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Post–Milestone B Funding Climate and Cost Growth in Major Defense Acquisition Programs

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Abstract

This paper is the fourth in a series that examines the association between outcomes of Major Defense Acquisition Programs (MDAPs) and changes in acquisition policy and process and funding climate. Like an earlier paper in the series, it finds that quantity normalized Program Acquisition Unit Cost (PAUC) growth measured from Milestone (MS) B is significantly higher in programs that passed MS B in bust climates than in boom climates. The new finding in this paper is that among MDAPs that passed MS B in a bust phase, only those that continued into a boom climate showed significantly higher PAUC growth than programs that passed MS B in a boom climate. This conclusion is important because it implies that much of the observed PAUC growth may have causes other than flaws in MS B baselines. The conclusion tells us less than might be hoped, however. This is so because the PAUC growth associated with the boom climate may reflect the purchase of capability beyond that specified in the MS B baseline or, alternatively, may reflect PAUC increases that occur when programs take advantage of a boom climate to “get well.”

Introduction

This paper examines whether Major Defense Acquisition Programs (MDAPs) that entered a boom climate for procurement funding some time after passing Milestone (MS) B on average had higher unit cost growth than programs whose acquisition cycles did not extend into a boom climate. While this conjecture seems plausible, possibly even obviously correct, it has not been recognized in the cost growth literature.

The topic is worth pursuing because it bears on why unit cost growth was significantly higher for MDAPs that passed MS B in bust periods than it was for those that passed in boom periods. This observation was reported by the first paper in this series, McNicol and Wu (2014; hereafter referred to as P-5126). The explanation offered there was a version of the “camel’s nose” hypothesis—that unrealistic cost, programmatic, and technological assumptions are made in the hope that, by making the program appear to be lower in cost or more capable, they will increase the odds that the program will be successful in competing for funds. P-5126 goes further by suggesting that the incentives for adopting very optimistic assumptions are stronger for programs that pass MS B in bust funding climates than they are for programs that pass in boom periods, and that, consequently, unrealistic MS B baselines are more common in programs that passed MS B in bust climates.

For present purposes, the key point to note is that the explanation offered by P-5126 supposes that most of the growth in unit cost shown by programs that pass MS B in a bust funding climate is “baked into” the baselines established at MS B. Other possibilities exist, however, one of which is that a significant part of these programs’ cost growth might be due to increases in program content made during a post-MS B boom climate, when funding is more readily available. To the extent that is the case, we may be mistaking the costs of decisions to improve the capabilities of an existing system for growth in the costs of acquiring the capabilities specified in the MS B baseline.

Framework

The topic of this paper requires distinguishing between bust funding and boom funding climates. The period Fiscal Year (FY) 1965–FY 2009 considered here spans two bust-boom cycles in Department of Defense (DoD) procurement funding: (1) The bust climate for modernization of weapon systems that began in the mid-1960s (as discussed in Appendix A of McNicol, Tate, Burns, & Wu [2016], hereafter referred to as P-5330 [Revised])[1] and lasted until the Carter–Reagan buildup of the early to mid-1980s, and (2) the long post–Cold War bust climate followed by the post-9/11 boom. The rationales for the break points between the funding climates are provided in P-5330 (Revised).

A measure of cost growth also is required. One option is based on Program Acquisition Unit Cost (PAUC). PAUC is the sum of Research, Development, Test, and Evaluation (RDT&E) cost and procurement cost, divided by the number of units acquired. For this paper, 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 last Selected Acquisition Report (SAR) for the program, normalized to the MS B quantity. Both the MS B baseline and the actual value of PAUC are stated in constant dollars. The alternative to PAUC growth is growth in Average Procurement Unit Cost (APUC), which does not include RDT&E cost.[2] The effects of changes in the capabilities procured may be more likely to show up clearly in APUC growth, which is an advantage, but it is a less comprehensive measure of unit cost growth. We compute the results for both cost growth measures, and report the results for APUC only in the one instance in which they differ in an important way from those obtained using PAUC. Note that PAUC growth and APUC growth are adjusted for quantity but not for changes in the capabilities the program is directed to acquire.

