Changes apparently account for a bit more than one-third of cost growth in bust periods, implying that about 55 percent of cost growth is due to Errors of Inception. Accordingly, it is reasonable to attribute the majority of the cost growth in Table 2 to Errors of Inception. That is, the DoD milestone

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[14] These data are discussed at length in David L. McNicol, *Cost Growth in Major Weapon Procurement Programs*, 2nd ed. (Alexandria, VA: Institute for Defense Analyses, 2004).

[15] See *Acquisition Policy*, 79–82, for estimates of average PAUC growth due to Program Changes and Errors of Execution.

review process has often accepted proposed MS B baselines that were unrealistic in significant respects that eventually resulted in cost growth.

The ability of a PM to stretch or avoid the acquisition policies that direct MS B baselines (including cost estimates) to be realistic is not unlimited, however, and the attempt to gain approval of an unrealistic baseline entails some risks to the program. An MDA can deny milestone approval, but over the period covered by this study, that last happened explicitly to a program seeking MS B authority in the early 1990s. More likely are a significant delay in obtaining MS B approval or changes to the cost estimate or some other feature of the program. Either of these could change the program's prospects in competition for funding.

Beyond the immediate risks of the MS B review, adoption of unrealistic program features entails long-term risks to the program because they predictably will generate cost growth and schedule slips, which are problems in themselves, and make it more difficult to meet the program's performance baseline. Nearly 20 percent of the programs that passed MS B during the period FY 1965–FY 2009 were cancelled before they went into production.[16] Not all these programs were cancelled because of cost growth, schedule slips, and performance shortfalls, but some were.

C. Specification of the Model

There are three distinct elements to the problem faced by a PM looking forward to MS B and the Program/Budget process. First, the PM must discern how high the program's projected cost can be while remaining competitive for funds in the Program/Budget process. Second, the PM must establish what combinations of controllable program features produce an apparent cost for the program consistent with this constraint. Third, the PM must assess both the near- and long-term risks to the program associated with different combinations of controllable program features. This section draws these three elements into a model of the PM's decisions on program features.[17]

The analysis of these decisions presented here is set at the start of the first POM cycle during which the program competes for funding as an MDAP. The context is further defined by the following:

- The program has completed the MS B review at both the MilDep and OSD levels before it submits a funding request in the POM process.

[16] See *Acquisition Policy*, 44.

[17] An early version of this material is in David L. McNicol, "A Reduced Form Model of Cost Growth of Major Defense Acquisition Programs," *Proceedings of the 16th Annual Naval Postgraduate School Acquisition Research Symposium*, Monterey, CA, 404–413, April 30, 2019.

- The cost estimate approved at the MS B review becomes the basis of the program's request for funding in the POM.

It is assumed that the PM selects program features at a single point in time before the MS B review but in anticipation of competition for funding in the POM process.

The problem of selecting program features is interesting in the case in which the PM has discerned, or been told by superiors, that his or her program will not be competitive for funding if the PM proposes to request funding based on a realistic estimate of the program's likely acquisition cost. The PM's problem is to select values for the program characteristic to reduce apparent cost sufficiently for the program to be competitive. It is assumed here that the criterion used in making these choices is the minimization of the risk to the program of proposing an MS B baseline that includes unrealistic elements, subject to the funding constraint. Problems mathematically similar to this, of course, appear throughout economic theory and often come up in applied work.

Figure 1 (p. 14) shows a highly simplified case, which helps illustrate the structure of this particular problem. It assumes that both the risk function and the cost function are linear in the two program features controlled by the PM, X_1 and X_2. The point labeled $\hat{C}(\hat{X}_1, \hat{X}_2)$ is the realistic cost estimate. The PM has discerned (or been told) that to be competitive in the POM process the proposed cost of the program cannot exceed $\bar{C}$. It is assumed that $\hat{C} > \bar{C}$. The instruments available for reducing $\hat{C}$ to $\bar{C}$ are X_1 and X_2. X_1 cannot be reduced below the regulatory limit r_1 and X_2 cannot be reduced below r_2. The heavy blue line in Figure 1 is the locus of feasible values for X_1 and X_2 that produce cost $\bar{C}$. Reductions in X_1 and X_2 below $\hat{X}_1$ and $\hat{X}_2$ reduce apparent cost but increase risk. It is assumed that the PM will adopt the point on this line segment with minimum risk. Since the risk function is assumed to be linear, an optimal solution will occur at one of the two end points; i.e., either at ($X_1^* < \hat{X}_1$, r_2) or (r_1, $X_2^* < \hat{X}_2$).

Some may balk at the apparent assumption that PMs and their staffs literally solve the optimization problem illustrated in Figure 1. Anyone who wishes to do so could replace optimization with some heuristic that seeks lower risk given cost. Insofar as the statistical work is concerned, the essential assumption is not that the decisions made by the PMs are optimal or near optimal but that they respond to changes in external events—especially the intensity of competition for funds and restrictions that they must observe—in the same way as the optimal solution. The statistical analysis does not "see" departures from optimality. What it sees are the responses to changes in relevant external conditions—funding climate and acquisition policies—across a wide array of MDAPs that passed MS B over a period of 44 years, and the model is rejected if these responses depart significantly from what it predicts.

