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Further Evidence on the Effect of Acquisition Policy and Process on Cost Growth

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Panel 5. Quantitative Analyses of Acquisition Outcome Drivers

Wednesday, May 4, 2016	
1:45 p.m. – 3:15 p.m.	**Chair: William Gates,** Dean, Graduate School of Business and Public Policy, NPS ***Consequences of BBP's Affordability Initiative*** Gregory Davis, Research Staff Member, Institute for Defense Analyses Lawrence Goeller, Defense Acquisition Analyst, Institute for Defense Analyses Stanley Horowitz, Assistant Director, Cost Analysis and Research Division, Institute for Defense Analyses ***Further Evidence on the Effect of Acquisition Policy and Process on Cost Growth*** David McNicol, Research Staff Member, Institute for Defense Analyses David Tate, Research Staff Member, Institute for Defense Analyses ***Preparing to Be Wrong*** Prashant Patel, Research Staff Member, Institute for Defense Analyses Michael Fischerkeller, Research Staff Member, Institute for Defense Analyses

Further Evidence on the Effect of Acquisition Policy and Process on Cost Growth

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David M. Tate—joined the research staff of the Institute for Defense Analyses' Cost Analysis and Research Division in 2000. Since then, he has worked on a wide variety of resource analysis and quantitative modeling projects related to national security. These include an independent cost estimate of Future Combat Systems development costs, investigation of apparent inequities in Veterans' Disability Benefit adjudications, and modeling and optimization of resource-constrained acquisition portfolios. Dr. Tate holds bachelor's degrees in philosophy and mathematical sciences from the Johns Hopkins University, and MS and PhD degrees in operations research from Cornell University. [dtate@ida.org]

Abstract

Institute for Defense Analyses Paper P-5126 found that additional acquisition reforms after those introduced in mid-1969 by then Deputy Secretary of Defense David Packard did not significantly reduce cost growth on Major Defense Acquisition Programs (MDAPs). That conclusion—while interesting—is incomplete, as it leaves open the possibility that the Packard reforms reduced cost growth compared to the record of the 1960s, which is the issue examined in this paper. The paper finds that average cost growth of MDAPs that entered Engineering and Manufacturing Development during fiscal year (FY) 1970–FY 1980 was significantly lower than the average of those that entered during FY 1964–FY 1969. It also probably was significantly lower than the average during FY 1994–FY 2000 when Office of the Secretary of Defense (OSD)–level oversight of MDAPs was less stringent. These stand as instances of a significant association between changes in OSD-level oversight and cost growth. The paper also provides evidence that average cost growth in FY 1964–FY 1969 and FY 1994–FY 2000 was particularly high largely because the proportion of MDAPs that experienced extremely high cost growth was significantly larger than it was in other periods.

Introduction

McNicol and Wu (2014; hereafter referred to as P-5126) reported two significant findings. First, Major Defense Acquisition Programs (MDAPs) that entered Engineering and Manufacturing Development (EMD) during "bust" funding climates on average had much higher cost growth than those that entered EMD during "boom" climates. Second, the paper found that additional reforms after those introduced in mid-1969 by then Deputy Secretary of Defense David Packard had not significantly reduced cost growth.

As P-5126 noted, the latter conclusion leaves open the possibility that the Packard reforms reduced cost growth compared to the record of the 1960s. If in fact they did, the conclusion of that paper would have to be amended to read: The introduction in 1969 of effective Office of the Secretary of Defense (OSD)–level oversight of major acquisition programs reduced cost growth, but the additional reforms of the 1970s, 1980s, and early 1990s did not result in further reductions. Along the same line, it is of interest to revisit the mixed evidence P-5126 found on the effect on cost growth of less active OSD-level oversight of 1994–2000. The crucial question is whether there is statistical evidence that

cost growth decreased when OSD-level controls were imposed and also increased when those controls were relaxed.

This is not simply an historical question, because the main features of today's OSD level acquisition oversight process remain those of the process installed by Packard in mid-1969. Moreover, the issue is salient now because of its implications for ongoing discussions of reform of the DoD weapon system acquisition process.

The database available for P-5126 did not contain cost growth estimates for any MDAPs that entered EMD during the 1960s, so that paper could not compare cost growth pre- and post-Packard. This paper uses cost growth data for programs that entered EMD in the 1960s from two previous studies (Jarvaise, Drezner, & Norton, 1996; Tyson, Om, Gogerty, & Nelson, 1992). It also uses a different cost growth metric and employs additional statistical tests.