In what follows, the term *PAUC growth* means PAUC growth from the MS B baseline, with the final SAR PAUC normalized to the MS B quantity. Similarly, the term *APUC growth* means APUC growth from the MS B baseline, with the final SAR APUC normalized to the MS B quantity. Appendix B of P-5330 (Revised) provides the conventions used in assembling the database, the sources of the data used, and the quantity normalization computations. The unit cost growth estimates were updated to the most recent comprehensive information available, that in the December 2015 SARs. Only completed programs (defined as programs with an end date of FY 2016 or earlier) are used in this analysis because some costs associated with a program may not be fully reflected in its SAR until the program is completed.

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[1] The DoD budget was high during the years of the Vietnam War, but much of the acquisition budget went for munitions and to weapon systems lost in combat. Consequently, funding for major system new starts was relatively constrained.

[2] PAUC and APUC growth measures used for purposes of Nunn-McCurdy Act reporting are not quantity normalized. The median MDAP that passed MS B in the period FY 1988–FY 2007 acquired 100% of MS B baseline quantity, and the average program acquired 111%. Compared to the PAUC growth measures used in Nunn-McCurdy reporting, quantity adjustment decreased measured PAUC growth for about half of the programs in the sample and increased it for the other half.

Average PAUC growth reported in Table 1 for programs that passed MS B in bust climates is significantly higher (43%) than it is for programs that passed MS B in boom periods (15%).[3] This observation serves only to confirm, for the data used in this research, the result mentioned above from P-5126.

Table 1. Average PAUC Growth for Completed MDAPs by MS B Funding Climate

Bust		Boom	
FY 1964–FY 1980	47% (64)	FY 1981–FY 1986	18% (35)
FY 1987–FY 2002	37% (44)	FY 2003–FY 2009	0% (9)
Total	**43% (108)**	**Total**	**15% (44)**

Note. Numbers of MDAPs that passed MS B and were completed by the December 2015 SARs are shown in parentheses.

Finally, it is necessary to recognize changes over time in acquisition policy and process configurations because they are associated with significant difference in average PAUC growth. P-5330 (Revised) distinguished the following six policy and process configurations:

1. McNamara-Clifford (FY 1964–FY 1969)
2. Defense Systems Acquisition Review Council (DSARC, FY 1970–FY 1982)
3. Post-Carlucci DSARC (P-C DSARC, FY 1983–FY 1989)
4. Defense Acquisition Board (DAB, FY 1990–FY 1993)
5. Acquisition Reform (AR, FY 1994–FY 2000)
6. DAB Post AR (DAB Post AR, FY 2001–FY 2009)

Average PAUC growth does not differ significantly among DSARC, P-C DSARC, DAB, and DAB Post AR within a budget climate.[4] Their statistical similarity permits these periods to be combined into a single acquisition policy and process configuration, which will be referred to as DSARC/DAB. The main text is concerned only with the DSARC/DAB. P-5330 (Revised) found that average APUC growth was significantly higher in the McNamara-Clifford and AR configurations, which for that reason are treated separately.[5] Appendix A presents results for the McNamara-Clifford and AR configurations.

[3] $P < 0.001$ for the Mann-Whitney U (M-W U) test ($U = 1261.5$, $n_1 = 108$, $n_2 = 44$)

[4] For bust climates, Analysis of Variance (ANOVA) fails to reject the null hypothesis that APUC growth for completed programs in each of these bins has the same normal distribution ($P = 0.996$). Kolmogorov-Smirnov (K-S), Anderson Darling (A-D), and an F-test of the variances indicate that the assumptions of ANOVA are satisfied. For boom climates, K-S and A-D find that the observations for the boom portion of DSARC and the DAB periods are consistent with a normal distribution, but K-S rejects normality for the boom portion of P-C DSARC. The M-W U test does not detect a significant difference between the means of the (1) DSARC-Boom and P-C DSARC-Boom ($P = 0.968$, $U = 88.5$, $n_1 = 29$, $n_2 = 6$); (2) DSARC-Boom and DAB Post AR-Boom ($P = 0.317$, $U = 36$, $n_1 = 9$, $n_2 = 6$); or (3) the P-C DSARC-Boom and the DAB Post AR-Boom ($P = 0.215$, $U = 94$, $n_1 = 29$, $n_2 = 9$).