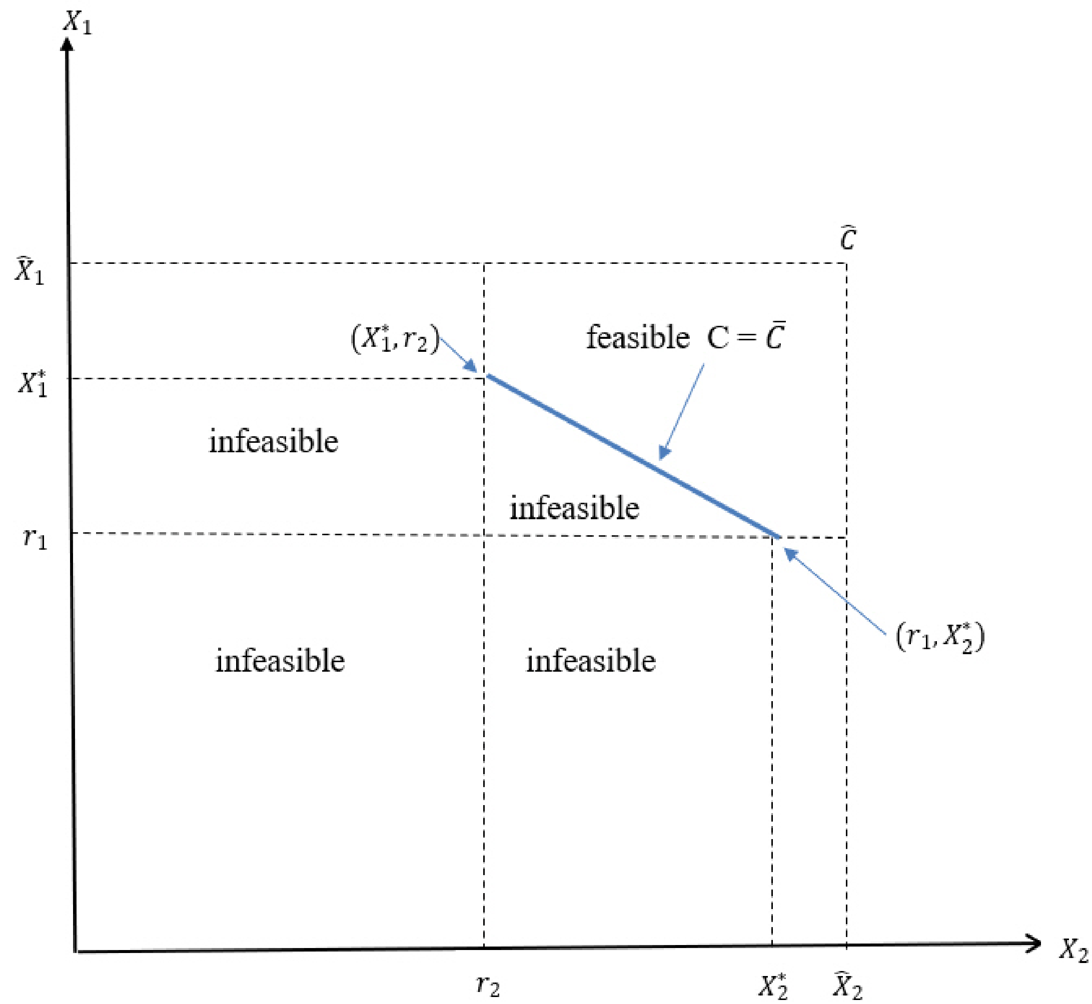

Figure 1. Feasible Set and Possible Optimal Solutions for a Two-Feature Case with Linear Cost and Risk Functions

The goal here is to derive an expression for cost growth due to Errors of Inception for a generalization of the risk minimization problem with many program features and which admits non-linear cost and risk functions. While the generalization is not spelled out here, it obviously would involve $\hat{C}$ and $\bar{C}$. Denote by C_{MSB} the acquisition cost in the MS B baseline. The funding the PM proposes be included in the MS B baseline is $\bar{C}$. These are related by:

$$\bar{C} + \delta = C_{MSB}, \tag{1a}$$

where δ is the amount by which the decisions made in the Milestone B and Program/Budget reviews change cost. The PM, of course, intends that the choice of $\bar{C}$ be such that δ will be zero. This is not assured. As was noted in the previous section, both the cost estimate as such and assumptions behind it can be changed by the results of the MS B and the Program/Budget reviews. Moreover, the requirement for an independent cost estimate (made by a unit in OSD) was introduced into the milestone review process to counter the incentive a PM has, especially in bust periods, to adopt a cost estimate that is unrealistically optimistic. Hence, the expected value of δ presumably is positive.

The assumption made here, however, is that:

$$\mathrm{E}(\bar{C}) \cong C_{MSB} \ . \tag{1b}$$

The only statistical information available on this assumption is in a 2005 paper published by IDA.[18] The study considered 63 MDAPs that passed MS B during the period FY 1985–FY1998. For 25 of these MDAPs, the study located the independent cost estimate (ICE), the Service cost estimate (SCE), and the outcome of the review. In only eight of the 25 cases was cost raised as an issue. The MDA accepted the SCE rather than the ICE in five of those cases. In one of the remaining three cases, the MDA directed that the program be restructured and the restructured program was funded on the basis of the SCE; in one, the direction was to fund the program based on the ICE; and in the third, funding was partially based on the ICE. In summary, in at most three of the 25 cases did the MDA direct changes to the program or its cost estimate. Even this is an overstatement, since it is highly likely that cost was not raised at the MS B review of the 38 MDAPs for which sufficient data could not be located—the data almost certainly would be available if cost had been raised as an issue in the MS B review.

Next, denote by $C_F\,(-)$ the final (i.e., actual) cost of the program adjusted back to the MS B quantity and with costs due to Errors of Execution and Program Changes deleted. (By convention, the realistic cost for the program ($\hat{C}$) does not include any allowance for Errors of Execution or for Program Changes post-MS B.) We assume that:

$$\mathrm{E}(\hat{C}) = C_F\,(-) \ . \tag{2}$$

The best evidence on $\hat{C}$ is the independent estimate made at the OSD level. These estimates, however, are not publicly available for the period considered in this study. As was argued above, a good indicator of how accurate cost estimates for MDAPs can be is provided by the cost growth of programs that passed MS B during boom periods. On average, these probably do not include substantial Errors of Inception and are notably low. It also is reasonable to assume that $\hat{C}$ and $\bar{C}$ assume the same quantity and that this quantity becomes that in the MS B baseline.