The next section briefly describes the OSD-level acquisition oversight introduced by Robert McNamara in the mid-1960s and the changes made to it in 1969 by Packard. It is necessary to do this because the McNamara reforms are no longer part of the collective memory of the DoD acquisition community. Subsequent sections then turn to the statistical analysis and the conclusions it suggests. These sections assume that the reader has a working familiarity with acquisition process and policies. Those who do not may wish to consult Fox (2011). Readers who want a more detailed understanding of the data used and the way they were binned should consult Appendixes A and B of McNicol, Tate, Burns, and Wu (2016).

Origins of the OSD-Level Acquisition Oversight Process

From the creation of the National Security Establishment in 1947 through 1960, the OSD had no institutionalized process for the oversight of major weapon system acquisitions.[1] The origins of the OSD-level process for overseeing major weapon system acquisitions lie in initiatives taken by McNamara, of which the following are especially relevant for current purposes:

- Promulgation of policy on contract types
- Establishment of milestone decision points and the Development Concept Paper (DCP)
- Active oversight of ongoing MDAPs[2]

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[1] The Secretary of Defense could, and on occasion did, act to cancel or initiate major acquisitions. Major acquisition programs were also subject to review during the budget cycle by the Office of the Assistant Secretary of Defense (Comptroller) and the Office of Management and Budget. Additionally, a major building block of McNamara's process began operating in 1959. See O'Neil and Porter (2011, p. 25).

[2] These categories are abstracted from Fox (2011, p. 35–45). Fox also notes that McNamara moved to consolidate acquisition functions in defense agencies—e.g., the agency that became the Defense Logistics Agency—and promoted the use by program managers of particular management tools such as PERT and earned value. In addition, there are several cases—most notably the F-111—in which McNamara played a very active role in the oversight of the program. These cases almost certainly are exceptions, but the literature survey done for this paper uncovered little about how the process worked in the more typical cases. Adding to the confusion, the sources consulted suggest that during

These initiatives were an embryonic OSD-level acquisition oversight process.

McNamara directed the use of Total Package Procurement (TPP) when it was judged to be practicable and, when not, Fixed Price Incentive Fee (FPIF) or Cost Plus Incentive Fee (CPIF) contracts.[3] By 1966, McNamara had concluded that TPP contracts were in fact not a practicable way to acquire major weapon systems, although acquisition policy apparently still had a tilt towards fixed price contracts, even for development. Packard picked up on this topic where McNamara left off. He ruled out the use of TPP and discouraged the use of FPIF for development contracts in favor of CPIF. (Cost Plus Award Fee may not have been included in the contracting play book yet.) As a general matter, Packard's policy was to match contract terms to the riskiness of the acquisition.

Packard's establishment of the Defense Systems Acquisition Review Council (DSARC) often is seen as the hallmark of his 1969 reforms. The notion of milestone reviews, however, entered the OSD-level acquisition process in 1964 with issuance of DoD Directive (DoDD) 3200.9, *Initiation of Engineering and Operational Systems Development*.[4] This original version of the directive set one point at which OSD—in principle, the Secretary of Defense—approval was required for an acquisition program to proceed. In 1965, a second decision point was added, and the Director, Defense Research and Engineering (DDR&E), instituted the precursor of the DCP, which, starting in 1968, was required to initiate any major development project. DDR&E coordinated initial DCPs with concerned OSD offices (and probably the Joint Staff and other Services; O'Neil & Porter, 2011) and acted as what now would be called the Milestone Decision Authority (MDA) for the initial DCP (Borklund, 1969). Once approved by DDR&E, the proposed new start went to the Secretary of Defense, although the sources consulted do not indicate whether it went as a separate action or as part of the Service's budget submission. It is also not clear which OSD official was the MDA for the second milestone.

Viewed against this background, the establishment of the DSARC was an evolutionary step. The Development Concept Paper was renamed the Decision Coordinating Paper (retaining the acronym) to reflect the broader scope of the new milestone definitions. The MDA at Milestone (MS) I and MS II was DDR&E; the Assistant Secretary of Defense for Installations and Logistics was the MDA for MS III. Decisions at the DSARC level were advisory to the Secretary and Deputy Secretary of Defense but, apart from exceptional cases, they probably reached that level by way of the Service's proposed budgets (and the Comptroller was the backstop enforcer of the requirement for milestone approval before a program could advance to the next stage).