[5] Appendix C of P-5330 (Revised) provides a Bayesian analysis using APUC growth data. That result also probably holds for the PAUC data

Appendix A of P-5330 (Revised) provides brief descriptions of the acquisition configurations as defined here. Readers who are not generally familiar with the Office of the Secretary of Defense (OSD)–level acquisition process and various acquisition reform efforts may wish to consult that source or Fox (2011).

Evidence of a Boom Effect

The term *boom effect* is used here to label a feature observed in the unit cost growth data—MDAPs that passed through a boom climate post MS B had a higher average unit cost growth than those that did not.

Many MDAPs that passed MS B in one of the bust climates continued into a boom climate, and some programs that passed MS B during the Carter–Reagan defense buildup continued into the post-9/11 boom. A two-part naming convention is used to label two bins of programs: those that did—and those that did not—pass through a boom climate post MS B. The first part of the label gives the funding climate prevailing when the program passed MS B—bust or boom. The second part—0, 1, or 2—denotes the number of boom climates a program passed through post MS B. For example, programs that were completed entirely within a single bust phase will be referred to as Bust0—Bust because they passed MS B in a bust funding climate and zero because they were completed without entering a boom climate. Programs that passed MS B in a bust period and continued into or through a subsequent boom period are called Bust1.

A detailed evaluation of content changes for programs that did and did not experience a boom funding climate after passing MS B would be the best approach to exploring the importance and character of boom. This type of analysis would require greater resources than were available, however. Instead, this paper uses a statistical approach that relies on data that are comparatively easy to acquire—PAUC growth from the MS B baseline, the year programs passed MS B, and the year the programs were completed. In the language of medical testing, the plan is to compare unit cost growth for a treatment group—programs that experienced a boom climate post MS B—with that of a control group—programs that did not. The question asked in this section is whether the observed boom effects are statistically significant. We look first at the two bust climates and then at the two boom climates.

PAUC growth for Bust0 and Bust1 is presented in Table 2 for each of the two bust periods of DSARC/DAB. In both periods, average PAUC growth for the treatment group (Bust1) is higher than it is for the control group (Bust0)—42% compared to 16% for the first period, and 51% compared to 13% for the second. These differences are statistically significant.[6] For programs that passed MS B in a bust period, subsequent entry into a boom period is then associated with higher PAUC growth.

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[6] K-S and A-D find the PAUC growth data in each of the two bins of the first bust period to be consistent with a normal distribution. An F-test found the two variances to be significantly different. A two-tailed t-test assuming unequal sample variances found the means of Bust1 and Bust0 for the first period to be significantly different (P = 0.011). K-S and A-D also find the PAUC growth data in each of the two bins of the first bust period to be consistent with a normal distribution. Again, an F-test found the two variances to be significantly different. A two-tailed t-test assuming unequal sample variances found the means of Bust1 and Bust0 for the first period to be significantly different (P = 0.004).

Table 2. Average PAUC Growth for Completed MDAPs in DSARC/DAB Bust by the Number of Boom Periods Experienced

Bin	1st Bust Period FY 1970–FY 1980	2nd Bust Period FY 1987–FY 1993
Bust0	16% (6)	13% (8)
Bust1	43% (39)	51% (17)
Bust2	19% (3)	none

Bust2 does not follow this pattern: Average PAUC growth for Bust2 is slightly higher than that of Bust0 but less than that of Bust1. The number of programs in this bin (N=3), however, is so small that there is no point in speculating about why it does not fit the pattern.[7] While no attempt is made to explain the observation for Bust2, it is included in an analysis discussed below that includes all of the MDAPs that passed MS B during the two DSARC/DAB bust periods.

APUC growth also does not entirely follow the pattern of PAUC growth for Bust0 and Bust1 of the two DSARC/DAB bust periods. In particular, APUC growth for programs initiated in the first DSARC/DAB bust period does not show a statistically significant boom effect in APUC growth. (The six programs of Bust0 have an average APUC growth of 21%, which is not significantly different from the 42% average APUC growth for the 39 programs of Bust1.[8]) APUC growth in the second bust period does follow the pattern—43% for Bust1, which is significantly higher than the 17% average APUC growth for Bust0.[9]

Table 3 presents data on PAUC growth for the two DSARC/DAB boom periods. The nomenclature used for the boom periods parallels that used for bust periods. Boom0 programs passed MS B in a boom climate and were completed in that boom or the succeeding bust climate. Boom1 programs passed MS B during the Carter–Reagan defense buildup and were completed during the post-9/11 boom or during the following three years. There is no treatment group (i.e., Boom1) for the second boom period and hence no experiment to examine.

