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Understanding Acquisition Speed for the Defense Department's Costliest and Most Complex Programs

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Abstract

Acquisition reform occurs in cycles and the most recent cycle prioritized acquisition speed. Despite this recent focus, the acquisition research community lacks a comprehensive understanding of how quickly the Defense Department has historically fielded major defense acquisition programs (MDAPs), what factors drive that speed, and how future schedule estimates can be improved. To address these gaps, this project leveraged a database which contained over 200 MDAPs that were initiated between 1963 and the present. Using this data, the report describes how various programmatic, technical, and strategic factors affect acquisition speed. Based on these observations, the report also suggests how MDAP schedule estimates can be improved in the future.

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Executive Summary

To assess defense acquisition speed, this report focuses on the Defense Department's most costly and complex programs: major defense acquisition programs (MDAPs). The report also uses two metrics for acquisition speed: cycle time and percent cycle time growth. Cycle time measures the duration between program initiation and initial operational capability. Percent cycle time growth compares an MDAP's actual cycle time to the cycle time that was estimated at program initiation. Using these metrics and over 200 MDAP programs and subprograms, the analysis motivated the following conclusions.

- Acquisition speed is no slower today than it was in the past, although there are valid reasons to perceive otherwise.

- The Department of Defense (DOD) has historically fielded new MDAPs at average speeds that are comparable to external benchmarks. DOD has not, however, fielded worst-case MDAPs at speeds comparable to external benchmarks.

- Within DOD's acquisition system, speed is consistent across the military services. Speed varies, however, according to certain technical and programmatic characteristics.

- Defense reformers should avoid using the experience of worst-case programs to motivate future reforms of the *entire* acquisition system.

- Changing DOD's topline budget is not an effective mechanism for affecting MDAP acquisition speed.

- Defense reformers should set goals for acquisition speed that are independent of broad swings in the overall defense budget.

- Even though oversight activities led by the Office of the Secretary of Defense (OSD) take time to complete, they do not appreciably slow down MDAP acquisition speed.

- MDAPs initiated during periods of strong, centralized OSD oversight experienced shorter cycle times and lower rates of percent cycle time growth.

- Defense reformers should centralize and strengthen OSD oversight as a means to increase acquisition speed.

- Strong, centralized OSD oversight can serve as a "check" against the military services' tendency to "sell" their programs using optimistic schedule estimates.

- When MDAPs are initiated with realistic schedule estimates, they experience less cycle time growth.

- MDAP acquisition may have a speed limit. To field systems faster, DOD may need to change its requirements or develop simpler systems than it has in the past.

- All things—including programmatic and broad, strategic factors—considered, DOD can improve future schedule estimates by basing them on historic schedule outcomes and by employing strong, centralized OSD oversight at program initiation.

1 Introduction

In defense acquisition, reform is constant. Over the past six decades, reforms have been initiated, implemented, and evaluated, only to be initiated all over again. This pattern—and its repetition throughout history—has led some to describe acquisition reform as a "never-ending cycle" whereby discrete periods of time are characterized by different initiatives.[1] Although these initiatives consistently seek to reduce cost, shorten schedule, and increase performance, reformers' priorities have varied throughout history.

Today, the acquisition community is focused on increasing speed. The *National Defense Strategy,* for example, states that the Department of Defense (DOD) must "deliver performance at the speed of relevance" by prioritizing rapid capability fielding, adopting streamlined management approaches, and realigning incentive and organizational structures.[2] This strategy, in turn, responds to multiple Congressional directives that also aimed to increase acquisition speed (e.g., see the National Defense Authorization Act (NDAA) 2016 Secs. 804, 810, 821, 823, 825 and NDAA 2017 Secs. 805, 806, 807, 901). Congressional reformers' focus on speed appears motivated by a belief that U.S. technological advantage vis-à-vis its adversaries is eroding and that the timelines to field new capabilities are dramatically different between DOD and the private sector.[3]

Policymakers' recent focus on speed raises important questions for the acquisition research community.

1) At what speed has DOD historically fielded new systems and how does that speed compare to the National Defense Strategy's proposed "speed of relevance"?[4]

2) What programmatic factors—such as technical complexity or organizational approach—are associated with acquisition speed?

3) How do broad, strategic factors that impact the entire department—such as acquisition reforms and budget climate—affect acquisition speed?

4) How can DOD improve the accuracy with which it predicts acquisition speed in the future?

Using quantitative data on major defense acquisition program (MDAP) schedules, this report addresses the questions above and generates recommendations for present and future reform efforts that focus on acquisition speed.

2 A History of Reform

Defense acquisition—broadly defined—consists of three intersecting processes: the Joint Capabilities Integration and Development System (JCIDs) process, the Planning, Programming, Budgeting, and Execution (PPBE) process, and the Department of Defense (DOD) Directive 5000.1 acquisition process. The JCIDs process articulates and validates joint warfighting requirements. When requirements can be satisfied via materiel (i.e., capabilities that can be created or bought), DOD manages capability development and procurement using the acquisition process. DOD determines what capabilities to procure, requests funding to support those capabilities, and executes capability acquisition via the PPBE process.

Acquisition reform, historically, has attempted to reduce the cost, improve the performance, and shorten the schedule of all three processes.[5] In terms of cost, past reforms sought to reduce cost growth, to eliminate "waste, fraud, and abuse," and to increase competition between prospective contractors. In terms of performance, past reforms sought to strengthen and empower the industrial base and to leverage commercial and small business innovation. Finally, in terms of schedule, past reforms sought to reduce the time required to award contracts, to upgrade existing systems, and to field new systems.

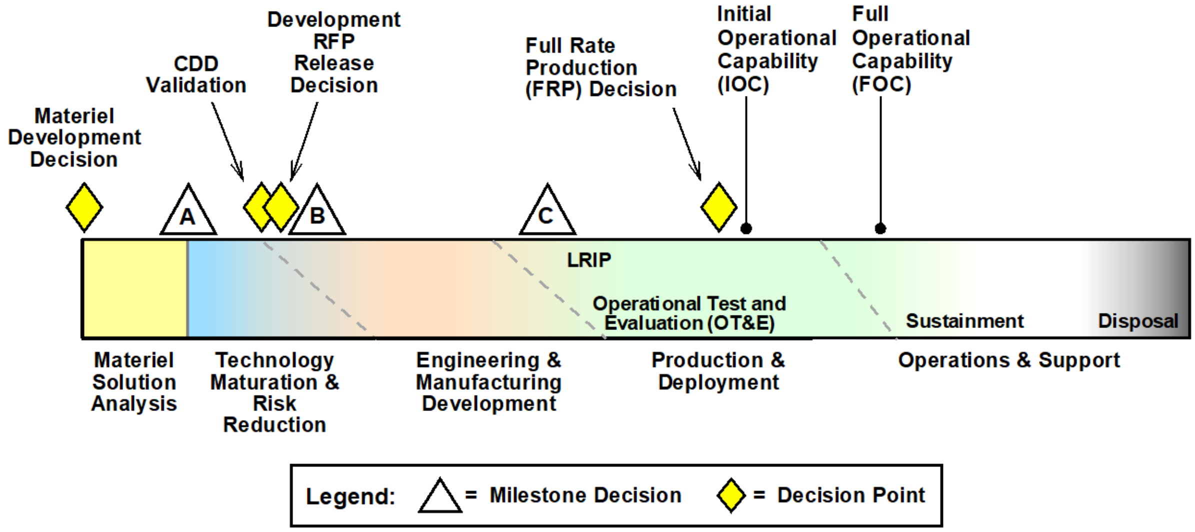
Research shows that, despite a robust history of reform, individual reforms' impact has varied. For example, Gansler, Lucyshyn, and Spiers observed that the Nunn-McCurdy amendment—which Congress passed to curb cost growth—did not significantly affect program outcomes.[6] Christensen, Searle, and Vickery concluded that Packard Commission reforms—also intended to reduce cost growth—instead had the opposite effect and appeared to increase cost growth.[7] DOD's internal analysis, on the other hand, observed a statistically significant reduction in Nunn-McCurdy breaches and in MDAP cost growth since 2009.[8]

Separate from this historic focus on cost, many of today's reformers aim to speed up the acquisition process that is defined by DOD Directive 5000.1. The traditional process, depicted in Figure 1, consists of several milestones. At each milestone, DOD officials review programs' progress and determine whether they should continue to the next phase.

DOD typically initiates MDAPs at milestone B, after which full-scale system engineering begins. DOD reviews system designs at milestone C, after which it begins producing systems at an initial, low rate. Next, DOD tests new systems. Once test results are satisfactory and a system can be used operationally, DOD certifies that the system has reached initial operational capability (IOC).

Occasionally, DOD instead initiates programs at milestone C. Programs initiated at this milestone are frequently incremental upgrades to existing systems (e.g., block upgrades) or variants on an initial system (e.g., for different military services).

Figure 1: DOD's Acquisition Process



Source: Department of Defense, *Operation of the Defense Acquisition System* (Washington, DC: Department of Defense, January 2015), Instruction Number 5000.02T*,* 12, https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/500002T.PDF?ver=2020-01-23-144112-220.

Today's defense reformers aim to speed up acquisition by shortening the time programs spend between initiation and IOC. To achieve this aim, Congressional reformers created alternatives to the linear acquisition process depicted in Figure 1.[9] Congress also changed which organizations have the authority to review MDAPs at each milestone.[10]

In implementing these reforms, DOD's stated objective was to deliver capabilities at the "speed of relevance."[11] Although DOD did not quantify the speed of relevance, the acquisition system's past performance may provide a useful benchmark. To assess past acquisition speed, researchers have used two metrics: **cycle time** and **percent cycle time growth**.

Cycle time is the time elapsed between program initiation (typically milestone B, but sometimes milestone C) and IOC.[12] Cycle time growth is the percent change in a program's estimated and actual cycle times. Cycle time, therefore, represents the speed with which DOD fields new capabilities. Cycle time growth represents the accuracy with which DOD is able to predict that speed.

Past studies—which calculated cycle times for MDAPs initiated between 1997 and 2015—found that DOD fielded MDAPs in approximately seven years. [13] These studies also found that percent cycle time growth ranged from zero to over one hundred percent.[14] Importantly, researchers have not observed acquisition speed to be worsening over time;[15] however, Tate found that several recent—and expensive—programs had longer than average cycle times and suggested that these programs may be driving a *perception* that acquisition is too slow.[16]

Perhaps it was this *perception* that motivated defense reformers' recent focus on speed. These recent reforms, of course, continue what has been described as a "never-ending" cycle of acquisition reform.[17] Indeed, numerous scholars, have identified reform cycles and characterized their impact.[18]

For instance, Levine concluded that reform cycles are most effective when they address the underlying incentives in acquisition and work to counter the military services' tendency to "sell" their programs.[19] Hunter observed that the acquisition system responds slowly to reforms and therefore, often fails to achieve reformers' desired ends before their priorities shift.[20]

Researchers at the Institute for Defense Analyses (IDA) and RAND, however, were unable to associate changes in MDAP costs or schedules with reform cycles.[21] Importantly, these researchers did not consider how common mechanisms—such as centralizing or decentralizing oversight—might have affected MDAPs across multiple cycles. Relatedly, McNicol and Wu did discover an association between budget cycles—or broad shifts in DOD's overall budget—and MDAP cost growth. [22] It remains an open question, however, how broad increases or decreases in DOD's budget might affect MDAP cycle times.

Finally, more work is required to help DOD improve the accuracy of its schedule estimates. For example, Van Atta noted that although DOD's initial schedule estimates are "analytically weak," they often form the basis of program plans and contracts.[23] This practice, of course, increases the risk that program schedules will grow over time.

Despite DOD's apparent lack of schedule discipline, numerous studies have explored drivers of schedule growth.[24] For instance, technical complexity—as represented by system type and technical maturity—appears to be associated with schedule growth. Programs initiated with low technical maturity—as measured by technology readiness level (TRL)—appear to exhibit higher schedule growth rates.[25] High technical complexity has also been associated with longer schedule durations,[26] and with system failure, if programs attempted to field highly complex systems on short timelines.[27] Finally, the relationship between cost and schedule growth remains ambiguous in the literature, with some authors suggesting that these outcomes are correlated and others suggesting that their relationship is more complicated.[28]

Tate also demonstrated that "schedule optimism" was associated with percent cycle time growth on MDAPs initiated after 1997. [29] Schedule optimism refers to the difference between a program's estimated schedule and the average cycle time for past systems of the same type.[30] In this way, Tate’s proposed schedule optimism metric captures MDAPs’ inherent technical complexity, as well as the benefit of using past outcomes to predict future performance.

The analysis below attempts to do just that: to use past schedule outcomes to inform future acquisition reform initiatives and management best practices. Specifically, by analyzing the schedule outcomes from past MDAPs, this report seeks to understand:

- DOD’s historic acquisition speed and how that speed compares to external benchmarks;
- What factors—such as technical complexity or schedule optimism—are associated with acquisition speed;
- How broad, strategic factors—such as reform and budget cycles—affect acquisition speed; and
- How DOD can improve the accuracy of its schedule predictions in the future.