The OSD had a much larger role in oversight of major acquisition programs under the DSARC process than it did pre-1961. The picture in contrast to the McNamara years is

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the McNamara years a major acquisition program might arise in either the Planning, Programming, and Budgeting System (PPBS) or in the acquisition process.

[3] Fox (2011, p. 38), following Adams, Murphy, and Rosenau (1983, pp. 19–20). A TPP contract is one that covers EMD, at least a significant portion of procurement, and at least part of the support of the system (e.g., depot maintenance).

[4] The first version of DoDD 3200.9 was issued in 1964. A revision that made provision for the Contract Definition Phase was issued July 1, 1965. See Glennan (1965, p. 12). O'Neil and Porter (2011, pp. 25–47) sketch how the process evolved and worked during the 1960s.

less clear-cut. On one hand, under the new acquisition directives, the Secretary of Defense, while retaining full legal authority over acquisition programs, would act through the established acquisition process except in extraordinary circumstances, which in comparison to cases such as the F-111 implied less OSD-level control over acquisitions. On the other hand, the DSARC had a greater substantive scope for the more typical program and was more tightly organized. For the large majority of major acquisition programs, then, the new DSARC process probably was more effective.[5]

The most consequential of Packard's 1969 reforms involved the substance of the milestones.[6] The 1965 version of the DoDD 3200.9 process had three phases. The first of these "was called concept formulation. During concept formulation OSD and the Service(s) involved assured themselves that they were buying the right system to meet real needs and that the technology was fully ready" (O'Neil & Porter, 2011, p. 30). Concept formulation typically was initiated by a Service but involved DDR&E and the Office of the Assistant Secretary of Defense for Systems Analysis (OASD[SA]), and included what would now be called an Analysis of Alternatives led by OASD(SA). It also apparently included what would later be called a Mission Element Need Statement as well as the main parts of an Acquisition Strategy and plans for oversight of the program as it proceeded.

Approval to proceed from the Concept Formulation phase authorized the Service sponsoring the program to fund at least one company to prepare a definitized contract proposal. The OSD (milestone) review of these proposals was the basis for award of a contract, usually to a single source, for development and procurement of the system. That is to say, the second of DoDD 3200.9's milestones combined what now would be called MS B and MS C authority.

Packard's reforms separated the decision to allow the program to enter EMD from the decision to enter the production phase (now MS C) and required OSD-level approval of each decision. Packard also established a new Validation Phase, which has at various times since been called Demonstration and Validation, Program Development and Risk Reduction and, currently, Technology Maturation and Risk Reduction. MS I (now MS A) authorized entry into this phase. DoDD 3200.9's Contract Definition phase was collapsed into the new and broader Validation phase. These changes were more revolutionary than evolutionary.[7]

The provisional judgment offered here is that Packard's acquisition reforms provide a plausible reason for expecting program outcomes—measured by cost growth, schedule slips, and performance shortfalls—to be better than what was achieved during the

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[5] Murdock (1974, pp. 155–179), disagrees with this judgment. Murdock is primarily concerned with Systems Analysis and resource allocation, but also comments specifically on the acquisition process. In particular, he notes that the new Decision Coordinating Paper did not provide "any mechanism for ongoing managerial control." This is accurate in that the Packard reforms placed management of the programs in the hands of the Services. It is incomplete in that the Services were responsible for staying within what would later be called the Acquisition Program Baseline, and the MDA was enjoined to act in cases in which they did not.

[6] Fox (2011, p. 57), provides a useful schematic comparison of the DoDD 3200.9 milestones and those of Packard's DoDD 5000.1/DoDI 5000.2.

[7] DoDI 5000.2, issued October 23, 2000, formally established MSs A, B, and C (replacing MSs I, II, and III) as the main decision points for an MDAP. The definitions are such that MS B is placed several months earlier in the process than MS II.

McNamara-Clifford years. This judgment does not imply that the DoD was doing a better job of deciding what to buy, but only that, as a result of the Packard reforms, the OSD became more effective in oversight of acquisition programs from MS II through the completion of procurement.