Table 3. Average PAUC Growth for Completed MDAPs in DSARC/DAB-Boom by the Number of Boom Periods Experienced

Bin	1st Boom Period MS B FY 1981–FY 1986	2nd Boom Period MS B FY 2003–FY 2009
Boom0	12% (28)	0% (9)
Boom1	45% (7)	none

[7] The programs in Bust2 are the CNV 68, with a PAUC growth of 7%; the NAVSTAR GPS (85%); and ATCCS-MCS (-34%).
[8] K-S and A-D find the APUC growth data in each of the two bins of the first bust period to be consistent with a normal distribution. An F-test found no significant difference between the two variances. A two-tailed t-test of the APUC data found the means of Bust1 and Bust0 for the first period not to be significantly different (P = 0.241).
[9] M-W U P = 0.041 (U = 32.5, n_1 = 17, n_2 = 8).

Average PAUC growth for the Boom1 programs of the first boom period (45%) is significantly higher than that for the Boom0 programs (12%).[10] This finding is somewhat unexpected, since the relevant programs passed MS B in a boom funding climate and presumably had realistic baselines and were robustly funded at least initially. In fact, the finding may be spurious. Average PAUC growth for the Boom1 bin of the first boom period is dominated by three MDAPs, each of which had PAUC growth of more than 40%: C-17 (57%), T-45 Goshawk (70%), and JSTARS (123%). These programs had the essential features of Total Package Procurement (TPP; McNicol, 2004). Acquisition reforms adopted in mid-1969 ruled out use of TPP and fixed-price development contracts because they typically resulted in severe cost growth and schedule problems (McNicol, 2004; McNicol et al., 2016; Tyson et al., 1992; O'Neil & Porter, 2011). During the Reagan Administration, however, TPP-like contracts were used for a few MDAPs, including the three programs noted here. (The other four of the seven programs in Boom1 had conventional cost plus incentive fee contracts for Engineering and Manufacturing Development [EMD].) The PAUC growth of the C-17, T-45, and JSTARS programs was on a par with that of TPP programs that passed MS B during FY 1965–FY 1969 and did not continue into the Carter–Reagan boom. Their contracting strategy, not their continuation into a boom funding climate, could then account for their high PAUC growth. If the three programs are excluded, the average PAUC growth for Boom1 is 17%, which is not significantly higher than the average for Boom0.[11]

Table 4 combines data from Table 2 and Table 3. The 73 MDAPs of the DSARC/DAB bust climates had an average PAUC growth of 38%, which was significantly higher than the 9% average of the 41 MDAPs in DSARC/DAB that passed during boom climates.[12] Average PAUC growth of MDAPs in Bust0 is not significantly different from the average PAUC growth of DSARC/DAB boom, and therefore has little effect on this result.[13] Instead, the higher average of DSARC/DAB bust is mainly due to the programs in Bust1. This adds an important point to the narrative of P-5126: The higher PAUC growth of MDAPs that passed MS B in bust climates largely reflects a subset associated with those programs—those that passed MS B in a bust climate and continued on into a boom climate.

Table 4. PAUC Growth for the Combined Bust and the Combined Boom Phases of DSARC/DAB

Bust0	14% (14)	Boom0	9% (37)
Bust1	45% (56)	Boom1	17% (4)*
Combined Bust**	**38% (73)**	**Combined Boom**	**9% (41)**

* Excludes C-17, T-45, and JSTARS.

** Includes the three programs in Bust2, which have an average PAUC growth of 19%.

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

[11] M-W U $P = 0.117$ ($UA = 83.5$, $UB = 28.5$, $n_1 = 28$, $n_2 = 4$).

[12] M-W U $P < 0.001$ ($U = 633$, $n_1 = 73$, $n_2 = 4$).