[18] David L. McNicol et al., "The Accuracy of Independent Estimates of the Procurement Costs of Major Systems," IDA Paper P-3989 (Alexandria, VA: Institute for Defense Analyses, August 2005).

Let z denote the cost growth (relative to $\bar{C}$) embodied in the program by decisions on program features made to reduce apparent cost to $\bar{C}$:

$$z = \frac{\hat{C} - \bar{C}}{\bar{C}}\text{, or} \tag{3a}$$

$$z = \frac{\hat{C}}{\bar{C}} - 1 \tag{3b}$$

Under fairly general conditions and to a first-order approximation:

$$E(z) \cong \frac{E(\hat{C})}{E(\bar{C})} - 1 \tag{4a}$$

$$E(z) \cong \frac{C_F(-)}{C_{MSB}} - 1 = \frac{C_F(-) - C_{MSB}}{C_{MSB}} \tag{4b}$$

The second expression in Equation (4b) is actual cost growth relative to the MS B baseline due to Errors of Inception.

In a broad-brush way, Equation (4b) implies that unit cost growth is related to funding climate, program priority, and the tightness of the regulatory constraints since $\bar{C}$ enters the derivation and it is related to these factors. The qualitative material in Section B does not, however, tell us anything about the form of the relationship. Absent such guidance, the analysis adopted the simplest and most convenient assumption:

$$\frac{C_F(-) - C_{MSB}}{C_{MSB}} = \mathrm{h(W, P, R)} + \mathrm{u}. \tag{5a}$$

In this relationship, W is a measure of funding climate, P measures the PM's assessment of the program's priority for funding, R—which is assumed to have a single dimension—is a measure of the intensity of the regulatory constraint, and u is the error term. It is assumed further that Equation (5a) is linear:

$$\frac{C_F(-) - C_{MSB}}{C_{MSB}} = a_0 + a_1W + a_2P + a_3R + u. \tag{5b}$$

None of the variables W, P, or R is easy to define in an operational way, but the problem of doing so is postponed to the next section.

There is an important point bearing on the interpretation of R that needs to be noted. The OSD data cited above (Section B, Subsection 4, on p. 9) imply that Errors of Inception account for a bit more than half of cost growth. Not all significantly unrealistic elements in their MS B baseline program features are due to competition for funds, however. Some are the result of direction from the Congress, the President, the Secretary or Deputy Secretary of Defense, or in a few instances, the Secretary of one of the MilDeps. The most common example is direction to use a contract type that proves to be problematic. Other examples are direction to undertake a joint program or adopt an unrealistically optimistic development schedule. The only evidence on this point suggests that high-level direction accounts for 25 percent of MDAPs with cost growth of at least 50 percent.[19] To be clear, these are Errors of Inception but not the result of competition for funds. They, instead, must be attributed to changes in acquisition policy.

One extension of this model is required. The analysis to this point has been concerned with Errors of Inception; in addition, there are two additional categories of cost growth—Errors of Execution and Program Changes. Errors of Execution appear to have accounted for at most 10 percent of the cost growth during the bust period FY 1987–FY 2002, while Program Changes accounted for about one-third of the total.

No attempt is made to analyze Errors of Execution and Program Changes in detail. Instead, the model incorporates the *ad hoc* assumption that both are associated with program duration and funding climate. Program duration is defined as the number of years from MS B to end of procurement. This is divided into the number of years spent in a boom climate (T_{boom}) and the number of years in a bust climate (T_{bust}). The model then becomes:

$$Ch_{PAUC} = a_0 + a_1W + a_2P + a_3R + a_4T_{boom} + a_5T_{bust} + v \,, \qquad (6)$$

where Ch_{PAUC} is growth in PAUC from the MS B baseline and v is a random variable. Equation (6) is the model eventually estimated.

D. Measurement of the Variables and *A Priori* Expectations for the Estimated Coefficients

The task of this section is to provide operational definitions of the variables that appear in Equation (6), and to articulate and justify the prior expectations on the coefficients of the model. Cost growth and the two duration variables can be defined readily. This is not the case for funding climate, priority, or the intensity of the regulatory constraint, which present difficult, intertwined problems of definition and data availability. The definitions adopted, while far from ideal, had the virtue of being easy to implement. Those interested in a more detailed explanation of how the variables of the model are defined should consult *Acquisition Policy*, especially Chapter 3 and Appendixes A and B.

1. Cost Growth (Ch_{PAUC})

This subsection passes by without comment the many MDAPs for which measuring cost growth presented a problem of some sort. For that reason, what follows should be

[19] *Acquisition Policy*, 87–96, provides a summary of readily available information on the topic. The database used by *Acquisition Policy* and here includes a PAUC growth estimate for 156 completed MDAPs and another 30 that were still ongoing at the end of FY 2016. Fifty-five of these programs had cost growth of at least 50 percent. Of these, 14—or about 25 percent—were at least in significant part due to acquisition policy initiatives of senior DoD officials.

understood as a statement of the objective that guided the work rather than as a complete description of what was done. As a rule of thumb, measuring cost growth for MDAPs that passed MS B after the mid-1980s is straightforward. Problems are encountered more frequently in MDAPs that passed MS B earlier, particularly those of the late 1960s and early 1970s.

The measure of cost used in this study (and in many other statistical studies of cost growth) is Program Acquisition Unit Cost (PAUC). Acquisition cost is the sum of Research, Development, Test, and Evaluation (RDT&E)[20] and procurement cost. A program's PAUC is its acquisition cost (i.e., acquisition cost over the entire acquisition cycle) 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 Selected Acquisition Report (SAR) for the program.[21] 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 an estimated cost or assumed progress curve as appropriate. The ratio of the MS B baseline value of PAUC to the quantity-adjusted actual value is an estimate of by what percent PAUC would have grown had the MS B baseline quantity been acquired.