Statistical Analysis of Average Cost Growth

The statistical analysis presented here rests on definitions of periods delimited by major changes in acquisition policy and process. Two of these already encountered are labeled “McNamara-Clifford” and “DSARC.” Four additional acquisition periods are introduced below. Another part of the scaffolding of the analysis is funding climate. Two climates are distinguished—“bust” and “boom.” Three of the acquisition periods include both bust and boom phases and three were entirely in a single funding climate. Finally, the analysis rests on a set of conventions concerning which MDAPs are included in the database and the way in which cost growth is measured. See Appendix A of McNicol et al. (2016) for an explanation of the basis of the boundaries separating the successive acquisition periods and the funding climates. Appendix B of McNicol et al. states the conventions used in assembling the database and identifies the sources of the data used.

This section considers whether there are statistically significant differences in cost growth across the successive acquisition regimes in bust climates. The measure of cost growth used is Average Procurement Unit Cost (APUC). “APUC growth” means growth in APUC in program base year dollars normalized to the baseline quantity approved at MS B. Attention in this section and most of the one that follows is limited to MDAPs that entered EMD during bust periods because the interesting findings arise from the analysis of those periods. Results for boom periods are briefly mentioned at the end of the following section.

Table 1 reports average APUC growth experienced by MDAPs that passed MS II/B during each of the six acquisition regimes in a bust climate. It is important to bear in mind that APUC growth is computed by comparing the MS II/B baseline value for APUC—which can be thought of as a goal or a prediction—to the actual APUC, normalized to the MS II/B quantity[8] (or, for ongoing programs, to the projected APUC in the December 2012 Selected Acquisition Reports [SARs], which were the most recent available when this project began).[9] The APUC growth figures shown are the quantity normalized average for the MDAPs in that acquisition regime, binned by the year the MDAP passed MS II/B. This is done on the hypothesis that the acquisition policies and processes in place when an MDAP passes MS II/B, particularly the rigor of the MS II/B review, have an effect on the amount of cost growth it experiences in the future.

[8] About three-quarters of the MDAPs that passed MS II/B in the period FY 1988–FY 2007 acquired at least 90% of their MS II/B baseline quantity. The median program acquired 100% and the average program acquired 111%. See McNicol et al. (2015, p. 7–8).

[9] We follow the convention of not including in the database any MDAP that was not at least five years beyond EMD (so that cost growth would have time to appear). The most recent SARs available when P 5126 was written were those for December 2012. Consequently, MDAPs that passed MS B during FY 2007 were the most recent included in the database.

Table 1. Average APUC Growth by Acquisition Regime for MDAPs That Entered EMD During a Bust Funding Climate

Acquisition Regime	Period (FY)	Average APUC Growth*
McNamara-Clifford	1964–1969	85% (20)
DSARC	1970–1980	39% (53)
Post Carlucci DSARC	1987–1989	44% (12)
Defense Acquisition Board (DAB)	1990–1993	32% (11)
Acquisition Reform (AR)	1994–2000	78% (27)
DAB post AR	2001–2002	113% (6)

Note. Numbers in parentheses are the number of observations in the cell.
* Normalized for changes in quantity.

A plausible reading of the averages in Table 1 is as follows: Packard's radically new acquisition phases and his more highly structured process were successful in reducing APUC growth, which fell to less than half the average level it had during the 1960s. Perhaps encouraged by Packard's success and public distaste for cost growth, acquisition reform efforts persisted, but had no appreciable further effect on average cost growth prior to the AR years. Reduction of OSD oversight during the AR era coincided with the return of average APUC growth to nearly its 1960s level. In sum, the Packard reforms of late FY 1969 appear to have reduced APUC growth; they were not significantly improved upon in this respect through the bust years that followed; and the AR years were associated with higher APUC growth, which may be related to a reduction of OSD-level oversight.

The question for the statistical analysis in an exploratory context is: Can cause reasonably be ascribed to the period-to-period changes in APUC growth, or are those changes more likely simply random fluctuations in the data?

It is useful to break this question into three parts. First, is the difference between the average APUC growth post Packard reforms (39%) and the average for FY 1964–FY 1969 (85%) statistically significant? The tests used found this difference to be statistically significant at the 9% level.[10] It is worth noting these reductions probably cannot be attributed only to the policies on contract type that Packard instituted. Four of the 20 programs in the data set for FY 1964–FY 1969 used TPP, and one used a Firm Fixed Price (FFP) development contract. The average APUC growth for these five contracts was 131%; the average cost growth for the remaining FY 1961–FY 1969 programs was 70%.[11] TPP and FFP contracts were less commonly used during FY 1970–FY 1980, but three of the MDAPs