[13] M-W U $P = 0.121$ ($U = 367.5$, $n_1 = 41$, $n_2 = 14$).

Funding Climate, Program Duration, and the Boom Effect

This section takes an additional step towards explaining why the data show boom effects. Table 5 presents rearranged data from Table 2 and Table 3 and, in addition, shows average program duration for each bin. Average PAUC growth is greater in Bust1 than in Bust0 for each of the two bust periods and greater for Boom1 than for Boom0 for the first boom period. (The second boom period is excluded because there are no programs in Boom1.) The programs in Bust1 and Boom1, however, also had a longer average duration than the programs in the corresponding Bust0 and Boom0 bins. Consequently, we need to examine the extent to which longer average duration in addition to an encounter with a boom period account for their higher PAUC growth. Note that including the three programs of Bust2 (of the first bust period) and the three programs excluded from Boom1 would not change this conclusion.

Table 5. Average PAUC Growth and Average Program Duration by Number of Boom Periods Encountered for Completed Programs in DSARC/DAB

Bin		Average PAUC Growth	Average Duration †
1st Bust Period ‡	Bust0	16% (6)	6.7
	Bust1	42% (39)	14.2
2nd Bust Period	Bust0	13% (8)	7.5
	Bust1	53% (17)	15.8
1st Boom Period	Boom0	12% (28)	9.2
	Boom1§	17% (4)	22.3

† From MS B through the year in which the program's last SAR was filed.
‡ Excludes the three programs of Bust2.
§ Excludes C-17, T-45, and JSTARS.

We approach this problem by dividing the duration of the program into two parts:

1. T_{boom} = number of years post MS B spent in boom climates
2. T_{bust} = number of years post MS B spent in bust climates

These two variables are hypothesized to have distinct linear relationships to PAUC growth (abbreviated as PAUC):

$$PAUC_i = a_0 + a_1 T_{boomi} + a_2 T_{busti} + e_i$$

In this equation, the subscript i denotes the ith MDAP in the sample and e_i is the error term, which is assumed to be a normally distributed random variable. The coefficient a_1 is the change in PAUC for each year the program spends in a boom climate. Similarly, a_2 is the change in PAUC per year in a bust climate. The estimated intercept term a_0 is the average net effect of excluded variables. The coefficients of the model are estimated (using multiple regression) separately for programs that passed MS B in bust periods of DSARC/DAB and those that passed MS B in its first boom climate. (The second boom climate is excluded because it has no programs.) The estimates obtained are presented in Table 6.[14]

Table 6. Years in Bust Climates and Years in Boom Climates and PAUC Growth for MDAPs in the DSARC/DAB Acquisition Policy and Process Configuration

	Passed MS B in Bust Period†		Passed MS B in Boom Period‡	
	Estimate	P-Value	Estimate	P-Value
Intercept	3.4%	0.719	3.7%	0.608
Years in Boom	5.0%/yr***	< 0.001	3.7%/yr**	0.039
Years in Bust	1.6%/yr**	0.042	0.05%/yr	0.937

** Statistically significant at less than the 5% level.
*** Statistically significant at less than the 1% level.
† R-Square = 0.22 F = 9.445 (P < 0.001) N= 70. Estimated by Ordinary Least Squares (OLS). Excludes the three MDAPs in the Bust2 bin of DSARC/DAB.
‡ R-Square = 0.20 F = 5.563 (P = 0.002) N= 32. Estimated by OLS. Excludes C-17, T-45, and JSTARS.

Programs that passed MS B in a bust climate characteristically experienced PAUC growth of 1.6% for each year spent in a bust climate. PAUC growth for each year spent in a boom climate post MS B was three times that level—about 5% per year. Each of these estimates is statistically significant.

The effect of boom years for programs that passed MS B in boom periods is smaller (about 3.7% per year). This is reasonable, as we expect programs that passed MS B in boom climates to have realistic baselines and to be adequately funded (at least initially). The estimated effect per bust year on PAUC growth for programs that passed MS B in boom periods is very small and statistically not significant, which also seems reasonable.