The cost growth data used were taken from what are called the December SARs, which typically are released in March following the DoD budget submission to the Congress in late January or early February. DoD guidance directs that the cost data in the December SARs be consistent with the budget submission. Hence, if costs adopted at a program's MS B are changed as a result of Program/Budget decisions, it is the changed costs (and changed program) that should be reported.

Currently, the only publicly available SAR cost growth database is that developed by IDA and used in this study.[22] It includes some data for all MDAPs that passed MS B during the period FY 1965 through FY 2009. This period includes two complete bust-boom cycles. Only MDAPs that had been completed by the end of FY 2016 were used in computing the regression equation presented below. The database includes 156 programs with a PAUC growth estimate and that were completed by the end of FY 2016.

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[20] In the database used for this study, an MDAP's RDT&E costs are measured from MS B.

[21] A SAR must be filed at least annually by each MDAP once it has passed MS B. Each SAR for a program reports separately RDT&E and procurement costs for each year of the then anticipated life of the program. The SAR also reports the number of fully configured units of the system acquired in each year. The costs reported in the first SAR filed after the program passes MS B are taken to be those of the baseline approved at MS B.

[22] A CD with the database and several related files is included with *Acquisition Policy*.

2. Funding Climate (W)

Fiscal Guidance (FG; see p. 7) probably would be the best single proxy measure for the intensity of competition for funds, but DoD does not make it publicly available.[23] As important, the intensity of competition for funds depends to an important extent on a number of factors in addition to funds made available for acquisition—funding demands of MDAPs already underway; force structure, which determines the requirements for various types of systems; the age and condition of equipment inventories; the MilDep's missions; technological opportunities; and changes in the threat.

The approach used identified four events that marked major changes in the funding climate, which then persisted for several years:

- 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)

In the first and third of these, the event was the main cause of the change in funding climate. The other two provide a clear marker that the budget climate had changed.

In each case, it is necessary to pay careful attention to the timing of the change in FG associated with the event. For example, the Soviet invasion of Afghanistan occurred in December 1979 (the first quarter of FY 1980). President Carter sent his FY 1981 budget request 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, therefore, is placed at FY 1981, not FY 1980. The Administration did submit a supplemental request for FY 1980, but this influenced programs that had already been approved, not programs that were coming up for MS B approval during 1980.

The result of these examinations was the definition of two complete bust-boom cycles:

- 1st cycle: FY 1965–FY 1980 (bust) and FY 1981–FY 1986 (boom)
- 2nd cycle: FY 1987–FY 2002 (bust) and FY 2003–FY 2009 (boom)

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[23] Some previous studies have used, as a surrogate for FG, amounts that the Congress appropriated for acquisition lagged by two years. Particularly during the second Reagan Administration, however, FG was not based on what the Congress could reasonably have been expected to appropriate.

No attempt was made to distinguish subperiods within the bust and boom periods. A zero/one categorical variable was used to distinguish the two funding climates, with zero denoting a bust climate year and one a boom climate year. Given this convention, the estimated coefficient of the funding climate variable (W) is expected to be negative.

3. Program Priority (P)

There is no publicly available record of the priority that the Services afforded various MDAPs in their POM deliberations. The obvious proxy is a program's size as measured by acquisition cost; it seems a matter of common sense that if funding is constrained, an MDAP with a high acquisition cost will be funded only if it has high priority. But program size is not in fact a reliable proxy for program priority. There are instances of large programs which were known to have relatively low priority (and which the Service funded somewhat grudgingly) and small programs with a high priority. For purposes of this analysis, "high priority" programs were defined as those that procured a platform central to one of the acquiring Service's main warfighting missions, e.g., the F-22. By this definition, 33 of the MDAPs in the database with a PAUC growth estimate were regarded as high priority. Program priority was represented by a categorical variable (high priority equal one, and low priority equal zero.)

The term high priority has been used here to mean "high priority for funding" so high priority programs would be relatively well funded and hence would be expected to show lower cost growth. The estimated coefficient of P then would be expected to be negative. There is, however, another point of view that at times has had some currency. This view starts from the premise that a high priority program enjoys strong support by the acquiring Service and probably also in the Congress and in parts of the defense industrial base. The argument has been made that the Service might adopt exceptionally optimistic costing for such programs to have more funds available for other, less popular programs. If this is the case, the estimated coefficient of P would be positive.

4. T_{boom} and 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. Recall that T_{boom} and T_{bust} are intended to account for cost growth due to Errors of Execution and Program Changes, each of which presumably increases with program duration. Consequently, we expected the estimated coefficient of each of these variables to be positive. Funding presumably is easier to find in a boom period for either increases in the capabilities a program acquires or to rectify underfunding at MS B. This implies that the estimated coefficient of T_{boom} should be larger than that of T_{bust}.

5. Acquisition Policy (R)

"Acquisition policy" is used to include process as well as policy as such. Depending on how fine a grid is used, over the period FY 1965–FY 2009 there were from a few dozen to a few hundred changes in DoD acquisition policy. Within the limitations of the data available, there is no possibility of representing these in detail in a regression model. As was done for competition for funding, the approach adopted is to look to events that mark major changes in acquisition policy.