[10] The Mann-Whitney U test rejected the null hypothesis (P = 0.093) that the samples for the DSARC period and the McNamara-Clifford period were drawn from the same population. (n_1 = 53, n_2 = 20, U = 394). A two-tail t-test assuming unequal sample variances found the difference in the means to be significant (p = 0.074). The Kolmogorov-Smirnov (K-S) test showed that APUC growth estimates for the McNamara-Clifford period probably are not normally distributed. The result of the t-test, even with the correction for unequal variances, is therefore somewhat suspect.
[11] For further discussion of TPP and FFP development contracts, see Tyson et al. (1992, Chapter X); McNicol (2004, pp. 53, 57–59); and O'Neil and Porter (2011, p. 29–31).

that passed MS II/B during this period used a TPP contract and one used an FFP development contract.

Second, are the differences in average APUC growth for the three periods between McNamara-Clifford and AR statistically significant? The tests used did not reveal any statistically significant differences between the averages of APUC growth in these three periods.[12] This implies that the lower average APUC growth (32%) of MDAPs that passed MS II during the DAB years (FY 1990–FY 1993), for example, cannot be attributed confidently to the full implementation of the DAB in 1990, because a change of this size has a considerable probability of occurring by chance.

Third, and finally, were the AR years associated with significantly higher average APUC growth? The results in this case were mixed. One test indicated that average APUC growth over the AR years was significantly higher than it was in FY 1990–FY 1993. That result, however, was not confirmed by another test.[13] This is similar to the result found in P-5126 and it occurs for the same reason—the variability of APUC growth in the AR period was too large for the differences in the means to be statistically significant.

The Bayesian analysis presented in Appendix C of McNicol et al. (2016) provides a stronger result for the AR years. It finds clear evidence that both the McNamara-Clifford period (FY 1964–FY 1969) and the AR years (FY 1994–FY 2000) had a much higher probability of high cost growth than did the bust climate portion of any of the three intervening periods (DSARC, Post-Carlucci DSARC, and DAB).

Returning to the interpretation of Table 1 offered above, the statistical analysis of average APUC growth supports two of the three points offered above—the Packard reforms did reduce APUC growth and the further reforms introduced post-Packard and pre-AR did not yield significant further reductions in APUC growth. The results on the third point are not clear-cut. The statistical tests reported above do not support attributing the high mean APUC growth during FY 1994–FY 2000 to acquisition reform, but the Bayesian analysis does support such an interpretation.

Statistical Analysis of the Proportion of Extremely High APUC Growth Programs

The preceding section looked for effects of acquisition policy and process in differences between successive periods in the average APUC growth of MDAPs that passed MS II/B during them. Although reasonable, framing the analysis in this way glosses over the possibility—explored in this section—that acquisition policy and process mainly work by influencing the proportion of MDAPs that experience extremely high cost growth.

Some relevant data are provided in Table 2. The average APUC growth figures are the same as those presented in Table 1. In addition, Table 2 reports the number of MDAPs

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[12] We compared the three periods using Analysis of Variance (ANOVA). ANOVA failed to reject the null hypothesis that the observations in the three periods were drawn from identical normal populations. The K-S test found it highly likely that the samples were consistent with ANOVA's assumptions.

[13] A two-tail t-test assuming unequal variances found the difference to be significant. (P = 0.084.) The K-S test rejected the null hypothesis that the observations for FY 1994–FY 2000 were normally distributed. A Mann-Whitney U test did not find a significant difference between the average APUC growth of the AR years and that for the period FY 1990–FY 1993.

in the cohort that experienced at least three different levels of APUC growth—50%, 100%, and one standard deviation (S) above the sample mean ($\bar{X}$). The sample mean is 57.4% and the standard deviation is 85.4%, so one standard deviation beyond the mean is 143%. ($\bar{X}$ and S are computed for the bust periods only.) In what follows, MDAPs in the last of the categories will be called "extremely high cost growth" programs. These are arbitrary breaks adopted because they proved to be useful. Note that the figures for the number of systems in the right tail are not additive. For example, of the 20 MDAPs that entered EMD during the period FY 1964–FY 1969, 10 had APUC growth of at least 50%. Of these 10, six had APUC growth of more than 100%, and of the six, four had APUC growth of more than 143%.