3 Data and Methods

To assess acquisition speed, two variables were used: **cycle time** and **cycle time growth**. As above, cycle time is defined as the elapsed time between a program's first milestone (milestone B or C) and IOC. **Cycle time growth** is determined by calculating the percent change between a program's estimated cycle time and its actual cycle time.[31]

To determine MDAP cycle times and percent cycle time growth, data was collected from two sources: the Defense Acquisition Management Information Retrieval (DAMIR) System and RAND's Defense Systems Cost Performance Database (DSCPD).[32] DAMIR aggregates data from the Selected Acquisition Reports (SARs) that DOD has submitted since 1997. RAND's database contains SAR data from 1960 to 1994. To combine RAND's data with DAMIR, duplicate information was eliminated by deferring to the more recent DAMIR data. DAMIR data, in turn, was largely pulled from a fiscal year (FY) 2019 summary of program schedules. When milestones or other program data were not available in the FY 2019 summary, raw DAMIR data from FY 2018 was collected.

In constructing this dataset, multiple assumptions were required. Each assumption is described in detail in the appendix; however, a few points are worth noting up-front. First, in several instances, SARs contained dates that were not explicitly identified as milestones B, C, or IOC. Table 1 summarizes the assumptions that were used to select alternative dates that approximated those milestones.

Table 1: Data Collection Assumptions

Milestone	Assumptions
Milestone B	▪ Milestone II ▪ Preliminary Design Review ▪ Critical Design Review ▪ Engineering Manufacturing Design
Milestone C	▪ Milestone III ▪ Low rate initial production (LRIP) ▪ Production start date
Initial Operating Capability	▪ Initial operational delivery or initial operational test and evaluation (IOT&E) complete, whichever came later (RAND database only) ▪ IOT&E complete date ▪ First unit equipped (FUE) ▪ Required assets available (RAA) ▪ 1st satellite launched

Second, where possible, MDAPs were broken into subprograms that contained additional increments or variants. Doing so captured the benefit of fielding systems incrementally, since follow-on systems tend to have shorter cycle times. Note that for the remainder of this report, the term “MDAPs” is used to refer to both the programs and the subprograms which were developed and fielded within the MDAP program management structure.

Third, all analysis in this report uses complete programs or active programs that are five years past initiation. This assumption is consistent with prior analysis of MDAP cost growth and helps to avoid maturity bias.[33] Finally, the report’s conclusions are also limited by the quality of the data that was available. By applying numerous assumptions, the report opted to use as much MDAP schedule data as was available. Data was only excluded when there was reason to believe that it might be suspect. These reasons are described in more detail in the appendix.

Using these assumptions, it was possible to construct a database containing over 200 MDAPs that DOD initiated between 1962 and the present. In addition to the limitations described above, however, all subsequent analysis using this data should be prefaced with several important caveats. First, because MDAP data was readily available, this analysis focused on MDAPs only. MDAPs represent only a fraction of DOD’s programs; and of those programs, MDAPs are the costliest and most complex. As such, MDAPs are subject to more stringent oversight requirements than other programs.

For these reasons, the drivers of MDAP schedules (i.e., the bottlenecks and items on the critical path) may be different than those for non-MDAP programs. This report’s conclusions are, therefore, limited to MDAPs only. If non-MDAP data becomes publicly available in the future, researchers may wish to perform similar analyses on smaller programs.

It is also important to note that the cycle time metrics employed in this analysis provide only one perspective on acquisition speed. Both metrics focus on the time to field new capabilities—a duration that is affected by the time it takes to design new systems, execute low-rate initial production, and successfully complete development and operational testing. These metrics, however, do not capture how rapidly programs produce s systems during the later phases of the system lifecycle. Future research, therefore, may wish to develop additional metrics for acquisition speed that specifically focus on full-rate production.[34]

Finally, by focusing on only a handful of variables, this research necessarily limited the perspective with which it explored MDAP acquisition speed. Of course, MDAP acquisition is complex and countless factors—including workforce, industrial base health, and regulations—can affect acquisition speed in non-simple and non-obvious ways. This analysis, therefore, contributes but one perspective on acquisition speed within an extensive history of acquisition reform and research.

4 Acquisition Speed

Despite decades of reform, DOD has fielded MDAPs at remarkedly consistent speeds. Figure 2 and Figure 3 illustrate these speeds for all active and complete MDAPs in the database. For complete MDAPs (i.e., MDAPs which have already reached IOC), a significant association between program initiation date and cycle time was not observed.[a] The same was true for percent cycle time growth.[b]

For active programs (i.e., MDAPs which have not yet reached IOC), an association between cycle time and program initiation date was observed.[c] A similar association was also observed between percent cycle time growth and program initiation date.[d] These results, however, should not be attributed to distinctions between active and complete MDAPs. Rather, it is likely that active programs may have optimistically estimated their cycle times and may be too immature to have experienced much cycle time growth.

To avoid such maturity bias in subsequent analysis, active MDAPs are only included if they were initiated prior to FY 2015.[35] Within this set of MDAPs, DOD fielded new capabilities in an average of 6.9 years and with 31.3 percent cycle time growth. DOD's median values for acquisition speed were 6.6 years and 15.4 percent cycle time growth, respectively.

Table 2 and Table 3 break down this MDAP data further and highlight some important differences between key slices of the data. First, even after excluding more recent active programs, there is still a notable difference between active and complete acquisition speeds. As shown, active programs—again, only those initiated before FY 2015—have *predicted* median cycle times that are longer than complete programs' *actual* cycle times. Furthermore, the difference in distributions was statistically significant.[e]

Active programs also have a larger median percent cycle time growth when compared to complete programs; however, the difference in distributions here was not statistically significant.[f] These results lend support to reformers' *perception* that acquisition is slower today than it was in the past.[36] Importantly, the time trend analysis discussed above—which included a larger swath of DOD's programmatic history—does not support this assertion more broadly.

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[a] We ran a simple linear regression of cycle time on complete program start date but did not find a statistically significant association ($p=0.86$, adjusted $R^2<0.01$).

[b] We also ran a simple linear regression of percent cycle time growth on program start date and again, did not find a statistically significant association ($p=0.54$, adjusted $R^2<0.01$).

[c] We ran a simple linear regression of cycle time on active program start date and found a statistically significant association at the one percent level ($p<0.01$, adjusted $R^2=0.52$). In assessing this fit, we observed residuals to be non-normal and heteroscedastic. To compensate for heteroscedasticity, we applied robust error measures.

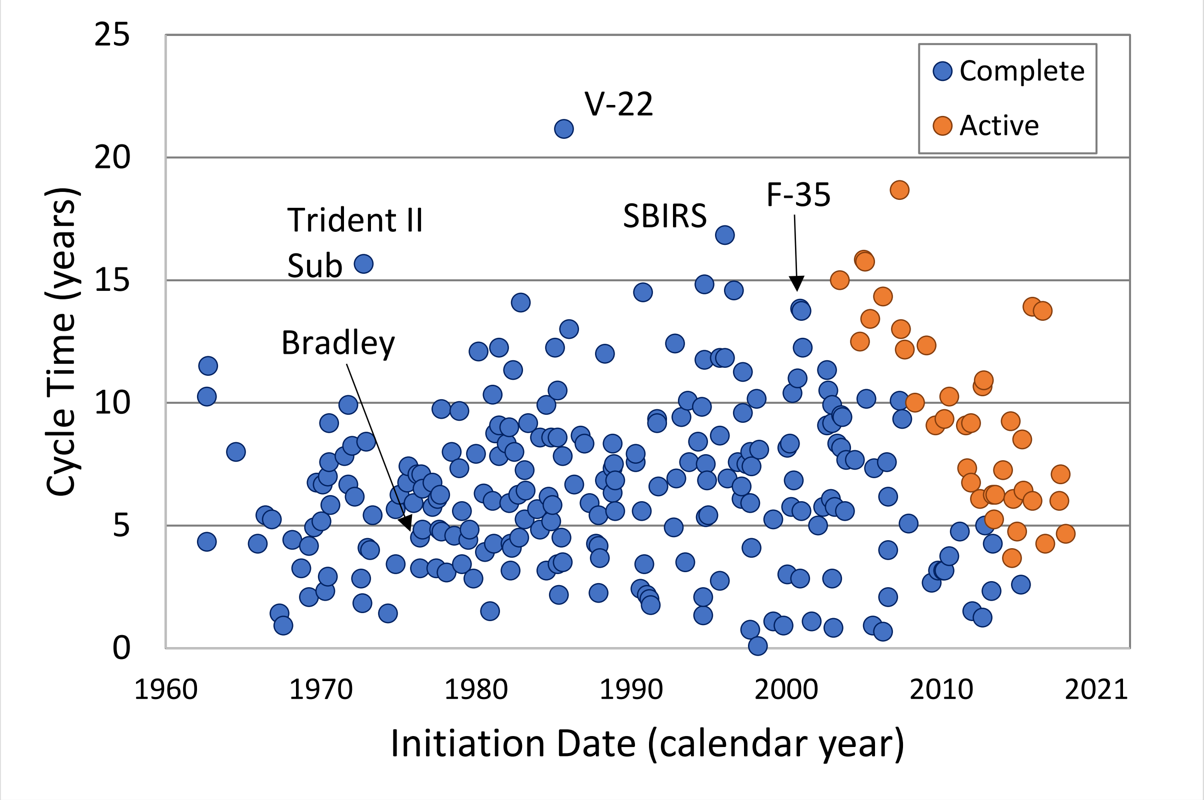
[d] We also ran a simple linear regression of percent cycle time growth on active program start date and again found a statistically significant association at the one percent level ($p<0.01$, adjusted $R^2=0.19$). In assessing this fit, we observed residuals to be non-normal and heteroscedastic. To compensate for heteroscedasticity, we applied robust error measures.

[e] Upon visualizing our data, we concluded that it was not consistent with a normal distribution. This observation was confirmed by running the Shapiro-Wilk (S-W) test and the Anderson-Darling (A-D) test. Using a Mann-Whitney U (M-W U) test, we observed a statistically significant difference in distributions between both populations ($p<0.01$).

[f] Upon visualizing our data, we concluded that it was not consistent with a normal distribution. This observation was confirmed by running the S-W and A-D tests. Using a M-W U test, we did not observe a statistically significant difference in distributions between both populations ($p=0.13$).

Rather, it seems possible that DOD may have more worst-case programs that are active today than it did in the past.

Figure 2: Cycle Times (Active and Complete MDAPs, FY 1963 – present)



Source: DAMIR; RAND DSCPD; and CSIS analysis.

Both tables also show acquisition speed to be consistent across the three military services. This conclusion was confirmed by statistical tests, which did not find the cycle times nor percent cycle time growth distributions to be significantly different across the three military services. [g]

Focusing instead on two proxies for technical complexity—platform type and technical maturity—important differences are visible. In particular, there is a statistically significant difference in satellite cycle time distributions as compared to all other platforms.[h] Compared to

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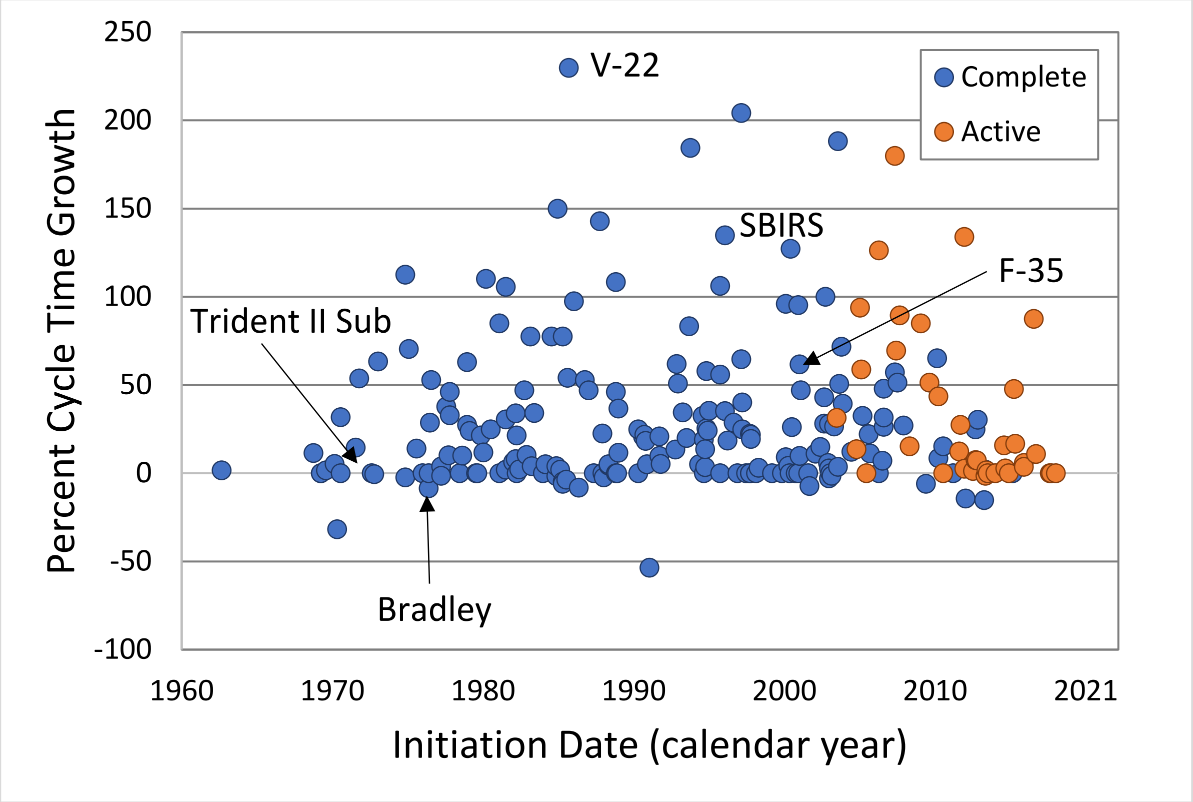
[g] Upon visualizing our data and running the S-W and A-D tests, we concluded that it was not consistent with a normal distribution. To compare cycle times between the military services, we ran separate tests comparing each service to the combination of the other two. In each instance, using a M-W U test, the difference in cycle time distributions was not statistically significant (p=0.08, p=0.10, p=0.95 for the Army, Navy, and Air Force, respectively). We used the same procedure to compare percent cycle time growth. In each instance, using a M-W U test, the difference in percent cycle time growth distributions was not statistically significant (p=0.67, p=0.48, p=0.74 for the Army, Navy, and Air Force, respectively).