There were six major clusters of changes in the top-level DoD acquisition policy documents over the period considered:

- Robert McNamara established the first OSD-level direction for MDAPs in 1964.
- Then Deputy Secretary of Defense David Packard instituted a thorough going restructuring of acquisition policy in 1969.
- The Carlucci Initiatives, named after then Deputy Secretary of Defense Frank Carlucci, were adopted in 1981, during the first year of the Reagan Administration, and implemented to varying degrees over the following three years.
- A major change in management structure was directed by the Congress in 1986 and then fully implemented in 1990.
- Then Secretary of Defense William Perry initiated a set of reforms to acquisition policies and statutes in 1994.
- In 2001, then USD(AT&L) Edward Aldrich dropped the preceding administration's changes on contract policy and, in general, reverted to policies much like those in effect during FY 1990–FY 1993.

These changes were used to define the six acquisition policy partitions (or cells) used in the study. The names used to refer to these cells and the break points adopted are given in Table 3. Care needed to be taken in identifying the first and last year of each cell because in several cases changes adopted in one year were not implemented until a later year; the start years reflect judgments on when the main changes adopted came into effect.

Table 3. Acquisition Policy Categorical Variables

Short Name	Long Name	Period (Fiscal Years)
McNamara	McNamara-Clifford	1965–1969
DSARC1	Defense Systems Acquisition Review Council 1	1970–1982
DSARC2	Defense Systems Acquisition Review Council 2	1983–1989
DAB1	Defense Acquisition Board 1	1990–1993
AR	Acquisition Reform	1994–2000
DAB2	Defense Acquisition Board 2	2002–2009

A zero/one categorical variable was specified for each cell, one for each year shown and zero elsewhere. McNamara-Clifford (FY 1965–FY 1969) was used as the reference period. (While McNamara's reforms were instituted in FY 1964, the first data point we use is for FY 1965.) The estimated intercept should be approximately the average of PAUC growth during the McNamara-Clifford period (74 percent), assuming any omitted variables taken together have a negligible effect and any nonlinearities are unimportant.

The coefficients of other acquisition policy categorical variables in the regression equation also are estimates of the difference between PAUC growth in McNamara-Clifford and the period in question, given values of the other variables. The estimated coefficient, of course, does not tell us which of the acquisition policy changes introduced in a period was responsible for the changes observed. Establishing that requires use of different data and methods.

Forming an expectation for the sign of DSARC1 requires consideration of just what it was that Packard's 1969 reforms changed. McNamara-Clifford had a restrictive policy on contract types but exercised less effective oversight of MDAPs at milestones. The contract types required were almost invariably associated with high cost growth, and its comparatively limited milestone review process also tended to permit high cost growth. McNamara-Clifford, however, included processes for oversight of ongoing programs that provided OSD staff with a considerable volume of data. Packard reversed McNamara's policies on contract type, required a more extended and a more robust version of the Technology Development phase, introduced a new oversight process that was more comprehensive and rigorous at milestone decision points, and made OSD oversight between milestone reviews less intrusive.

The first three of Packard's changes would be expected to reduce PAUC growth, which is to say that the estimated coefficient of DSARC1 on this basis is expected to be negative. The opposite conclusion can be reached only by arguing that Packard's changes weakened OSD oversight of ongoing programs and that such oversight is particularly important to PAUC growth. This argument is not tenable, however, because over half of PAUC growth is due to problems baked into the MS B baseline, and Errors of Execution are comparatively small—on the order of 10 percent of total cost growth. The estimated coefficient of DSARC1 is then expected to be negative. This is the one case in which the estimated coefficient might tell us something about the importance of the different acquisition policy changes that characterize the cell.

The Packard reforms were maintained through each of DSARC2, DAB1, AR, and DAB2; in fact, in many respects they were refined and strengthened. Looking just at this factor, it would be expected that the estimated coefficient of each of these variables would be negative and have an absolute value at least as large as that of the estimated coefficient of DSARC1. Some changes in acquisition policy were adopted in each of these periods, however—these changes are what delineates them. Not all of these changes were directed at cost growth, but some were, and those tended to reduce it. It is reasonable then to expect the coefficients of DSARC2, DAB1, AR, and DAB2 to be negative, and possibly larger in absolute value than that of DSARC1.

E. Results and Discussion

The equation estimated is:

$$\begin{aligned} Ch_{PAUCi} = {} & \alpha_0 + \alpha_1 W_i + \alpha_2 P_i + \alpha_3 DSARC1_i + \alpha_4 DSARC2_i + \alpha_5 DAB1_i + \alpha_6 AR_i \\ & \alpha_7 DAB2_i + \alpha_8 Tboom_i + \alpha_9 Tbust_i + e_i\,, \quad i = 1, \ldots, n, \end{aligned} \tag{7}$$

where i indexes MDAPs in the sample and e_i is a random variable assumed to be normally distributed with mean zero and constant variance. Table 4 presents the estimated parameter values and their associated p-values.

The estimated coefficient of each of the independent variables has the expected sign and is highly significant except for that of T_{bust}; it is insignificant, which is not surprising. The estimated equation is highly significant. It also is reassuring that the estimated intercept is close to the average PAUC growth for the reference period. The proportion of the variation in PAUC growth within the sample that is captured by the estimated equation (about 25 percent) is towards the upper end of what can be reasonably expected for combined cross section-time series data. These results are truly remarkable in view of the crudeness with which the right-hand side variables are measured. Moreover, small changes in specification or in the set of observations used to estimate the model proved to have little effect on the estimates.

The most important coefficient estimates, from the perspective of the theory developed in sections B and C, are those of funding climate (W) and program priority (P). It would be a blow to the theory to find that either of these estimates had a positive sign. In fact, both estimated coefficients are negative and statistically significant. Put in positive terms, the hallmarks of the theory of cost growth offered here is that, because of competition for funding, MDAPs that passed MS B in boom periods tended to have lower cost growth than those that passed in bust periods, and high priority programs tended to have lower cost growth than low priority programs. These estimates are the last step in a chain of argument that began with the institutional material presented in Section B and continued with Section C's theoretical analysis of why and how a PM would adjust a program MS B baseline to the intensity of the competition for funding. While the statistical results are highly satisfactory, it is their grounding on the preceding material that makes them particularly persuasive.