A sense of the importance of the boom periods entered into post MS B is provided by Table 7. The table shows the estimated relationship evaluated at the sample means for T_{Boom} and T_{Bust} for Bust0 and Bust1, respectively. Programs in Bust0 have an average PAUC growth of about 14%. Of this, about 11.4 percentage points are associated with years spent in bust climates, and, of course, none for continuation into a boom climate. For Bust1 programs, boom years post MS B account for about 26 percentage points of the Bust1 average PAUC growth of 45%; the years spent in bust climates account for 15.2 percentage points.

[14] An alternative to the model above posits two categories of MDAPs, one that tends to short duration and low unit cost growth and another that tends to long duration and higher unit cost growth. Modifications and upgrades would seem to be examples of the first category and major platforms an example of the second. The “short duration” and “long duration” programs were defined, respectively, as the 20% of programs in the bin with the shortest durations, and the 20% with the longest durations. The results for all of the forms of this model considered rejected the hypothesis that shorter vice longer duration is a statistically significant factor in PAUC growth.

Table 7. Amount of PAUC Growth in Boom Climates and Bust Climates for MDAPs in DSARC/DAB That Passed MS B in Bust Climates

Period	Intercept	T_{Boom}	T_{Bust}	Average PAUC Growth
Bust0	3.4%	0	11.4%	14.3% (14)
Bust1	3.4%	26%	15.2%	45% (56)

Note. Evaluated at the sample means for T_{Boom} and T_{Bust}

Conclusions and Limitations

This paper, like earlier papers in the series, finds that PAUC growth measured from MS B is significantly higher in programs that passed MS B in bust climates than in boom climates. Moreover, among MDAPs that passed MS B in a bust phase of DSARC/DAB, only those that continued into a boom climate showed PAUC growth significantly higher than that of programs that passed MS B in a boom climate. This conclusion is important because it implies that much of the observed PAUC growth may have causes other than flaws in MS B baselines. The conclusion tells us less than might be hoped, however. This is so because the PAUC growth associated with the boom may reflect the purchase of capability beyond that specified in the MS B baseline or, alternatively, PAUC increases that occur when programs take advantage of a boom climate to "get well."

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

> The current GBS architecture is based on Asynchronous Transfer Mode (ATM) technology. … In December 2002, DoD directed GBS's migration to a more sustainable commercial and standards-based open architecture, based upon the Internet Protocol (IP). Also, the GBS program received FY03 Iraqi Freedom Funds (IFF) supplemental funding for IP Acceleration of production units to replace deployed ATM units. Based upon extensive warfighter inputs, the accelerated IP production effort included design and development of a new, single case version of the Receive Suite (88XR) for the Army, Navy, and Marine Corps. (*Selected Acquisition Report*, 2003)

Space Based Infrared Satellite-High (SBIRS-High) is a convenient and useful contrast to GBS, even though it passed MS B in 1997 and hence is not included in DSARC/DAB. As of the December 2015 SARs, funding for the Baseline SBIRS-High program was expected to end in FY 2018. A large portion of the growth in SBIRS-High unit procurement cost for the baseline program—roughly one-third—occurred before FY 2003, while most of the other two-thirds occurred during FY 2003–FY 2009. This increase was not driven by increased capability, however, but by the unrealistic cost estimate in the MS B SBIRS-High baseline (Kim et al., 2015; Porter et al., 2009; Younossi et al., 2008).

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

The average PAUC growth of all DSARC/DAB bust programs is 38%. Without making a specific estimate, P-5126 suggested that most of this PAUC growth stemmed from flawed MS B baselines. In the language of the present paper, if all of the unit cost growth actually is a matter of "getting well," the PAUC growth due to flawed MS B baseline problems remains at 38%. It is less than 38% to the extent that PAUC growth of MDAPs in Bust1, in the years they spent in both bust climates and boom climates, is due to decisions to acquire capabilities beyond those of the MS B baselines. Parts of PAUC growth in years spent in both boom and bust climates post MS B very probably do reflect acquisition of capabilities beyond that of the MS B baseline. Unfortunately, we do not have a way to differentiate between PAUC growth due to acquisition of additional capability and that due to an increase in the actual costs of the MS B capability. Further statistical analysis along the lines of that presented here seems unlikely to be useful in untangling these two elements. Instead, progress on the question of why some programs but not others in Bust1 experienced a boom effect probably will require detailed examination of changes in the relevant programs post MS B.