[h] Upon visualizing our data and running the S-W and A-D tests, we concluded that it was not consistent with a normal distribution. Using a M-W U test to compare satellite cycle times to the cycle times of all other systems, we observed a statistically significant difference in distributions (p=0.04).

other platform types, satellites also have the largest percent cycle time growth; however, the difference in distributions was not significant to the same level.[i]

Satellites' slow acquisition speed can be attributed—at least in part—to their unique operating environment which largely prohibits incremental upgrades after launch. For this reason, DOD must take extra time and care to get individual satellite designs "right" before they are launched. With other platform types, DOD may be able to reach IOC faster by planning to incrementally upgrade a system's capabilities throughout its lifecycle and after it reaches IOC.

Figure 3: Percent Cycle Time Growth
(Active and Complete MDAPs, FY 1963 – present)



Source: DAMIR; RAND DSCPD; and CSIS analysis.

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[i] Upon visualizing our data and running the S-W and A-D test, we concluded that it was not consistent with a normal distribution. Using a M-W U test to compare percent cycle time growth, we did not observe a statistically significant difference in distributions, at least at the five percent level that we have used throughout this report (p=0.07).

Table 2: Summary of Cycle Time Data (Complete MDAPs and Active MDAPs, FY 1963 – FY 2015)

Category		Mean	Median	Max.	Min.	N
Program Status	Active	10.8 yrs	10.5 yrs	18.7 yrs	5.3 yrs	24
	Complete	6.5 yrs	6.2 yrs	21.2 yrs	0.1 yrs	236
Military Service	Air Force	6.8 yrs	6.5 yrs	16.8 yrs	0.1 yrs	83
	Army	6.3 yrs	6.2 yrs	18.7 yrs	0.7 yrs	72
	Navy	7.4 yrs	6.8 yrs	21.2 yrs	0.8 yrs	105
Platform Type	Aircraft	6.6 yrs	6.4 yrs	14.5 yrs	0.9 yrs	56
	C4I	6.6 yrs	6.6 yrs	18.7 yrs	0.1 yrs	51
	Helicopter	8.0 yrs	6.5 yrs	21.2 yrs	0.9 yrs	20
	Missile / Munitions	6.8 yrs	6.7 yrs	14.6 yrs	1.5 yrs	74
	Satellite	8.8 yrs	8.2 yrs	16.8 yrs	4.2 yrs	17
	Ship / Sub	7.5 yrs	6.0 yrs	15.8 yrs	1.3 yrs	31
	Vehicle	4.6 yrs	4.5 yrs	8.7 yrs	0.7 yrs	11
Program Initiation	Milestone B/II	7.5 yrs	6.9 yrs	21.2 yrs	1.1 yrs	220
	Milestone C/III	3.6 yrs	3.2 yrs	10.4 yrs	0.1 yrs	40
TOTAL		6.9 yrs	6.6 yrs	21.2 yrs	0.1 yrs	260

Source: DAMIR; RAND DSCPD; and CSIS analysis.

The benefits of incremental upgrades can also be observed by comparing MDAPs initiated at milestone B and milestone C. Frequently, upgrades to existing systems are initiated at milestone C. The analysis shows that the difference in cycle time distributions between MDAPs initiated at different milestones was statistically significant; however, the difference in percent cycle time growth was not.[j] Importantly, there is also a substantial difference in means between programs initiated at milestone B and milestone C. This observation is not entirely surprising, as it suggests that one strategy for avoiding worst-case instances of schedule growth is to initiate programs with mature technology.

Relatedly, both the cycle time and percent cycle time growth data have outliers, or MDAPs which experienced notably worse outcomes than other programs. For example, the worst-case cycle time in any particular category (i.e., military service, platform type) is over twice as long as the median cycle time in that category. The duration of many of these outlier programs also exceeds the upper quartile of cycle times for a particular category. These sharp differences suggest that worst-case programs are not representative of DOD's overall acquisition speed.

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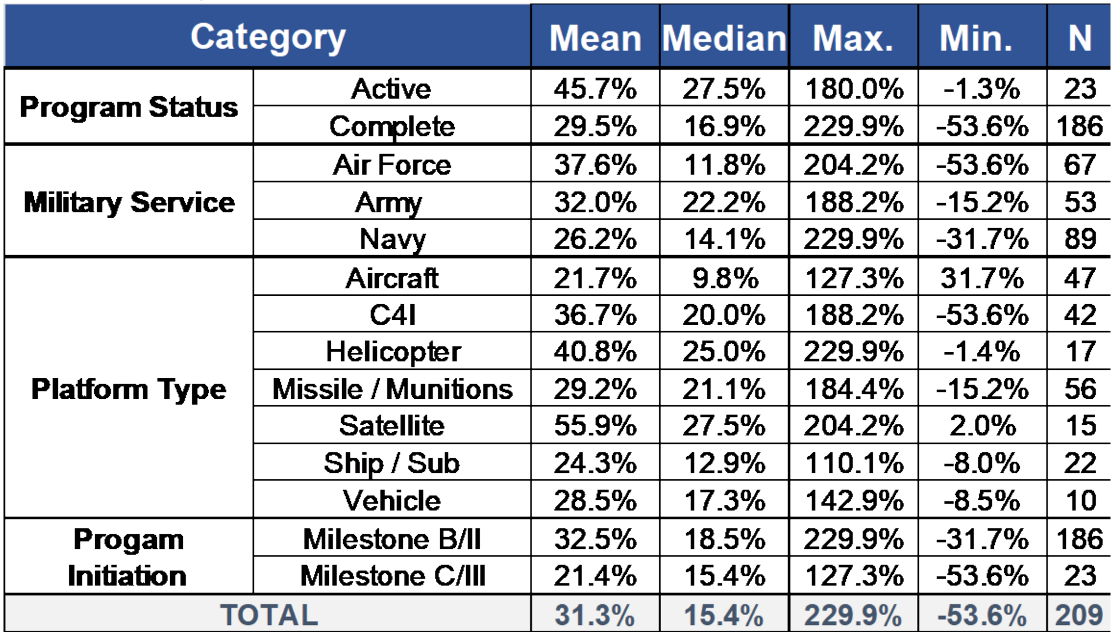
[j] Upon visualizing our data and running the S-W and A-D test, we concluded that it was not consistent with a normal distribution. Using a M-W U test to compare cycle times, we observed a statistically significant difference in distributions ($p<0.01$). Using the same methods for percent cycle time growth, we concluded that this data was not consistent with a normal distribution. Using a M-W U test to compare percent cycle time growth, we did not observe a statistically significant difference in distributions ($p=0.21$).

Table 3: Summary of Cycle Time Data
(Complete MDAPs and Active MDAPs, FY 1963 – FY 2015)



Category		Mean	Median	Max.	Min.	N
Program Status	Active	45.7%	27.5%	180.0%	-1.3%	23
	Complete	29.5%	16.9%	229.9%	-53.6%	186
Military Service	Air Force	37.6%	11.8%	204.2%	-53.6%	67
	Army	32.0%	22.2%	188.2%	-15.2%	53
	Navy	26.2%	14.1%	229.9%	-31.7%	89
Platform Type	Aircraft	21.7%	9.8%	127.3%	31.7%	47
	C4I	36.7%	20.0%	188.2%	-53.6%	42
	Helicopter	40.8%	25.0%	229.9%	-1.4%	17
	Missile / Munitions	29.2%	21.1%	184.4%	-15.2%	56
	Satellite	55.9%	27.5%	204.2%	2.0%	15
	Ship / Sub	24.3%	12.9%	110.1%	-8.0%	22
	Vehicle	28.5%	17.3%	142.9%	-8.5%	10
Progam Initiation	Milestone B/II	32.5%	18.5%	229.9%	-31.7%	186
	Milestone C/III	21.4%	15.4%	127.3%	-53.6%	23
TOTAL		31.3%	15.4%	229.9%	-53.6%	209

Source: DAMIR; RAND DSCPD; and CSIS analysis.

But how does that speed compare to DOD's desired "speed of relevance"? To address this question, DOD cycle times were compared to external benchmarks from the U.S. private sector and China's People's Liberation Army (PLA). The comparisons are limited, however, by the availability and quality of open-source data. The best option, therefore, was to compare the data set of over 200 MDAP cycle times to a handful of benchmark systems with rough schedule estimates.

To estimate non-DOD cycle times, the analysis leverages a DARPA report that contains data on the U.S. private sector and uses open-source reporting on PLA systems. In both instances, it is assumed that the dates reported are consistent with the definitions of program initiation and IOC. For PLA systems in particular, program initiation dates were identified using media reports which stated when the PLA began system development or issued contracts. Such assumptions, of course, limit the ability to draw definitive conclusions. As such, U.S. private-sector and PLA cycle times were used only as rough benchmarks for the "speed of relevance."

Acknowledging these limitations and using DARPA's U.S. private-sector data, commercial aircraft cycle times increased from approximately four to seven years since 1965.[37] Commercial vehicle cycle times decreased during this time, from approximately seven to two years.[38] As shown in Table 2, DOD's mean aircraft and vehicle cycle times are consistent with the U.S. private sector, but DOD's worst-case MDAPs significantly exceeded private-sector cycle times.

Based on limited, open-source data on example PLA systems, DOD average cycle times, for the most part, appear to outpace comparable PLA systems—even though the PLA frequently accelerates technology development using espionage, intellectual property theft, and foreign military procurement.[39] For example, although DOD's mean cycle time for aircraft is 6.6 years, the PLA appears to have fielded the J-20 and the Y-20 in approximately 15 and 10 years, respectively.[40] Compared to the DOD aircraft shown in Table 2, these example PLA cycle times are closer to DOD's worst-case cycle time for aircraft.

DOD's mean cycle time for subs and ships—7.5 years—also appears to outpace some open-source PLA examples. For instance, the PLA appears to have fielded both the Type 093 Shang-class submarine and the Type 052 destroyer in approximately 10 years.[41] Notably, the PLA appears to have fielded its new aircraft carrier, the Type 001A *Shandong* (CV-17), rather quickly, in approximately five years.[42] Compared to DOD capabilities, however, many of these benchmark systems appear inferior by at least some performance metrics.[43] In each example, however, the PLA's cycle times do appear to outpace DOD's worst-case cycle times.

While these comparisons are limited by the availability and quality of data, examples of U.S. private-sector and PLA cycle times provide a rough benchmark for the "speed of relevance." Using this benchmark, it appears that DOD's acquisition system has, on average, historically fielded MDAPs at the "speed of relevance." Note, however, that several of DOD's worst-case cycle times did significantly exceed the cycle times of benchmark systems.

Key Take-aways

- Acquisition speed is no slower today than it was in the past, although there are valid reasons to perceive otherwise.
- DOD has historically fielded new MDAPs at average speeds that are comparable to external benchmarks.
- DOD has not, however, fielded worst-case MDAPs at speeds comparable to external benchmarks. Rather, the schedule outcomes on worst-case programs differ substantially from median program outcomes.
- Within DOD's acquisition system, speed is consistent across the military services. Speed varies, however, according to certain technical and programmatic characteristics.
- Based on the above findings, defense reformers should avoid using the experience of worst-case programs to motivate future reforms of the *entire* acquisition system.
- DOD should also initiate MDAPs with mature technology by increasing support to technology development outside of formal programs and by incrementally upgrading existing systems.

5 Budget Cycles and Cycle Times

That acquisition speed has remained consistent over time is somewhat surprising—especially given the many strategic shifts that have occurred throughout DOD's history. Nowhere are those shifts more obvious than in the defense budget, which often varies widely in response to geopolitical events and broad administration priorities. Budget cycles—or broad shifts between periods of increasing or decreasing budget—are therefore readily visible in a plot of DOD's topline budget.