Table 4. Estimated Coefficients and p-values for a Model that Includes the Effects of Post-MS B Funding Climate and Duration

	Coefficients	p-value
Intercept	78.3%***	< 0.001
Errors of Inception—Intensity of Competition for Funds		
W (Funding Climate)	-22.7%*	0.070
P (High Priority)	-16.2%*	0.070
Errors of Inception—Acquisition Policy		
DSARC1	-58.5%***	< 0.001
DSARC2	-54.2%***	0.001
DAB1	-56.9%***	0.001
AR	-83.7%***	< 0.001
DAB2	-69.4%***	< 0.001
Errors of Execution and Program Changes		
T_{boom}	3.7%/yr**	0.020
T_{bust}	0.6%/yr	0.492

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

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

* Statistically significant at less than the 10 percent level.

R-Squared = 0.25, F = 5.383 (P < 0.001), N= 156. Estimated using Ordinary Least Squares. Wald's test for the equality of the estimated coefficients of the categorical variables for acquisition policy periods fails to reject the hypothesis that they are equal. F= 1.27, p = 0.285. In addition, Wald's F finds each of the estimated coefficient of the acquisition policy variables to be significantly different from the estimated constant term at p < 0.001. I am indebted to Dr. David Tate of IDA for suggesting the use of Wald's F and to Dr. Sarah John, also of IDA, for supervising the computations. The database used to compute this regression can be obtained by ordering *Acquisition Policy* with the accompanying CD from the IDA library. Alternatively, it is accessible at https://www.researchgate.net/publication /328202587_MDB_V54_CDxlsx. (Accessed June 6, 2020.)

In addition to highlighting the role of competition for funds in cost growth, the estimates in Table 4 shed a good deal of light on the extent to which changes in acquisition policy were associated with changes in PAUC growth. Dews et al. was the first major statistical study of whether the 1969 Packard reforms had reduced PAUC growth compared to McNamara-Clifford.[24] They found that it had. Drezner et al. provided evidence showing that this effect disappeared when account was taken of program duration.[25] There the question of the effect of the Packard reforms rested for some 15 years. The few statistical studies that appeared in the meantime shifted attention to a different question: Did the changes in acquisition policy post-Packard lead to reduced PAUC growth?[26] The consensus of these studies was that they did not. Taking the conclusion of Drezner et al. together with that of the later studies, the conclusion from the statistical work was that changes in acquisition policy had no significant association with reductions (or increases) in PAUC growth. If true, this is a startling and important conclusion.

The estimates in Table 4 disagree with Drezner et al. in that the estimated coefficient of DSARC1is negative and highly significant in the presence of variables that account for program duration. Moreover, this effect persisted: the estimated coefficient of each of the other four periods (DSARC1, DAB1, AR, and DAB2) is also negative and highly significant. This is what would be expected because, as was noted above, the central features of the Packard reforms were retained throughout these four periods. The 1969 Packard reforms are, then, associated with a persistent and significant reduction in PAUC growth.

It is interesting to note that this effect was not produced by systematically altering the PAUC growth of most MDAPs. Rather, the Packard reforms worked by significantly reducing the number of programs that experienced extremely high PAUC growth—a truncation of the right tail of the distribution, rather than a change in cost growth in the central portions of the distribution.[27]

The estimates in Table 4 agree with the conclusions of the more recent studies on the association of post-Packard changes in acquisition policy with PAUC growth. The estimated coefficients of the five post-McNamara-Clifford acquisition policy bins do not

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[24] 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), https://www.rand.org/pubs /reports/R2516.html.

[25] J. A. Drezner et al., "An Analysis of Weapon System Cost Growth," MR-291-AF (Santa Monica, CA: The RAND Corporation, 1993), https://www.rand.org/content/dam/rand/pubs/monograph_reports /2006/MR291.pdf.

[26] 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, http://dau.dodlive.mil/files/2014/11/Oneil_ARJ59.pdf.

[27] *Acquisition Policy*, 28; D. 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: IDA, August 2016), Appendix D.

differ significantly from one another.[28] That is, the results provide no indication that the changes post-Packard—and most of the changes in acquisition policy occurred during the 1980s and 1990s—have any association with PAUC growth. It is not clear what target these changes in acquisition policy in fact hit, but the statistical evidence says that they did not hit PAUC growth. Cast in policy terms, this experience can be read as a long list of things that do not work if the intent is to curb cost growth.

As was noted in Section C, the two duration variables are an *ad hoc* extension of the theory of cost growth due to Errors of Inception to cover two other sources of cost growth present in the data, Errors of Execution and Program Changes.[29] Although the estimated coefficient of each is positive, that for the time spent in boom periods (T_{boom}) is much larger and statistically significant. The moral from these results is that PAUC growth mainly occurs when it can, in periods when funding is more readily available. Using the sample averages for T_{bust} and T_{boom}, these coefficients imply that the Errors of Execution and Program Changes is 23 percent. In contrast, the OSD data mentioned earlier imply a figure of about 15 percent. There is no basis for judging one of these estimates to be more reliable than the other. The appropriate conclusions probably are, first, that the two estimates reside in the same statistical neighborhood and, second, that PAUC growth due to Program Changes and Errors of Execution may be somewhat larger than the one previous study available indicated.