The striking feature of the data in Table 2 is the paucity of extremely high cost growth programs after the introduction of the Packard reforms in 1969 and before AR. A total of 76 programs in our sample passed MS II during the 18 years of the DSARC, Post-Carlucci DSARC, and DAB periods in bust funding climates. Only one of these has an estimated quantity normalized APUC growth from the MS II baseline of at least 143%.[14] The other side of this coin is the greater frequency of extremely high cost growth systems in the McNamara-Clifford years and during the AR period. Four out of 20 programs of the McNamara-Clifford years showed extremely high cost growth, as did seven out of 27 MDAPs that passed MS II during the AR years.

Table 2. Average APUC Growth by Acquisition Regime and the Number of High Cost Growth MDAPs in Each Cohort, Bust Funding Climates

Acquisition Regime	Period (FY)	Average APUC Growth*	≥ 50%	≥ 100%	≥ $\bar{X}$ + S
McNamara-Clifford	1964–1969	85% (20)	10	6	4
DSARC	1970–1980	39% (53)	19	7	0
Post-Carlucci DSARC	1987–1989	44% (12)	4	3	1
DAB	1990–1993	32% (11)	5	1	0
Acquisition Reform	1994–2000	78% (27)	11	7	7
DAB post-AR	2001–2002	113% (6)	2	1	1

Note. Numbers in parentheses are the number of observations in the cell.
* Normalized for changes in quantity.

Statistical analysis gives substantially the conclusions suggested by inspection of the data in Table 2:

- The frequency of extremely high cost growth programs was significantly higher in the McNamara-Clifford years than in the DSARC period.

[14] This is the FGM-148A Javelin. Roland also had a very high APUC growth (308%) but was placed on the cancelled list. Roland was developed during the mid-1960s by a French-German consortium. In 1975, the U.S. Army decided to develop and procure a U.S. version. The planned procurement was severely reduced, but enough was acquired to equip one Army National Guard battalion. This does not fully meet the definition of a cancellation but was judged to be closer to a cancellation than to a truncation of the program.

- The frequency of extremely high cost growth programs also was significantly higher during the AR years than during the DSARC period.[15]

In contrast to the results of the preceding section, both the McNamara-Clifford period and the AR period, then, stand out as having a significantly larger proportion of extremely high cost growth programs.

Table 3 lists the extremely high cost growth systems. Thirteen of the 14 passed MS II/B during bust climates. Helicopters (2), satellite programs (3), and launch vehicles (2) are over-represented but do not dominate the list, particularly for the 1960s.

Table 3. Extremely High Cost Growth Systems

System Name	MS II/B FY	APUC
Bust Climates		
AGM-69 Short Range Attack Missile (SRAM)	1967	4.56
MIM-23 Hawk (Improved Hawk)	1965	2.07
Versatile Avionics Shop Test (VAST)	1968	1.83
M47 Dragon Guided Missile	1966	1.72
FGM-148A Javelin Advanced Anti-Tank Weapon System	1989	1.59
Space Based IR Sensor (SBIRS) High	1997	3.90
Evolved Expendable Launch Vehicle (EELV)	1998	3.42
Global Broadcast Service (GBS)	1998	2.60
Guided Multiple Launch Rocket System (GMLRS)	1998	2.15
H-1 Upgrades	1996	1.97
CH-47F (Improved Cargo Helicopter)	1998	1.81
Patriot Advanced Capability-3 (PAC-3)	1994	1.49
Advanced Extremely High Frequency (AEHF) Satellite	2001	4.78
Boom Climates		
Titan IV Expendable Launch Vehicle (ELV)	1985	1.49

We also explored whether the proportions of systems with cost growth of at least 50% or 100% might show the same pattern across acquisition periods as the extremely high cost growth systems. Analyses parallel with those just described, with observations of at least 50% APUC growth and 100% APUC growth showing no significant differences across the acquisition periods.

Appendix D of McNicol et al. (2016) presents results obtained from a technique (quantile regression) that compares the APUC growth distributions across acquisition regimes at several points. The comparison reported used deciles. The results were

[15] These statements are based on results for Fisher's Exact Tests: (1) $p = 0.004$ in the comparison of McNamara-Clifford to the DSARC years, and (2) $p < 0.001$ for the comparison of FY 1994–FY 2000 with the DSARC years.

consistent with those stated above in two respects: (1) There were no significant differences across the six acquisition periods in the central portions of the distribution (4th through the 7th deciles), and (2) the McNamara-Clifford and AR periods had significantly fatter right tails. It also is interesting to note that there is some evidence that the left tails of these two periods were somewhat fatter than those of other periods; that is, McNamara-Clifford had higher highs and perhaps higher lows.