Figure 4 shows that since 1960, seven budget cycles—where DOD's overall budget was substantially increasing or decreasing—can be identified. These cycles are summarized in Table 4 and described briefly below:

1) **Vietnam War:** DOD's overall budget increased during this period, to support the war in Vietnam.[44]

2) **Decade of Neglect:** After the Vietnam War, DOD moved into the so-called "decade of neglect" wherein its overall budget declined.[45]

3) **Reagan Defense Buildup:** The "decade of neglect" ended with President Reagan's commitment to build-up the military and invest in defense capabilities.[46]

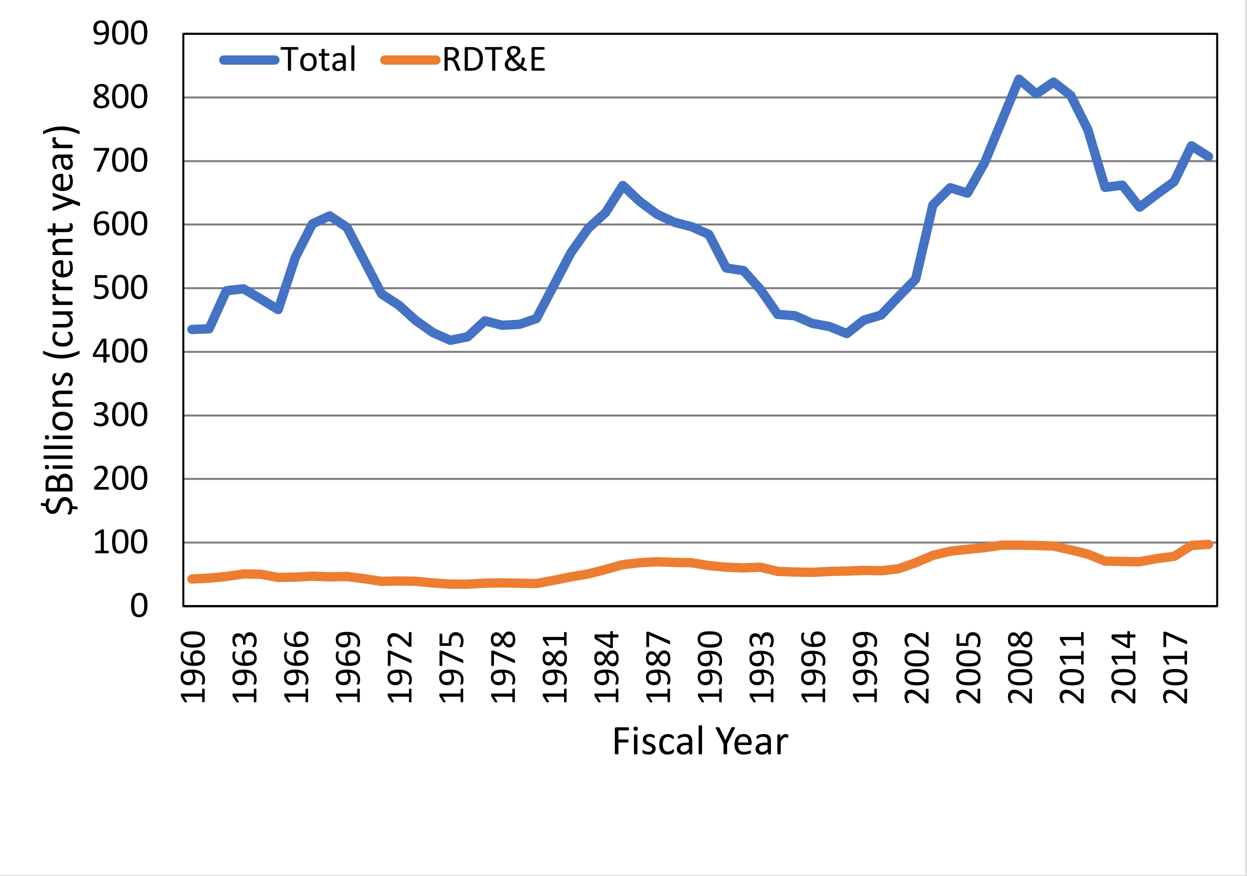
4) **Gramm-Rudman-Hollings Act:** The Gramm-Rudman-Hollings Act initiated funding constraints on DOD's budget that effectively ended Reagan's defense buildup.[47]

5) **Post 9/11 Attacks:** After the 9/11 attacks, defense spending again increased as DOD supported dual wars in Iraq and Afghanistan.[48]

6) **Budget Control Act:** All federal spending—including for defense—was constrained by the Budget Control Act of 2011.

7) **Trump Buildup:** Since assuming office in 2017, President Trump began increasing DOD's budget in order to reverse the trend initiated by the Budget Control Act.

Figure 4: Cycles in DOD's Topline Budget



Source: Department of Defense, *National Defense Budget Estimates for FY 2020,* https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/FY20_Green_Book.pdf

Table 4: Budget Cycles

Cycle Type	Reform Cycle
Increasing Budget	Vietnam War (FY 1962-1969)
	Reagan Defense Buildup (FY 1981-1986)
	Post 9/11 Attacks (FY 2003-2011)
	Trump Build-up (FY 2018-present)
Decreasing Budget	Decade of Neglect (FY 1970-1980)
	Gramm-Rudman-Hollings Act (FY 1987-2002)
	Budget Control Act (FY 2012-2017)

Source: DAMIR; RAND DSCPD; Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II*; McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs*; and CSIS analysis.

Figure 4 also plots DOD's research, development, test, and engineering (RDT&E) budget, which has clearly remained approximately constant throughout history. Importantly, prior to IOC, MDAPs are primarily funded through RDT&E.

To explore how budget cycles might affect acquisition speed, MDAPs were classified according to the cycle during which they were initiated.[49] MDAPs were further classified according to whether those cycles involved substantial increases or decreases in DOD's topline budget.

The results shown in Table 5 and Table 6 illustrate that cycle times and percent cycle time growth do not discernably vary across budget cycles. Although there is a noticeable—and statistically significant—increase in acquisition speed between cycle #5 and cycle #6, other trends are not immediately apparent.[k]

Table 5: Budget Cycles and Cycle Times

#	Budget Cycle	Type	Mean	Median	Max.	Min.	N
1	Vietnam War (FY 1962-1969)	Increasing	5.0 yrs	4.3 yrs	11.5 yrs	0.9 yrs	13
2	Decade of Neglect (FY 1970-1980)	Decreasing	6.0 yrs	5.9 yrs	15.7 yrs	1.4 yrs	55
3	Reagan Defense Buildup (FY 1981-1986)	Increasing	7.3 yrs	6.3 yrs	21.2 yrs	1.5 yrs	44
4	Gramm-Rudman-Hollings Act (FY 1987-2002)	Decreasing	7.1 yrs	6.9 yrs	16.8 yrs	0.1 yrs	83
5	Post 9/11 Attacks (FY 2003-2011)	Increasing	8.2 yrs	8.7 yrs	18.7 yrs	0.7 yrs	48
6	Budget Control Act (FY 2012-2017)	Decreasing	5.8 yrs	6.1 yrs	10.9 yrs	1.3 yrs	17
TOTAL			6.9 yrs	6.6 yrs	21.2 yrs	0.1 yrs	260

Source: DAMIR; RAND DSCPD; Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II*; McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs*; and CSIS analysis.

Table 6: Budget Cycles and Percent Cycle Time Growth

#	Budget Cycle	Type	Mean	Median	Max.	Min.	N
1	Vietnam War (FY 1962-1969)	Increasing	3.3%	0.8%	11.4%	-31.7	4
2	Decade of Neglect (FY 1970-1980)	Decreasing	23.0%	11.8%	112.5%	-8.5%	35
3	Reagan Defense Buildup (FY 1981-1986)	Increasing	37.9%	10.5%	229.9%	-6.0%	31
4	Gramm-Rudman-Hollings Act (FY 1987-2002)	Decreasing	31.7%	19.5%	204.2%	-53.6%	77
5	Post 9/11 Attacks (FY 2003-2011)	Increasing	40.8%	28.1%	188.2%	-7.1%	46
6	Budget Control Act (FY 2012-2017)	Decreasing	13.8%	2.3%	134.0%	-15.2%	16
TOTAL			31.3%	15.4%	229.9%	-53.6%	209

Source: DAMIR; RAND DSCPD; Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II*; McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs*; and CSIS analysis

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[k] After visualizing our cycle time data and performing both an S-W and A-D test, we concluded that it was consistent normal distribution. Therefore, we ran both a two-sided t-test assuming unequal variances and a M-W U test which found statistically significant differences in both the mean and median ($p=0.02$ and $p=0.05$, respectively). After visualizing our percent cycle time growth data and performing both an S-W and A-D test, we concluded that it was not consistent normal distribution. Therefore, we ran a M-W U test to compare distributions and observed a statistically significant difference ($p<0.01$).

Table 7: Budget Cycles and Overall Acquisition Speed

Cycle Type	Statistic	Mean	Median	Max.	Min.	N
Increasing Budget	Cycle Time	7.4 yrs	7.3 yrs	21.2 yrs	0.7 yrs	105
	Cycle Time Growth	37.9%	25.0%	229.9%	-6.0%	81
Decreasing Budget	Cycle Time	6.6 yrs	6.5 yrs	16.8 yrs	0.1 yrs	155
	Cycle Time Growth	27.1%	13.9%	204.2%	-53.6%	128

Source: DAMIR; RAND DSCPD; Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II*; McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs*; and CSIS analysis.

Table 7, however, suggests that changing DOD's topline budget is not an effective mechanism for affecting MDAP cycle times. Instead, MDAPs initiated during periods of increasing budget reached IOC an average of 9.6 months slower than MDAPs initiated during periods of decreasing budget. The different in medians was also 9.6 months; however, the difference in distributions was not statistically significant. [l]

Similarly, the data shows that MDAPs initiated during periods of increasing topline budget experienced an average of 10.7 percent more cycle time growth. The difference in medians—11.1 percent—was also substantial; however, the difference in distributions was not statistically significant.[m] As above, these results still suggest that changing DOD's topline budget may not be an effective mechanism for affecting MDAP percent cycle time growth.

This finding—that overall budget climate at program initiation does not significantly affect acquisition speed—is somewhat surprising given McNicol and Wu's analysis of budget climate and cost growth.[50] Specifically, McNicol and Wu suggest that when DOD initiates MDAPs during periods of decreasing budget, program managers respond to funding constraints by underestimating cost.[51] Those programs then experience cost growth later in their lifecycle.

Taken in this context, the analysis on MDAP schedules suggests that DOD may estimate program costs and schedules independently. For example, although programs may be compelled to underestimate costs so as to "fit" into a constrained budget, analogous accommodations may not be not made for schedule.[52] Such behavior would be consistent with Van Atta's finding that DOD's schedule estimating capabilities are "analytically weak."[53]

That said, since the majority of MDAP funding prior to IOC is classified as RDT&E, it is also quite reasonable to expect that cycles in DOD's topline budget would not impact acquisition speed—at least as measured by cycle time and percent cycle time growth. It is possible that other measures of acquisition speed—particularly those focused on production—may be more

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[l] After visualizing our data and performing both an S-W and A-D test, we concluded that it was not consistent with a normal distribution. Using a M-W U test to compare cycle time distributions, we did not observe a statistically significant difference in distributions (p=0.12).

[m] As above, after visualizing our data and performing both an S-W and A-D test, we concluded that it was not consistent with a normal distribution. Therefore, we used an M-W U test to compare distributions and found the differences between groups to be significant at a higher level of statistical significance than is quoted throughout this report (p=0.07).

significantly affected by budget cycles. For example, DOD might slow down procurement rates in response to budget cuts. Future research, therefore, should explore the relationship between budget cycles and alternative measures of acquisition speed.[54]

Key Take-aways

- The data on budget cycles and cycle times suggest that DOD fields MDAPs with shorter cycle times and less percent cycle time growth when MDAPs are initiated during periods of decreasing budget.
- Changing DOD's topline budget is not an effective mechanism for affecting MDAP acquisition speed.
- Based on these findings, defense reformers should set goals for acquisition speed that are independent of broad swings in the overall defense budget.

6 Reform Cycles and Cycle Times

Just as budget cycles occur throughout DOD's history, so too do cycles of acquisition reform. When speed is priority, reformers often look to reduce and decentralize DOD's oversight of the acquisition process. For example, today's reformers sought to reduce and decentralize OSD oversight of MDAPs by creating alternative acquisition pathways (e.g., NDAA 2016 Sec. 804's "middle tier acquisition") that largely eschew traditional, OSD-led oversight activities.[55] Reformers also delegated much of OSD's authority to conduct MDAP milestone reviews back to the military services.[56]

Oversight—which often takes the form of reporting requirements and reviews—can lengthen program schedules by adding activities that take time to complete. For example, the Government Accountability Office found that, in a sample of 24 programs, staff spent an average of two years completing the steps necessary to pass an Office of the Secretary of Defense (OSD)-led milestone review and 5,600 total staff days documenting that work.[57] Relatedly, RAND found that 5% of a program office staff's time was dedicated to regulatory and statutory compliance[58] and researchers at George Washington University found that between five and forty percent of a contractor's time was spent complying to oversight requirements.[59]

Importantly, reformers recent moves to decentralize OSD oversight follow nearly six decades and multiple cycles of prior acquisition reform. Although the specifics of each reform initiative are distinct and complex, from a macroscopic perspective it is possible to characterize past cycles according to the mechanisms that reformers employed.