Finally, the estimated coefficients provide an indication of the magnitude of Errors of Inception. An estimated 23 percentage points of PAUC growth is not present in boom periods for both low- and high-priority programs. This is reasonably interpreted as PAUC growth due to Errors of Inception that is present for both high- and low-priority programs in bust periods. In addition, in each of the climates, high-priority programs avoid 16 percent of PAUC growth that low-priority programs do not, and this, too, is reasonably assumed to reflect Errors of Inception. Granting these conjectures, Errors of Inception are at 39 percentage points for a low-priority program in a bust period and 16 percentage points in a boom period. Similarly, average PAUC growth due to Errors of Inception for high priority MDAPs in a bust period is about 23 percentage points. Cost growth due to Errors of

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[28] This statement rests on the results of Wald's F test, which was used to test whether, considered jointly, any of $\hat{a}_3$, $\hat{a}_4$, $\hat{a}_5$, $\hat{a}_6$, and $\hat{a}_7$ is significantly different from the others. See the notes under Table 4.

[29] Cost growth due to Program Changes is fundamentally different from that due to Errors of Inception or Errors of Execution. The latter mean that DoD paid more for the same or less capability than that approved when the program was launched. In contrast, Program Changes are a matter of paying more for more capability. Program Changes get counted as a part of cost growth only because of the difficulty of separating it out in the available reports of cost growth. There are two main problems in measuring cost growth due to Program Changes. First, there are cases in which MS B requirements were loosely stated and the system placed on contract was unlikely to achieve what the Service interpreted those requirements to mean. Cost growth in these cases should be classed an Error of Inception. Second, it is often hard to tell whether a quantity change was made for reasons exogenous to the program or was a response to problems the program was encountering.

Inception for a high-priority program that passed MS B in a boom climate would be expected to be near zero. These conjectures are accumulated in Table 5.

The weighted average of the two figures in Table 5 for the bust periods is about 35 percent. Using a value of 4 percentage points for Errors of Execution, the OSD data referenced earlier imply Errors of Inception in bust periods of 17–20 percentage points. (The OSD data provide no estimate for boom periods.) The significance of this difference, however, is very hard to gauge because the two estimates were made in such different ways.

Table 5. Inferred PAUC Growth due to Errors of Inception by Funding Climate and Program Priority

	Program Priority	
Funding Climate	**Low**	**High**
Bust	39 percent	23 percent
Boom	16 percent	near zero

F. Concluding Comments on Root Causes

This paper has been concerned mainly with cost growth in MDAPs due to Errors of Inception—that is, unrealistic features in the MS B baseline. Laying aside cost growth caused by direction from the Congress, the President, the Secretary of Defense, or the Secretary of one of the MilDeps, cost growth due to Errors of Inception results from the conjoint action of two underlying causes:

- Decisions by the PM, in anticipation of competition for funding in the Program/Budget process, to include unrealistic elements in the proposed MS B baseline.
- Acceptance by the MDA of a proposed MS B baseline in the face of creditable evidence that it is unrealistically optimistic, and subsequent acceptance of the relevant elements of that baseline in the Program/Budget process.

The first of these points has been explained here with reasonable clarity. The second was offered as a matter of fact, but no attempt was made to explain it.

Part of an explanation is that there were legitimate grounds for disagreement about what policy was best in the circumstances of a bust climate. Three broad policy options available for acquisition of major systems during a prolonged bust climate are:

1. Develop highly capable systems and procure them during full-rate production at considerably less than economic annual rates.[30]
2. Develop a smaller number of highly capable systems and procure them at economic annual rates.
3. Develop a comparatively large number of less capable systems and procure each at its economic rate.

The procurement cost of the total number of systems procured is lower for the second option than that of the first and, at least per unit, it provides more capability than the third. If total acquisition funding over a considerable span of years is assumed to be the same across the options, the second option apparently dominates the other two. This conclusion, however, ignores the different implications of the options for the defense industrial base, a term used here to include the defense technology base. Without diving further into the matter, the second option implies fewer, although possibly larger, defense industrial facilities, and the third would involve less advanced development programs. Consequently, considering these aspects, it is by no means clear that option 2 is superior to the other options.

During the period covered by this study, the Services' choices implied a preference for option 1 in many cases. The obvious way to arrive at option 1 is to propose an MS B baseline in which the system is procured at less than the economic rate. That, however, would increase the apparent cost of the program, which is not something a PM concerned about competition for funds would care to do. An unrealistic MS B baseline, and in particular an unrealistic cost estimate, is an alternative way of reaching option 1. As reality sets in, usually towards the end of EMD or during LRIP, higher unit production costs would be recognized, and to stay within funding limits, annual buy rates typically would be reduced. Consequently, the program would be at an approximation to option 1 at about the time full-rate production began.

The designated defense at MS B against the crabwise and often corrosive slide to option 1 via an unrealistic baseline was DoD's mechanism for challenging the realism of a cost estimate proposed by a Service. As was noted in Section B, since such disagreements typically involve several obscure and factually dense issues and inevitably a degree of

[30] The economic production rate is best defined as the production rate that minimizes the present value of procurement costs. The dominant factors in the computation differ among commodity classes. Physical capacity constraints, for example, are likely to impose a limit on the rate at which a new class of submarines can be procured and expanding production capacity is very costly. In contrast, bricks and mortar usually are not usually a major constraint on the rate at which a tactical aircraft can be procured.

judgment, they seldom can be resolved conclusively. Moreover, there was some difference of opinion within DoD over the extent to which cost growth is a significant substantive problem. Most programs that pass MS B with an unrealistic baseline survive in about the form initially proposed. Viewed from this angle, adoption of an unrealistic MS B baseline and the consequent cost growth looks like a backdoor way of incrementally funding the program, which *per se* does not increase its cost. In a familiar metaphor, the assertion is that contracting for the capabilities of a Cadillac and funding for a Chevrolet does not increase the price of the Cadillac. This is not in fact the case—the Cadillac does cost more. Laying aside the possibility that cost growth will lead to truncation or cancellation of the program, cost growth must be accommodated somewhere. Usually it is accommodated within the acquisition portion of the budget, typically by stretches, which increase procurement costs. The magnitude of these costs, however, is extremely difficult to estimate and it is not widely known that they may well be significant.[31]

Two other factors tended to enable the emergence from the MS B reviews and the Program/Budget process of an unrealistic baseline for a significant number of systems. First, there was an increasing differentiation of functions in OSD. By the early 1990s, MS B reviews, each phase of the PPBS (Planning, Programing, and Budgeting), and requirements determination were carried out by separate organizations. Coordinated policy making was possible in this situation but difficult. Second, it also would be difficult to adopt any policy (such as option 1) that on its face was suboptimal.