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Appendix A: Boom Effects for McNamara-Clifford, Acquisition Reform (AR), and the Bust Phase of the DAB Post AR

Table A-1 presents average Program Acquisition Unit Cost (PAUC) growth and average program duration data for the McNamara-Clifford and the Acquisition Reform (AR) periods.

Table A-1. Average PAUC Growth and Program Duration for Completed Programs for McNamara-Clifford and AR

		Average PAUC Growth	Average Duration
McNamara-Clifford	**Bust0**	87% (12)	9.3
	Bust1	34% (4)	20.5
Acquisition Reform	**Bust0**	2% (1)	7
	Bust1	38% (18)	14.6

* Quantity APUC from the MS B baseline
** From MS B through the year in which the program's last SAR was filed

In contrast to what was found for the DSARC/DAB-Bust period, for McNamara-Clifford, average PAUC growth for Bust0 programs is about two and one-half times that of Bust1 programs. The difference is statistically significant.[15] This may be due to the fact that the Bust1 programs continued into at least the early 1980s and therefore presumably were more strongly influenced by the 1969 Packard acquisition reforms, which are associated with a significant reduction in PAUC growth.

The cost growth data for AR are not useful for statistical analysis because only one program that passed MS B during that period (AV-8B Remanufacture) had been completed by the December 2015 SARs.

Appendix B. RDT&E Cost Growth for the DSARC/DAB Period

Table B 1 presents data on Research, Development, Test, and Evaluation (RDT&E) cost growth and duration in the DSARC/DAB period that parallel the PAUC and duration data presented in Table 2, Table 3, and Table 4. The number of observations in some cells differs from that given for PAUC because the database does not have an RDT&E estimate for all programs for which there is a PAUC growth estimate.

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[15] K-S and A-D find the distributions of PAUC growth in Bust0 and Bust 1, respectively, to be consistent with a normal distribution. P = 0.048 for a two-tailed t-test with correction for unequal variances.

Table B-1. Average RDT&E Growth and Average Program Duration by Number of Boom Periods Encountered for Bust and Boom Climates

Bin		Average RDT&E Growth[a]	Average Duration[b]
1st Bust Period	Bust0	5% (5)	6.7
	Bust1	53% (38)	14.1
2nd Bust Period	Bust0	37% (7)	8.0
	Bust1	45% (17)	15.8
1st Boom Period	Boom0	41% (26)	9.6
	Boom1	65% (7)	22.3
2nd Boom Period	Boom0	1% (9)	66.1
	Boom1	n/a (0)	n/a

a Quantity APUC from the MS B baseline
b From MS B through the year in which the program's last SAR was filed

The pattern of growth in RDT&E in the first bust period is consistent with that observed for PAUC growth: (1) Average RDT&E growth for programs in Bust1 is significantly higher than the average for Bust0; and (2) the proportion of programs of Bust1 that fall into the right tail of the distribution also is significantly higher than it is for Bust0.[16]

Average RDT&E growth in the second bust period is noticeably higher in Bust1 than in Bust0, but the difference is not statistically significant. The proportion of programs with RDT&E cost growth of more than 40% also is not significantly higher in Bust1 than in Bust0.[17]

In the first boom period, average RDT&E cost growth is significantly higher for MDAPs in Boom1 than for those in Boom0, and the proportion of MDAPs with RDT&E growth of at least 40% also is significantly higher in Boom1 than in Boom0.[18]

[16] M-W U P = 0.025 (U = 35.5, n_1 = 38, n_2 = 5). P = 0.051 for Fisher's Exact Test (FET) using the number of programs in Bust0 and Bust1 with an RDT&E growth of at least 40%.
[17] M-W U P = 0.308 (U = 43, n_1 = 17, n_2 = 7). P = 1.000 for FET using the number of programs in Bust0 and Bust1 with an RDT&E growth of at least 40%.
[18] M-W U P = 0.075 (U = 132, n_1 = 26, n_2 = 7). P = 0.027 for FET using the number of programs in Bust0 and Bust1 with an RDT&E growth of at least 40%.

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