This section focuses on one mechanism—OSD oversight's centralization or decentralization—which has been both the focus of prior research and which uniquely affects MDAPs.[60] It is worth acknowledging, however, that reformers sometimes employ multiple mechanisms simultaneously and that these mechanisms may interact in non-simple, non-obvious ways. This analysis, therefore, provides just one perspective on acquisition reform cycles and MDAP cycle times.

Acknowledging these limitations, it is possible to identify eight reform cycles—including today's –and to classify them according to their preference for centralized or decentralized oversight. These cycles are summarized in Table 8 as well as briefly below:

1) **McNamara Reforms:** Secretary Robert McNamara leveraged authorities granted by the DOD Reorganization Act of 1958 to centralize OSD control over military service budgets and major program decisions.[61]

2) **Defense Systems Acquisition Reform Council:** Deputy Secretary David Packard created the Defense Systems Acquisition Reform Council (DSARC) to limit OSD involvement in the acquisition process. Through the DSARC, OSD assessed programs at discrete milestones but otherwise delegated management responsibility to the military services.[62]

3) **Brown Strengthens Control:** In response to Packard's "management by objective" approach, Secretary Harold Brown sought to regain and centralize OSD authority over the acquisition process.[63]

4) **Acquisition Improvement Program:** In response to Brown's tighter OSD control, Secretary Caspar Weinberger and Deputy Secretary Frank Carlucci initiated the Acquisition Improvement Program to enable the "controlled decentralization" of OSD's authority.[64]

5) **Defense Acquisition Board:** Congress initiated a series of reforms—including the creation of an under secretary of defense for acquisition—aimed at centralizing and strengthening OSD control over the acquisition process.[65] Toward this end, OSD established the Defense Acquisition Board to oversee MDAPs throughout their lifecycle.[66]

6) **Mandate for Change and Transformation:** During this extended period—which spanned nearly two administrations—OSD emphasized deregulation and management streamlining, but not scrupulous oversight of early program decisions.[67] DOD also heavily relied on Total System Performance Responsibility (TSPR) contracts during this period. These contracts delegated a significant amount of authority and responsibility to DOD contractors and in doing so eroded the department's ability to conduct rigorous oversight.[68]

7) **Weapon Systems Acquisition Reform Act:** Responding to cost growth during the prior cycle, Congress implemented a series of reforms aimed at centralizing OSD authority—especially over early program milestones.[69] OSD's *Better Buying Power* initiative attempted to further strengthen program management throughout the system lifecycle.[70]

8) **Restructuring AT&L:** Today's reformers intend to increase acquisition speed and strengthen DOD's technological edge by splitting up the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics into two separate offices. To reduce cycle times, the procurement-focused office has delegated much of its oversight authority to the military services.[71]

These cycles provide a framework for assessing DOD's historic acquisition speed. Specifically, by classifying programs according to reform cycle or cycle type (i.e., centralized or decentralized oversight), it is possible to observe past reforms' macroscopic impact on acquisition speed. As in the analysis of budget cycles, MDAPs are classified according to the cycle during which they are initiated.[72]

Table 8: Reform Cycles

Cycle Type	Reform Cycle
Centralized Oversight	McNamara Reforms (FY 1963-1969)
	Brown Strengthens Control (FY 1977-1982)
	Defense Acquisition Board (FY 1990-1993)
	Weapon Systems Acquisition Reform Act (FY 2010-2017)
Decentralized Oversight	Defense Systems Acqusition Reform Council (FY 1970-1976)
	Acquisition Improvement Program (FY 1983-1989)
	Mandate for Change and Transformation (FY 1994-2009)
	Restructuring AT&L (FY 2018-present)

Source: Fox, *Defense Acquisition Reform 1960-*2009; Levine, *Defense Management Reform*; Lewis et al., *Acquisition Reform Regimes on Their Own Terms*; Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next"; McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process* 2014; and CSIS analysis.

Table 9 shows that earlier reform cycles (i.e., cycles #1-3) had lower mean and median cycle times relative to more recent cycles (i.e., cycles #4-6). Although the distribution of cycle times was significantly different between groups, this difference cannot be attributed to changes in oversight type, since OSD oversight was both centralized and decentralized during both periods.[n] Future research, therefore, should explore alternative explanations for the difference between early and later reform cycles.

Table 9 and Table 10 also indicate that cycle #7, which immediately preceded today's reforms, marked an increase in acquisition speed compared to the cycle immediately prior (i.e., cycle #6). In this instance, differences in both the cycle time and percent cycle time growth distributions were statistically significant.[o] This finding suggests that the reforms implemented during cycle #7 positively impacted program outcomes, at least as compared to the cycle immediately prior. Further, this improvement does not suggest an urgent need to reform the acquisition process, as reformers ultimately did by decentralizing OSD oversight in cycle #8.

Additionally, historical data shows little evidence that decentralizing OSD oversight actually increases acquisition speed. Instead, as shown in Table 11, MDAPs initiated during periods of decentralized oversight reached IOC an average of 15.6 months slower than MDAPs initiated during periods of centralized oversight. Furthermore, the disparity in medians was also

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[n] Upon visualizing our data, we concluded that it was not consistent with a normal distribution. This observation was confirmed by one of two tests that we ran to check for normality. The S-W test found our data to be non-normal, while the Anderson-Darling A-D did find the data to be consistent with a normal distribution. Careful of the skew that we visually observed in our data, we opted to use a non-parametric test. Using a M-W U test, we observed a statistically significant difference in distributions ($p<0.01$).

[o] Upon visualizing our cycle time data, we observed that it was consistent with a normal distribution. This observation was confirmed by both an S-W and A-D test for normality. To compare cycle time means between cycle #6 and cycle #7, we used a two-sided t-test assuming unequal variances and found the differences in means to be statistically significant ($p=0.02$). For consistency with our analysis of percent cycle time growth, we also compared distributions using a M-W U test and found the differences to be statistically significant as well ($p=0.04$). Upon visualizing our percent cycle time growth data, we observed that it was not consistent with a normal distribution. This observation was also confirmed with S-W and A-D tests for normality. Using a M-W U test, we observed a statistically significant difference in distributions between cycle #6 and cycle #7 ($p=0.02$).

substantial, with MDAPs initiated during periods of decentralized oversight reaching IOC 15.6 months slower. This difference in cycle time distributions also statistically significant: suggesting that decentralizing OSD oversight may not be an effective mechanism for reducing MDAP cycle time.[p]

Table 9: Reform Cycles and Cycle Times

#	Reform Cycle	Type	Mean	Median	Max.	Min.	N
1	McNamara Reforms (FY 1963-1969)	Centralized	5.0 yrs	4.3 yrs	11.5 yrs	0.9 yrs	13
2	Defense Systems Acqusition Reform Council (FY 1970-1976)	Decentralized	6.1 yrs	6.2 yrs	15.7 yrs	1.4 yrs	30
3	Brown Strengthens Control (FY 1977-1982)	Centralized	6.3 yrs	6.0 yrs	12.3 yrs	1.5 yrs	38
4	Acquisition Improvement Program (FY 1983-1989)	Decentralized	7.1 yrs	6.4 yrs	21.2 yrs	2.2 yrs	48
5	Defense Acquisition Board (FY 1990-1993)	Centralized	6.4 yrs	6.6 yrs	14.5 yrs	1.8 yrs	15
6	Mandate for Change and Transformation (FY 1994-2009)	Decentralized	8.0 yrs	7.8 yrs	18.7 yrs	0.1 yrs	90
7	Weapon Systems Acquisition Reform Act (FY 2010-2018)	Centralized	6.0 yrs	5.7 yrs	12.3 yrs	1.3 yrs	26
TOTAL			**6.9 yrs**	**6.6 yrs**	**21.2 yrs**	**0.1 yrs**	**260**

Source: DAMIR; RAND DSCPD; Fox, *Defense Acquisition Reform 1960*-2009; Levine, *Defense Management Reform*; Lewis et al., *Acquisition Reform Regimes on Their Own Terms*; Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next"; McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process* 2014; and CSIS analysis.

Table 10: Reform Cycles and Percent Cycle Time Growth

#	Reform Cycle	Type	Mean	Median	Max.	Min.	N
1	McNamara Reforms (FY 1963-1969)	Centralized	3.3%	0.8%	11.4%	0.0%	4
2	Defense Systems Acqusition Reform Council (FY 1970-1976)	Decentralized	22.2%	5.3%	112.5%	-31.7%	15
3	Brown Strengthens Control (FY 1977-1982)	Centralized	26.5%	21.4%	110.1%	-8.5%	29
4	Acquisition Improvement Program (FY 1983-1989)	Decentralized	35.4%	7.8%	229.9%	-8.0%	38
5	Defense Acquisition Board (FY 1990-1993)	Centralized	15.4%	18.4%	62.0%	-53.6%	13
6	Mandate for Change and Transformation (FY 1994-2008)	Decentralized	39.4%	25.8%	204.2%	-7.1%	86
7	Weapon Systems Acquisition Reform Act (FY 2010-2017)	Centralized	20.2%	7.5%	134.0%	-15.2%	24
TOTAL			**31.3%**	**15.4%**	**229.9%**	**-53.6%**	**209**

Source: DAMIR; RAND DSCPD; Fox, *Defense Acquisition Reform 1960*-2009; Levine, *Defense Management Reform*; Lewis et al., *Acquisition Reform Regimes on Their Own Terms*; Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next"; McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process* 2014; and CSIS analysis.

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[p] Again, after visualizing our data and performing both an S-W and A-D test, we concluded that it was not consistent with a normal distribution. Therefore, we used a M-W U test to compare distributions and found the differences between groups to be statistically significant ($p<0.01$).

Table 11: Reform Cycles and Overall Acquisition Speed

Cycle Type	Statistic	Mean	Median	Max.	Min.	N
Centralized Oversight	Cycle Time	6.1 yrs	5.7 yrs	14.5 yrs	0.9 yrs	92
	Cycle Time Growth	20.9%	10.9%	134.0%	-53.6%	70
Decentralized Oversight	Cycle Time	7.4 yrs	7.0 yrs	21.2 yrs	0.1 yrs	168
	Cycle Time Growth	36.5%	21.4%	229.9%	-31.7%	139

Source: DAMIR; RAND DSCPD; Fox, *Defense Acquisition Reform 1960*-2009; Levine, *Defense Management Reform*; Lewis et al., *Acquisition Reform Regimes on Their Own Terms*; Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next"; McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process* 2014; and CSIS analysis.

Similarly, the data shows that MDAPs initiated during periods of decentralized oversight experienced an average of 15.6 percent more cycle time growth. The difference in medians—10.5 percent—was also substantial; however, the difference in distributions had a lower level of statistical significance than the comparisons described above.[q] That said, these results still suggest that decentralizing OSD oversight may not be an effective mechanism for reducing MDAP cycle time growth.

This analysis suggests that even though OSD oversight activities take time, they do not result in appreciably longer MDAP cycle times or higher rates of cycle time growth. Instead, it seems likely that other technical factors—such as system type and complexity—may determine an MDAP's critical path and schedule duration. Additionally, the data suggests that strong, centralized OSD oversight may reduce cycle times and cycle time growth—perhaps by serving as a "check" on the military services' incentives to "sell" their programs using optimistic cost and schedule estimates.[73]

Overall, the data also suggest that today's reforms—cycle #8, which decentralized OSD oversight—may not increase MDAP acquisition speed in the future. Given the *National Defense Strategy's* intent to "deliver performance at the speed of relevance,"[74] this outcome seems troubling. Thankfully, by comparing historic MDAP data to external benchmarks (as in Section 3 above), it was possible to observe indications that that—despite decades of reform—DOD's acquisition system, on average, may already field systems at the "speed of relevance."

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[q] As above, after visualizing our data and performing both an S-W and A-D test, we concluded that it was not consistent with a normal distribution. Therefore, we used an M-W U test to compare distributions and found the differences between groups to be statistically significant at the ten percent level (p=0.07).

Key Take-aways

- The data on reform cycles suggests that even though OSD-led oversight activities take time to complete, they do not appreciably slow down MDAP acquisition speed.
- Instead, MDAPs initiated during periods of strong, centralized OSD oversight experienced shorter cycle times and lower rates of percent cycle time growth.
- Based on these findings, defense reformers should centralize and strengthen OSD oversight as a means of increasing acquisition speed.

7 Optimistic Schedule Estimates

As noted above, OSD oversight can serve as a “check” on the military services’ incentives to “sell” their programs using optimistic cost and schedule estimates.[75] By this logic, strong OSD oversight should result in DOD initiating MDAPs with more realistic schedule estimates. Realistic schedule estimates, in turn, should be associated with lower rates of cycle time growth. Stated another way, MDAPs initiated with optimistic schedules are more likely to experience higher rates of percent cycle time growth.

To explore this hypothesis, it is possible to calculate a “schedule optimism” variable for each MDAP in the dataset. This variable compares an MDAP’s initial schedule estimate with the historic mean cycle time for all other MDAPs of the same platform type (e.g., aircraft, satellites, ships/subs). Mean cycle time by platform type was shown previously in Table 2.