The upshot of these comments is that, in the state of policy guidance, empirical evidence, and organization during the period considered in this paper, it could be argued reasonably that in bust periods and for selected MDAPs, acceptance of an unrealistic MS B baseline was the best of the available options, all of which have undesirable features.

Finally, it is relevant to ask where bust periods come from. During bust periods, the funding made available to DoD was not sufficient to meet all demands for funding, which are determined primarily by force structure and the missions DoD is expected to be capable of executing, but also by such factors as policy on readiness levels, the age of fielded equipment, and levels of military and civilian pay. In principle, what this study labels a bust period could be created either by a cut in funding without an offsetting decrease in

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[31] The one published estimate is in McNicol, *Cost Growth in Major Weapon Procurement Programs*; see p. 10 and Appendix B. The cost of cost growth due to all sources except program changes is found to be equivalent to a tax of between 2 percent and 8 percent of the acquisition cost of all MDAPs in the portfolio. Care must be taken in interpreting this estimate:

> *The 2 percent to 8 percent tax does not imply that avoiding cost growth and the program stretches it causes would have permitted more procurement programs to be accommodated in any given period of a few years. In fact, the opposite is true. More realistic cost estimates at MS B would imply fewer programs at any point in time. These programs would be procured more rapidly, however, and over a span of years, a given total amount of procurement funding could buy 2 to 8 percent more programs. Alternatively, if the industrial base could be adjusted downward, a given set of programs could be produced at roughly 2 to 8 percent less funding.*

force structure or missions or by an increase in force structure or missions without an increase in funding. In the run of history considered, bust periods reflected the first of these. Each of the bust periods was eventually brought to an end by increases in funding or by cuts in force structure, missions, or other determinants of funding demands. Bust periods then reflect long lags in decision making.

In summary, the causal chain described here begins with unrealistic features in a proposed MS B baseline for an MDAP, which are the largest source of cost growth. Unrealistic baselines are proposed almost exclusively in bust periods, during which the competition for acquisition funds is particularly intense. It is the looming competition for funds, which is intrinsic to the Program/Budget process, that provides the PMs with an incentive to propose an unrealistic baseline, and especially an unrealistically optimistic cost estimate. The unrealistic proposed baseline becomes an unrealistic actual baseline on its acceptance by the MDA and funding in the Program/Budget process. A short explanation of why this happens is: DoD has not developed policy that is clear enough and strong enough to prevail in the factually tangled situations presented by bust periods. Finally, long bust periods reflect delays at the top levels of the US government in reconciling decisions on DoD funding and force structure and missions. Ultimately, then, a large part of cost growth in MDAPs over the period considered in this study is a symptom of underlying flaws in high-level defense policy and decision making.

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Abbreviations

AAP	Office of Acquisition Analytics and Policy
AR	Acquisition Reform
DAB	Defense Acquisition Board
DDR&E	Director, Defense Research and Engineering
DoD	Department of Defense
DoDD	Department of Defense Directive
DSARC	Defense Systems Acquisition Review Council
EMD	Engineering and Manufacturing Development
FG	Fiscal Guidance
FY	Fiscal Year
FYDP	Future Years Defense Plan
GRH	Gramm-Rudman-Hollings (Act)
ICE	Independent Cost Estimate
IDA	Institute for Defense Analyses
LRIP	Low-Rate Initial Production
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MilDep	Military Department
MS	Milestone
NDAA	National Defense Authorization Act
OSD	Office of the Secretary of Defense
PARCA	Office of Program Assessment and Root Cause Analysis
PAUC	Program Acquisition Unit Cost
PM	Program Manager
POE	Program Office Cost Estimate
POM	Program Objective Memorandum
PPBS	Planning, Programming, and Budgeting System
RDT&E	Research, Development, Test, and Evaluation
SAR	Selected Acquisition Report
SCE	Service Cost Estimate
USD(A&S)	Under Secretary of Defense (Acquisition and Sustainment)
USD(A)	Under Secretary of Defense (Acquisition)
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology and Logistics)
USD(R&E)	Under Secretary of Defense (Research and Engineering)
WSARA	Weapon Systems Acquisition Reform Act

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

The proximate cause of a large part of cost growth experienced by Major Defense Acquisition Programs (MDAPs) over the period Fiscal Year (FY) 1965–FY 2009 was unrealistic features in the program's initial baselines. This paper develops a theory of the root causes of this part of cost growth and provides statistical estimates of the model implied by this theory. Just upstream from most unrealistic program features lies competition for funding. Further upstream are circumstances that help explain why senior Department of Defense (DoD) decision makers sometimes approve unrealistically optimistic baselines. These are complex, but notably almost all occurred in periods during which funding made available to DoD was not sufficient to meet all reasonable demands imposed by such factors as force structure and the missions which DoD was expected to be able to perform. Yet further upstream are delays in adjusting the determinants of funding requirements to the funding provided. This causal chain accounts for the largest part (although not all) of cost growth in MDAPs. The statistical evidence for the model based on these factors is excellent.

15. SUBJECT TERMS

Major Defense Acquisition Programs; cost growth; root causes of cost growth; proximate causes of cost growth; Defense Acquisition Board

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