Finally, we considered the pattern in average APUC growth across the six acquisition periods if the 13 extremely high cost growth programs are removed. The means of the truncated distributions are presented in Table 4. Pair-wise tests found the average APUC growth for the AR years (without the extremely high cost growth systems) to be significantly lower than the averages for the McNamara-Clifford and DSARC periods. None of the other differences was statistically significant and a test of the table as a whole did not reveal significant differences.[16] It appears, then, that the significant differences in average APUC growth reported in the previous section (Statistical Analysis of Average Cost Growth) stem from the significantly higher proportion of extremely high cost growth systems during the McNamara-Clifford and AR periods.

Table 4. Average APUC Growth by Acquisition Regime for Bust Funding Climates, Excluding Extremely High Cost Growth Programs

Acquisition Regime	Period (FY)	Average APUC Growth*
McNamara-Clifford	1964–1969	0.43 (16)
DSARC	1970–1980	0.39 (53)
Post Carlucci DSARC	1987–1989	0.34 (11)
DAB	1990–1993	0.32 (11)
Acquisition Reform	1994–2000	0.18 (20)
DAB post-AR	2001–2002	0.40 (5)

Note. Numbers in parentheses are the number of observations in the cell.
* Normalized for changes in quantity.

Appendix E of McNicol et al. (2016) presents an analysis of the boom case that parallels that of this and the preceding section for the bust case. There was no indication of significant association between acquisition period and average APUC growth and no indication of statistically significant differences across the acquisition regimes in the boom periods with the proportion of MDAPs in the right tail of the distributions.

Interpretation of the Statistical Results

The conclusions of the preceding section add a level of detail to the interpretation of the APUC growth data offered in the earlier section titled Statistical Analysis of Average

[16] Two-tail t-test of the differences of the means of two independent samples. ANOVA for the table as a whole yielded P = 0.45. K-S found four of the distributions to be normal. The exceptions were those for FY 1964–FY 1969, which K-S found to only marginally satisfy the test for normality, and FY 2001–FY 2002, which had too few data points to test.

Cost Growth. Packard's radically new acquisition phases and his more highly structured process were almost completely successful in preventing instances of extremely high cost growth and, for this reason, significantly reduced average APUC growth. The relaxation of OSD oversight of MDAPs during the AR era saw a return of a significant number of extremely high cost growth systems and, for that reason, average APUC growth returned to nearly its 1960s level. In sum, the Packard reforms of late FY 1969 worked well in essentially eliminating instances of extremely high cost growth and in that way reduced average APUC growth; they were not significantly improved upon in this respect through the early 2000s; and the relaxation of OSD-level oversight of the AR years was associated with a significant number of extremely high cost growth programs and, therefore, of higher average APUC growth.

The DAB process is a mechanism the Under Secretary of Defense for Acquisition, Technology, and Logistics can use to bring MDAPs into conformance with acquisition policy at MS II/B. Among other things, programs should have use the appropriate contracting mechanism, should have a sound test plan, should not proceed until the technologies to be employed are reasonably mature, should rest on realistic programmatic assumptions, and should be fully funded to a realistic cost estimate. It is not surprising, then, to find that (except in the AR years when OSD-level oversight was relaxed) the DSARC process and its successor, the DAB process, largely eliminated instances of extreme cost growth. This might be due to direct OSD-level modification of particular MDAPs. Alternatively, the certainty of reviews by the DSARC/DAB might have prompted the Services to avoid in the programs they proposed the characteristics that cause high cost growth. The best way to gain a deeper insight into the matter probably is to compare closely the AR period with the DSARC period and to examine the extremely high cost growth programs.

It is surprising that the statistically significant differences are found only for the extremely high cost growth systems. The description of the process certainly suggests that it also should have an effect on programs with smaller but still very substantial cost growth. This finding, however, does not necessarily imply that the OSD-level process has no effect. Instead, the statistical finding as such is that the fairly rudimentary OSD-level process of the McNamara-Clifford years did as well as its more elaborate successors except on extremely high cost growth systems.

It is, finally, important to note that this paper has been concerned almost entirely with cost growth of MDAPs that passed MS II/B in bust periods. A complete summary also would need to take into account parallel analyses for the boom periods and the comparisons of cost growth in bust and boom periods for a given acquisition regime. That task, however, is postponed to a subsequent study.

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