This schedule optimism variable—originally proposed by Tate—captures how much faster a program predicted that it could reach IOC, as compared to other programs that fielded similar platforms.[76] In this way, the variable captures how optimistic an MDAP’s predicted schedule was, relative to other MDAPs that fielded similar platform types. Tate calculated schedule optimism according to the following equation:[77]

$$\%\, Schedule\ optimism = \frac{platform\ average\ cycle\ time - estimated\ progam\ cycle\ time}{average\ cycle\ time} * 100$$

In the above equation, the average cycle time was calculated by platform type (e.g., vehicles, satellites) whereas the estimated cycle time corresponded to each program’s predicted schedule.

Figure 6 plots the percent schedule optimism variable against percent cycle time growth. A relationship between the two variables is visible, with higher rates of optimism associated with higher rates of cycle time growth. Using the simple linear regression shown in equation 1, a statistically significant association between percent cycle time growth and percent schedule optimism was observed.[r]

$$\log(y) = \beta * \log(x) + \varepsilon \qquad (1)$$

In equation 1, y corresponds to a percent cycle time growth factor, x corresponds to a percent schedule optimism factor, β is the estimated coefficient, and ε is an approximately normally distributed error term.[s] Growth factors were adopted so that it was possible to take the logarithm of negative percent. The log transformation, in turn, was necessary to preserve the assumption

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[r] We ran a simple linear regression of the natural log of the schedule optimism factor on the natural log of the percent cycle time growth factor and found a statistically significant association ($p<0.01$, adjusted $R^2=0.03$). In assessing this fit, we observed residuals to be non-normal and heteroscedastic. To compensate for heteroscedasticity, we applied robust error measures.

[s] For the simple linear model shown, we used a Jarque-Bera test to determine that the residuals were non-normal.
Given our large sample size (N>200), we assume that these residuals nonetheless approximate a normal distribution.

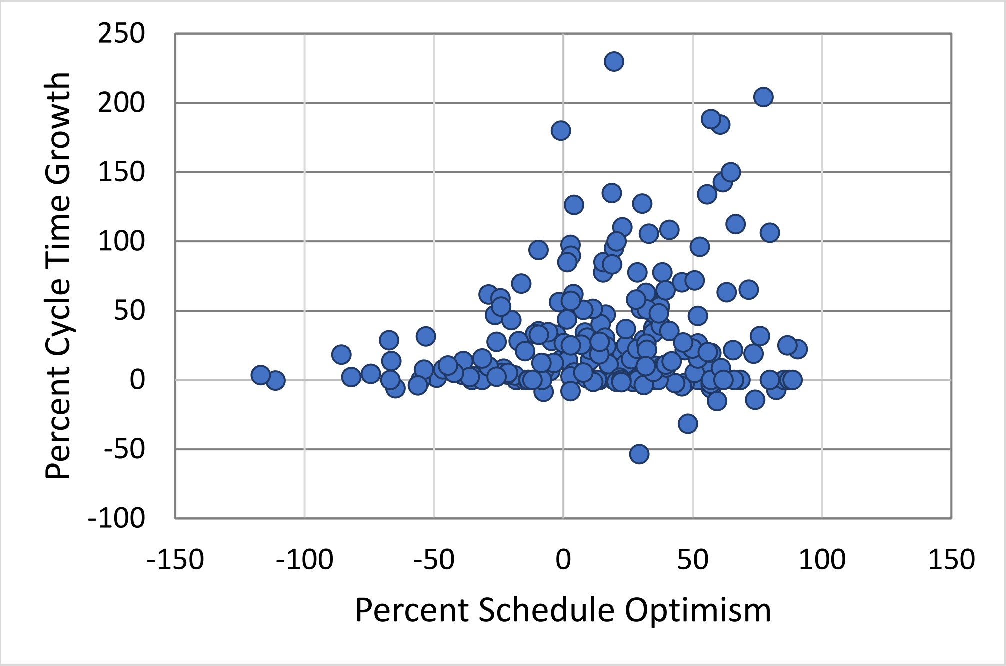
that the model's error terms approximated a normal distribution. Percentages were converted to growth factors according to equation 2.

$$Growth\ factor = 1 + \frac{percent}{100} \qquad (2)$$

The model results predict, for example, that for every ten percent an MDAP's schedule estimate is optimistic, that MDAP can expect approximately 26 percent cycle time growth.[t] These results are consistent with Tate's, who also observed that the average percent schedule growth for a given amount of schedule optimism was greater than the actual amount of optimism.[78] Tate suggested that, in this way, excessive schedule optimism may be a "symptom of a deeper problem" on MPAPs.[79]

It is possible that programs which optimistically estimate their schedules also under-estimate their costs. Similarly, such programs may set overly ambitious technical requirements or develop systems which are more complex than systems in the past. Such behavior, of course, is often associated with limited or ineffective OSD oversight, which can serve as a "check" on the military services' incentives to "sell" their programs using ambitious requirements and optimistic cost and schedule estimates.[80]

Figure 6: Percent Schedule Optimism and Percent Cycle Time Growth



Source: DAMIR; RAND DSCPD; David M Tate, *Acquisition Cycle Time: Defining the Problem*; and CSIS analysis.

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[t] To calculate these values, we used the estimated values for the intercept (0.219956) and beta (0.122649) in equation 1.

The relationship between schedule growth, schedule optimism, and other factors—including cost growth—will explored sin the next section. It is also worth noting that given the trend observed in Figure 6—as well as the low adjusted R^2 value associated with the linear model—that other factors clearly contribute to percent cycle time growth. These factors will be considered in the next section.

That said, the analysis of schedule optimism is relevant to the acquisition community's current focus on speed, because it suggests that there may be a *speed limit* for MDAP acquisition. Specifically, when MDAPs predict that they will reach IOC in less time than it took similar systems in the past, those MDAPs are more likely to experience cycle time growth. This suggests that by simply prioritizing acquisition speed and optimistically predicting program schedules, DOD is unlikely to achieve its objective of shortening cycle times.

Instead, if DOD wishes to improve the accuracy with which it is able to predict program schedules, it should consider past performance when developing future schedule estimates. For example, DOD should not expect to field new aircraft in less than 6.6 years unless future MDAPs set less stringent requirements and develop less technically complex aircraft than in the past. Essentially, without changing its requirements or developing simpler systems, DOD has little reason to expect that future MDAPs will reach IOC any faster than MDAPs in the past.[81]

More specifically, the "middle-tier" authorities granted by NDAA 2016 Sec. 804 enable programs to follow an alternative acquisition pathway—that bypasses the JCIDS and DOD 5000.01 process—if those programs can reach IOC in less than five years. This analysis suggests that "typical" (i.e., average) MDAPs have been historically unable to meet this five-year requirement. Unless the performance requirements and technical complexity of these MDAPs changes substantially, there is little reason believe that such programs can reach IOC in five years. As such, for most platform types—with the exception of vehicles—it may be inappropriate for DOD to leverage "middle tier" authorities when managing MDAPs.

Key Take-aways

- Strong, centralized OSD oversight can serve as a "check" against the military services' tendency to "sell" their programs using optimistic schedule estimates.
- When MDAPs are initiated with realistic schedule estimates, they experience less cycle time growth.
- MDAP acquisition may have a speed limit. To field systems faster, DOD may need to change its requirements or develop simpler systems than it has in the past.
- DOD should exercise caution when using "middle tier" acquisition authorities to manage MDAPs.

8 Improving Schedule Predictions

The above analysis improves the acquisition community's understanding of how various factors—such as technical complexity, oversight approach, and schedule optimism—can affect acquisition speed. This section evaluates all of those factors together and addresses the question: in the future, how can DOD improve the accuracy with which it predicts MDAP acquisition speed?

Percent cycle time growth can be used as a proxy for schedule accuracy. For instance, MDAPs that experience little cycle time growth estimated their schedules more accurately than those which experienced substantial schedule growth before IOC. Therefore, to improve the accuracy of future schedule estimates, DOD should consider how various factors might affect an MDAP's actual cycle time, and plan accordingly. As above, the following factors are considered in this analysis:

- Program initiation date;
- Military service (i.e., Army, Navy);
- Program maturity (i.e., active or complete);
- Technical maturity (i.e., initiating programs at milestone B or C);
- Platform type (e.g., satellites, helicopters); and
- Reform cycle (i.e., centralized or decentralized OSD oversight);
- Budget cycle (i.e., increasing or decreasing budgets);
- Schedule optimism; and
- Percent RDT&E cost growth.

To understand how each factor might ultimately contribute to cycle time growth, a generalized, linear multilevel model was employed. In particular, it was assumed that percent cycle time growth could be related to each of the above factors according to equation 3[82]

$$\log(y_i) = \beta_i x_i + \varepsilon_i \qquad (3)$$

where y_i corresponds to the cycle time growth factor associated with program i, x_i corresponds to the input variables associated with each program (e.g., platform type, reform cycle), β_i is the vector of coefficients to be estimated, and ε_i is an approximately normally distributed error term.[u]

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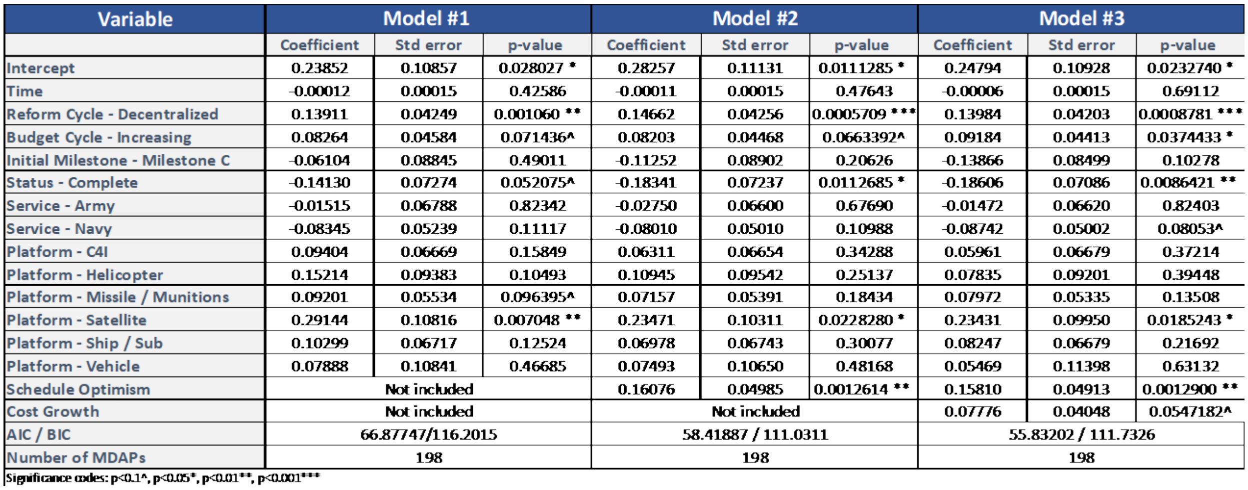
[u] For each of the models discussed in this section, we assessed evaluated the residuals for normality. In each case, using a Jarque-Bera test, we assessed that the residuals were non-normal. Given our large sample size (N>200), we assume that these residuals nonetheless approximate a normal distribution.

Table 12: Models to Predict Schedule Uncertainty



Variable	Model #1			Model #2			Model #3		
	Coefficient	Std error	p-value	Coefficient	Std error	p-value	Coefficient	Std error	p-value
Intercept	0.23852	0.10857	0.028027 *	0.28257	0.11131	0.0111285 *	0.24794	0.10928	0.0232740 *
Time	-0.00012	0.00015	0.42586	-0.00011	0.00015	0.47643	-0.00006	0.00015	0.69112
Reform Cycle - Decentralized	0.13911	0.04249	0.001060 **	0.14662	0.04256	0.0005709 ***	0.13984	0.04203	0.0008781 ***
Budget Cycle - Increasing	0.08264	0.04584	0.071436^	0.08203	0.04468	0.0663392^	0.09184	0.04413	0.0374433 *
Initial Milestone - Milestone C	-0.06104	0.08845	0.49011	-0.11252	0.08902	0.20626	-0.13866	0.08499	0.10278
Status - Complete	-0.14130	0.07274	0.052075^	-0.18341	0.07237	0.0112685 *	-0.18606	0.07086	0.0086421 **
Service - Army	-0.01515	0.06788	0.82342	-0.02750	0.06600	0.67690	-0.01472	0.06620	0.82403
Service - Navy	-0.08345	0.05239	0.11117	-0.08010	0.05010	0.10988	-0.08742	0.05002	0.08053^
Platform - C4I	0.09404	0.06669	0.15849	0.06311	0.06654	0.34288	0.05961	0.06679	0.37214
Platform - Helicopter	0.15214	0.09383	0.10493	0.10945	0.09542	0.25137	0.07835	0.09201	0.39448
Platform - Missile / Munitions	0.09201	0.05534	0.096395^	0.07157	0.05391	0.18434	0.07972	0.05335	0.13508
Platform - Satellite	0.29144	0.10816	0.007048 **	0.23471	0.10311	0.0228280 *	0.23431	0.09950	0.0185243 *
Platform - Ship / Sub	0.10299	0.06717	0.12524	0.06978	0.06743	0.30077	0.08247	0.06679	0.21692
Platform - Vehicle	0.07888	0.10841	0.46685	0.07493	0.10650	0.48168	0.05469	0.11398	0.63132
Schedule Optimism	Not included			0.16076	0.04985	0.0012614 **	0.15810	0.04913	0.0012900 **
Cost Growth	Not included			Not included			0.07776	0.04048	0.0547182^
AIC / BIC	66.87747/116.2015			58.41887 / 111.0311			55.83202 / 111.7326		
Number of MDAPs	198			198			198		

Significance codes: p<0.1^, p<0.05*, p<0.01**, p<0.001***

Source: DAMIR; RAND DSCPD; and CSIS analysis.

Table 12 compares the results from three separate models.[v]

- Model #1 incorporates the variables considered in the early sections of this report (program initiation date, military service, program maturity, technical maturity, platform type, reform cycle, and budget cycle).
- Model #2 adds percent schedule optimism to the variables above. Note that percent schedule optimism was converted to an optimism factor using equation 2.
- Model #3 adds a cost growth factor to model #2. Here cost growth for each MDAP was calculated by comparing the original RDT&E cost estimate to the actual RDT&E cost of the MDAP.

With a few caveats, model 1 is consistent with previously reported results. Even when multiple variables were considered simultaneously, reform cycle, platform type, and program status remain associated with cycle time growth. Notably, however, in model 1, percent cycle time growth for two platform types was statistically different from the model's reference platform (in this case, the model's reference platform was aircraft). In particular, the model predicts that—all else equal—compared to the mean percent cycle time growth for aircraft—satellite programs may experience approximately 35 percent more cycle time growth. Similarly, missile and munitions may experience approximately ten percent more cycle time growth. For MDAPs that develop other platform types, the predicted cycle time growth was not statistically different from MDAPs that develop aircraft.

Compared to model 1, model 2 improves the overall fit to the data and unsurprisingly, schedule optimism was significantly associated with cycle time growth. The same variables as model 1

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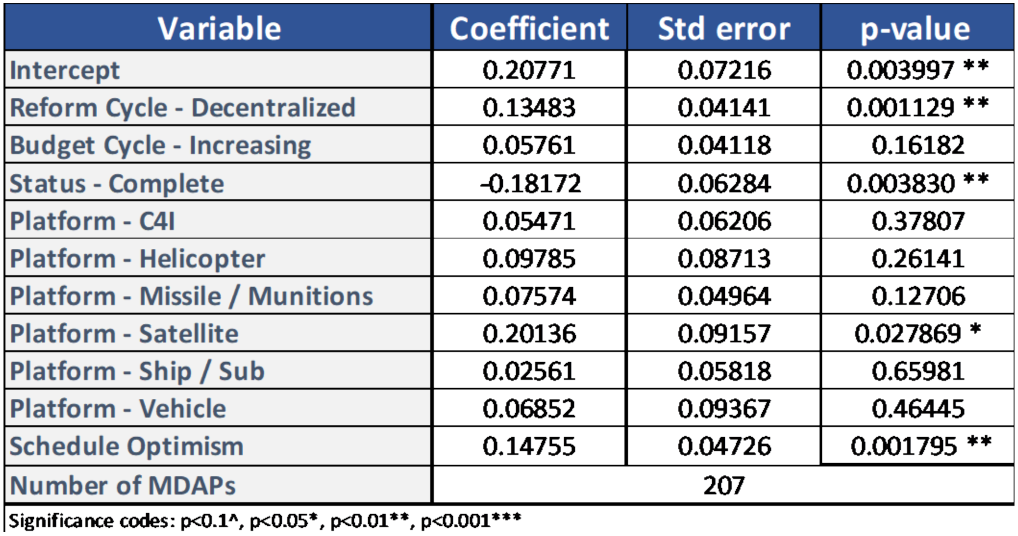
[v] To compensate for heteroscedasticity of unknown origin in our residuals, we applied robust error measures to each of the models.

were also found to be significant, albeit at different levels. Finally, when cost growth was added to model 3, a mixed impact to the model's overall fit was observed.

Table 13: Schedule Uncertainty Model #2



Variable	Coefficient	Std error	p-value
Intercept	0.20771	0.07216	0.003997 **
Reform Cycle - Decentralized	0.13483	0.04141	0.001129 **
Budget Cycle - Increasing	0.05761	0.04118	0.16182
Status - Complete	-0.18172	0.06284	0.003830 **
Platform - C4I	0.05471	0.06206	0.37807
Platform - Helicopter	0.09785	0.08713	0.26141
Platform - Missile / Munitions	0.07574	0.04964	0.12706
Platform - Satellite	0.20136	0.09157	0.027869 *
Platform - Ship / Sub	0.02561	0.05818	0.65981
Platform - Vehicle	0.06852	0.09367	0.46445
Schedule Optimism	0.14755	0.04726	0.001795 **
Number of MDAPs	207		

Significance codes: p<0.1^, p<0.05*, p<0.01**, p<0.001***

Source: DAMIR; RAND DSCPD; and CSIS analysis.

Furthermore, although cost growth is associated with cycle time growth, the causation relationship between these variables is unclear. The model was constructed to suggest that cost growth may cause schedule growth; however, it's also possible that the reverse is true or that underlying programmatic characteristics (e.g., platform type, technical maturity) may induce both cost and schedule growth. Future research should explore this causality link using alternative models. For this research, however, it is possible to interpret model 3 as indicating that MDAP cost and schedule growth are statistically associated with one another.

Given the uncertain relationship between cost and schedule, model 2 is further refined in Table 13.[w] Using fewer independent variables and a larger sample size, the same factors—reform type, program maturity, platform type, and schedule optimism—were found to be statistically associated with cycle time growth. The model can be interpreted as follows:

- Compared to complete MDAPs, MDAPs that are active today experience more cycle time growth;
- Compared to MDAPs initiated during periods of centralized OSD oversight, MDAPs initiated during periods of decentralized OSD oversight experience more cycle time growth;
- Compared to aircraft, MDAPs that develop satellites experience more cycle time growth; and,

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[w] Using this model, we observed the residuals to have a mean of zero. Using a Breusch-Pagan test, we observed that the residuals were homoscedastic; as done previously, we applied robust estimators regardless. Using a Durbin-Watson test for independent, we observed that the residuals were independent. Using a Jarque-Bera test and visual inspection, we observed the residuals to be non-normal. Given our large sample size (N>200), we assume that these residuals nonetheless approximate a normal distribution.

- MDAPs that employ optimistic schedule estimates experience more cycle time growth than MDAPs which do not.

For instance—all else equal—MDAPs initiated under decentralized OSD oversight can expect approximately 15 percent more cycle time growth than MDAPs initiated during periods of centralized OSD oversight. Similarly, for every 10 percent that a program's schedule is optimistic, it can expect approximately one percent of cycle time growth. This finding is consistent with Tate's suggestion that schedule optimism may be a "symptom of a deeper problem" on MPAPs.[83]

Specifically, when incorporated into a multi-variable, multi-level model, schedule optimism affects schedule growth less substantially than it did in the linear model presented in section 7. Instead, other factors—and lack of strong, centralized OSD oversight in particular—have a more substantial impact on schedule growth. The model, therefore, provides context as to what Tate's "deeper problem(s)" might be. Potential "problems" include today's active programs, a lack of strong, centralized OSD oversight, and issues that are unique to MDAPs which develop satellites.

Finally, these results are particularly relevant to today's reform community, which hopes to increase acquisition speed. The results suggest that reformers are right to focus on speed, since today's active MDAPs have experienced more schedule growth than complete MDAPs. They also suggest, however, that the mechanisms which reformers employed to increase acquisition speed may ultimately prove ineffective. Specifically, the model suggests that to improve schedule estimates in the future, DOD should exercise strong, centralized OSD oversight over MDAPs, especially at program initiation.

Acquisition reformers should also recognize that it takes time to field DOD's most costly and complex systems. OSD oversight and realistic schedule estimates may help reduce schedule growth, but ultimately, it takes years for MDAPs to reach IOC. If DOD hopes to field MDAPs faster and with less schedule growth, it should address the technical complexity that is inherent in nearly every MDAP system—and in satellites in particular. DOD's best opportunity to increase acquisition speed may come not from reforming the acquisition system, but rather from reducing the complexity of the technical systems that it develops.

Key Take-aways

- All things—including programmatic and broad, strategic factors—considered, DOD can improve future schedule estimates by basing them on historic schedule outcomes and by employing strong, centralized OSD oversight at program initiation

9 Conclusions

In defense acquisition, reform is constant and—it turns out—so is acquisition speed. Despite reformers' recent focus on speed, since 1962, DOD has fielded MDAPs at remarkably consistent speeds. More detailed analysis of acquisition speed, however, uncovered important insights both for the acquisition research and reform communities. Specifically:

1) Since 1962, DOD's average MDAP cycle time is 6.9 years, a value that is consistent with external benchmarks for the "speed of relevance;"

2) Reforms that strengthened and centralized OSD oversight of MDAPs resulted in shorter cycle times and lower rates of percent cycle time growth; and

3) DOD can improve future schedule predictions by considering platform type and past MDAP schedule outcomes.

Importantly, the analysis also found that recent reforms—which reduced and decentralized OSD oversight—are unlikely to increase acquisition speed. It also found that DOD is unlikely to increase acquisition speed through optimistic schedule estimates alone. Rather, if DOD wishes to field MDAPs faster, it may need to trade-offs performance requirements and reduce the technical complexity that is inherent in its MDAP systems. Strong, centralized OSD oversight can encourage the military services to undertake these activities. However, DOD—as well as future defense reformers—should also recognize that there is a speed limit to MDAP acquisition and that it simply takes time to field the department's most costly and complex systems.

10 Appendix

10.1 Additional Discussion Data and Methods

As noted in the body of the report, numerous assumptions were required to construct the dataset. This appendix provides more detail on those assumptions, the data quality issues encountered during database construction, and recommendations for future research.

First, to construct the dataset of over 200 MDAPs, the following assumptions were required.

- Milestone B or C was used for program initiation, even if an earlier date (i.e., milestone A) was available. This decision was made to maximize consistency across programs, since only a few programs had data from milestone A.

- In several instances, SARs contained dates that were not explicitly identified as milestones B, C, or IOC. Table 1 summarizes the assumptions that were used to select alternative dates that approximated those milestones.

- When programs did not have dates corresponding to the milestones listed in Table 1, they were omitted from the database.

- SARs typically provide two schedule estimates: development and production. When it was available, the development estimate was used, since programs make this estimate earlier in their lifecycles. When development estimates were unavailable, production estimates were used. Importantly, the decision to calculate cycle time growth using production estimates when development estimates were not available may result in a more optimistic picture of DOD schedule growth than if only development estimates were used. This analysis opted to include all of the data that was available, rather than to take a more conservative approach of excluding any suspect data and working with a smaller sample size.

- Cancelled programs were excluded from the dataset because DAMIR's data appeared unreliable after program cancellation. This assumption may make subsequent analysis appear more optimistic than reality, since cancelled programs may have longer than average cycle times. This impact was accepted, however, because the analysis focuses on the time it takes DOD to field systems, and cancelled programs, by definition, were never fielded.

- Where possible, MDAPs were broken into subprograms that contained additional increments or variants. For example, some MDAPs have a lead increment that was initiated at milestone B and a follow-on increment that was initiated at milestone C. When it was possible to discern separate initiation and IOC dates, dates from both subprograms were included. Doing so captures the benefit of fielding systems incrementally, since follow-on systems have shorter cycle times. Note that in this report, the term “MDAPs” is used to refer to both the programs and the subprograms which are developed and fielded within the MDAP program management structure.

- With the exception of the data contained in Figure 2 and Figure 3, all analysis in this report uses complete programs or active programs that are five years past initiation only. This assumption is consistent with prior analysis of MDAP cost growth and helps to avoid maturity bias.[84]

- Finally, where possible, corrupt data (e.g., programs where the IOC date was before the initiation date) was identified and corrected, often by consulting external sources or prior years’ data. In the handful of cases where it was possible to make manual corrections, those corrections were made; otherwise, the corrupt data was excluded.

Second, the report’s conclusions are also limited by the quality of the data that was available. By applying the assumptions outlined above, the report opted to use as much MDAP schedule data as was available. Data was only excluded when there was reason to believe that it might be suspect. Example reasons include: the predicted cycle time was zero, variants from the same program were fielded ten years earlier, and a program stopped producing SARs years before it reached IOC.

In many cases, there were no overt signs that the data was corrupt; however, there was reason to believe that some schedule estimates were not reflective of a program’s earliest schedule baseline. For instance, when a program is re-baselined, its new schedule estimate replaces its *original* schedule estimate in the SARs. To capture the earliest schedule baseline available, schedule estimates were collected from the earliest available SARs. However, in some cases, the earliest SAR may have been released after a program was re-baselined; such SARs, therefore, may not contain the *original* schedule estimate. Because it was difficult to verify whether a schedule baseline had changed, these programs were included in the dataset. Future researchers, however, may consider excluding these programs or working with development estimates only.

Relatedly, the process of collecting data and applying the assumptions above was highly manual and, oftentimes, was subjective. The milestones, baselines, and variant or increment data that was available for each MDAP was highly specialized. This suggests that DOD has historically tailored its MDAP acquisition strategies to meet the needs of specific programs and technologies. It also points to a need to collect better schedule data in the future.

Finally, if acquisition speed remains priority, reformers should understand how fast DOD acquires systems. By understanding the problem first (i.e., acquisition speed or the lack thereof), reformers can then develop targeted solutions to speed up acquisition. Good data helps reformers understand the problem they are trying to solve. Collecting quality data, therefore, is a critical first step to implementing effective reforms.

In the context of MDAP acquisition speed, there is clearly room to improve data quality. Future researchers should evaluate the assumptions described above and consider opportunities to increase confidence in and consistency across programs. DOD should also standardize how it reports schedules and should preserve data from a program's initial baseline.

10.2 Additional Schedule Driver Analysis (Budget Instability)

During this research, the impact of one additional variable was explored: budget instability. This variable assesses how significantly a program's yearly actual RDT&E budget differed from the RDT&E budget that it anticipated the year prior. In all cases, the most recent budget available was used to identify the actual budget. The prior year's budget was used to identify the anticipated budget.

For example, to compare the actual and anticipated budgets for FY 2015, one would collect actual FY 2015 budget from the most recent budget report available (for this analysis, the most recent budget report was published in FY 2018). One would then collect the anticipated FY 2015 budget from the FY 2014 budget report. Example data collected from the Evolved Expendable Launch Vehicle (EELV) program is shown in Figure 7.

Using these values, a percent change in actual versus anticipated RDT&E budgets can be calculated for every year between program initiation and IOC. An average can then be taken to represent a program's overall budget instability. The process for calculating program budget instability can also be described by the equation below:

$$Budget\ Instability = \frac{\sum_{i=1}^{N} \frac{100 * (B_A - B_P)}{B_P}}{N}$$

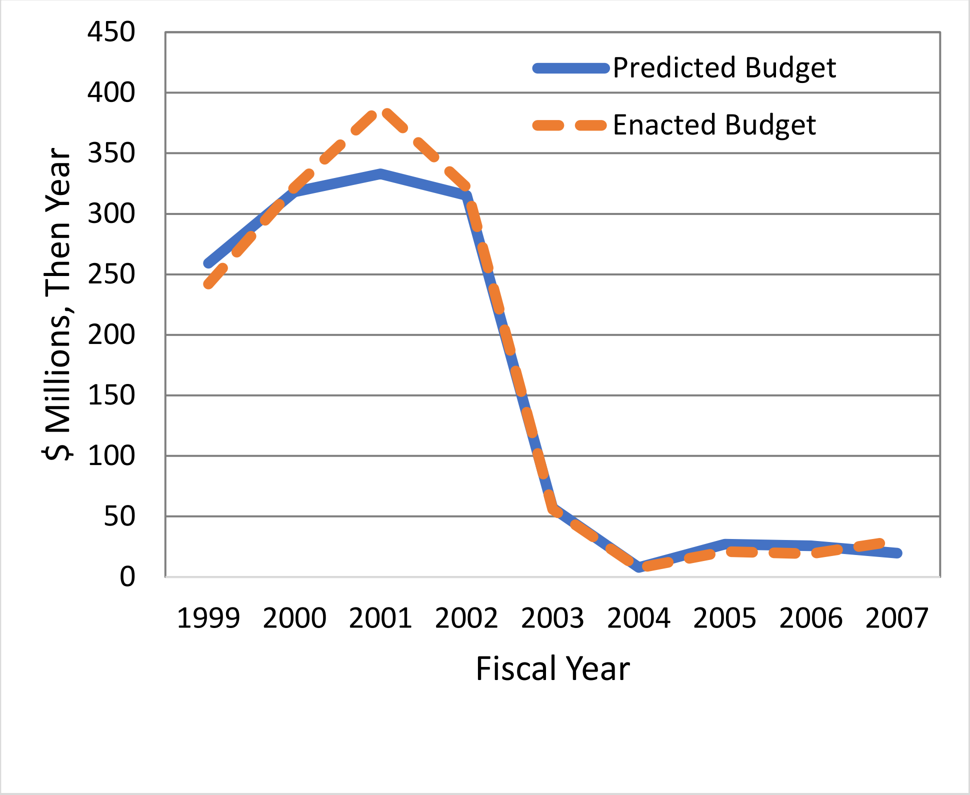
Here, B_A and B_P refer to actual and predicted RDT&E budgets, respectively and N represents the number of years between program initiation and IOC. High budget instability levels correspond to programs that experienced substantial RDT&E budget increases between program initiation and IOC. Low budget instability, of course, corresponds to the opposite scenario.

Unfortunately, budget data for many MDAPs in the database were unavailable. In particular, the RAND's DSCP database did not include budget data. Many of the programs in DAMIR were also missing budget data. As such, the analysis of budget instability was necessarily limited to the handful of programs for which data was available.

For an initial look at budget instability, the average yearly instability between program initiation and IOC was calculated for each program using the equation above. Using a simple linear regression, no statistically significant association was observed between percent cycle time growth and average budget instability.[x]

Importantly, for many programs, average budget instability included both positive and negative numbers (i.e., some years a program's budget increased, and some years a program's budget decreased). For this reason, two additional metrics were explored: median budget instability and minimum budget instability between program initiation and IOC. Minimum budget instability corresponds to the largest budget cut that a program experienced prior to IOC. If no budget cuts occurred, then minimum budget stability corresponds to the minimum budget increase experienced. For both metrics, running a simple linear regression yielded no statistically significant association between budget instability and percent cycle time growth.[y]

Figure 7: Mean Percent Budget Instability and Percent Cycle Time Growth



Source: DAMIR and CSIS analysis.

Although no association was observed between acquisition speed—as measured by percent cycle time growth—and various measures of budget instability, confidence in these results should be tempered by the quality and availability of data. Future research, therefore, may consider

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[x] Using a simple linear regression of percent cycle time growth on average budget instability, we did not find a statistically significant association (p=0.36, $R^2<0.0$).

[y] Using a simple linear regression of percent cycle time growth on median budget instability, we did not find a statistically significant association (p=0.33, $R^2<0.0$). Following the same approach for minimum budget instability, we also did not find a statistically significant association (p=0.22, $R^2<0.0$).

matching DAMIR data with external sources for budget data, in order to improve the quality and quantity of available data.

About the Authors

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[1] Peter Levine, *Defense Management Reform: How to Make the Pentagon Work Better and Cost Less* (Stanford, CA: Stanford University Press, 2020), 83. For additional discussion of acquisition reform cycles, see: J. Ronald Fox, *Defense Acquisition Reform 1960-2009: An Elusive Goal* (Washington, DC: Center for Military History United States Army, 2011), https://www.hbs.edu/faculty/Publication%20Files/11-120.pdf; Rosalind Lewis et al., *Acquisition Reform Regimes on Their Own Terms: Context, Mechanisms, Effects, and Space Program Impact* (El Segundo, CA: The Aerospace Corporation, 2019), https://aerospace.org/sites/default/files/2019-02/Lewis-Hastings_AcqReform_01302019.pdf; Rhys McCormick, Andrew Hunter, and Gregory Sanders, *Measuring the Outcomes of Acquisition Reform by Major DOD Components* (Washington, DC: CSIS, 2015), https://www.csis.org/analysis/measuring-outcomes-acquisition-reform-major-dod-components; David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs* (Alexandria, VA: Institute for Defense Analyses, 2014), https://apps.dtic.mil/dtic/tr/fulltext/u2/a609472.pdf; and Andrew Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next," *Texas A&M Journal of Property Law* 5, no. 1 (2018): 37-56, https://scholarship.law.tamu.edu/journal-of-property-law/vol5/iss1/3.

[2] Department of Defense. *Summary of the 2018 National Defense Strategy of the United States of America,* 2018, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf, 10.

[3] For example, Senator John McCain stated "America's technological advantage is eroding—and fast. Over the last decade, our adversaries have invested heavily in anti-access and area denial technologies specifically to counter American military strengths. Our adversaries are building weapon systems while we shuffle paper. If we continue

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with business as usual, I fear the United States could lose its military technological advantage altogether." See: Ryan Evans, "5 Questions with Sen. John McCain on Defense Acquisition Reform and Drinking with Deng," War on the Rocks, July 2015, https://warontherocks.com/2015/07/5-questions-with-sen-john-mccain-on-defense-acquisition-reform-and-drinking-with-deng/; for another example, Senator McCain also stated, "For years, we have been warned that America is losing its technological advantage . . . that is why the DoD needs acquisition reform. Not just for efficiency or to save money. Simply put we will not be able to address the threats facing this nation with the system of organized irresponsibility that the defense acquisition enterprise has become." See: "Department of Defense Acquisition Reform Efforts," Hearing before the Armed Services Committee, United States Senate, 115th Cong., 1st sess., 2017, https://www.armedservices.senate.gov/hearings/17-12-07-department-of-defense-acquisition-reform-efforts; finally, as another example, Assistant Secretary of the Air Force for Acquisition Will Roper stated: "We live in a world where we can't wait 10 years to get a program right ultimately because outside technology, commercial technology is driving this." See: Mark Pomerleau, "DOD acquisition not broken, just slow," C4ISRNet, July 2016, https://www.c4isrnet.com/c2-comms/2016/07/20/dod-acquisition-not-broken-just-slow/.modernizing their militaries with a focus on

[4] Department of Defense. *Summary of the 2018 National Defense Strategy of the United States of America,* 10.

[5] For example, see Peter Levine, *Defense Management Reform: How to Make the Pentagon Work Better and Cost Less*; J. Ronald Fox, *Defense Acquisition Reform 1960-2009: An Elusive Goal*; Rosalind Lewis et al., *Acquisition Reform Regimes on Their Own Terms: Context, Mechanisms, Effects, and Space Program Impact;* Rhys McCormick, Andrew Hunter, and Gregory Sanders, *Measuring the Outcomes of Acquisition Reform by Major DOD Components;* David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs;* and Andrew Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next.

[6] Gansler, J.S.; Lucyshyn, W.; Spiers, A. (2010). *The Effect of the Nunn-McCurdy Amendment on Unit Cost-Growth of Defense Acquisition Projects.* Center for Public Policy and Private Enterprise, School of Public Policy, University of Maryland.https://calhoun.nps.edu/bitstream/handle/10945/55287/UMD-AM-10-155.pdf, vi.

[7] Christensen, D.S.; Searle, D.A.; Vickery, C. "The Impact of the Packard Commission's Recommendations on Reducing Cost Overruns on Defense Acquisition." *Acquisition Review Quarterly,* 1999, https://apps.dtic.mil/dtic/tr/fulltext/u2/a372859.pdf, 257.

[8] Under Secretary of Defense, Acquisition, Technology, and Logistics, *Performance of the Defense Acquisition System, 2016 Annual Report,* Washington, DC: Department of Defense, https://www.acq.osd.mil/fo/docs/Performance-of-Defense-Acquisition-System-2016.pdf, 22.

[9] National Defense Authorization Act for Fiscal Year 2016, Pub. L. 114-92 (2015) Sec. 804; and National Defense Authorization Act for Fiscal Year 2017, Pub. L. 114-328 (2016).

[10] National Defense Authorization Act for Fiscal Year 2017, Pub. L. 114-328 (2016), Sec. 901.

[11] Department of Defense. *Summary of the 2018 National Defense Strategy of the United States of America,* 10.

[12] Our decision to measure cycle time using milestone B or C is consistent with previous cycle time analysis (e.g., see Department of Defense, *Performance of the Defense Acquisition System,* (Washington, DC: Department of Defense, October 2016), 45, https://www.acq.osd.mil/fo/docs/Performance-of-Defense-Acquisition-System-2016.pdf). Although a few programs did report milestone a dates, we opted to use their milestone b dates instead. While this decision shortens reported cycle times in a few instances, we sought to maximize consistency across programs and to measure cycle time from the point at which DOD formally initiates programs and makes resource commitments (i.e., milestone b or c).

[13] Under Secretary of Defense, Acquisition, Technology, and Logistics, *Performance of the Defense Acquisition System, 2016 Annual Report,* 46

[14] Ibid. and David M. Tate, *Acquisition Cycle Time: Defining the Problem,* (Alexandria, VA: Institute for Defense Analyses, 2016), https://www.ida.org/-/media/feature/publications/a/ac/acquisition-cycle-time-defining-the-problem-revised/d-5762.ashx, 2.

[15] David M Tate, *Acquisition Cycle Time: Defining the Problem,* (Alexandria, VA: Institute for Defense Analyses), https://www.ida.org/-/media/feature/publications/a/ac/acquisition-cycle-time-defining-the-problem-revised/d-5762.ashx, 2; and Under Secretary of Defense, Acquisition, Technology, and Logistics, *Performance of the Defense Acquisition System, 2016 Annual Report,* 46.

[16] David M Tate, *Acquisition Cycle Time: Defining the Problem,* 3.

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[17] Peter Levine, *Defense Management Reform: How to Make the Pentagon Work Better and Cost Less* (Stanford, CA: Stanford University Press, 2020), 83.

[18] For example, see Peter Levine, *Defense Management Reform: How to Make the Pentagon Work Better and Cost Less*; J. Ronald Fox, *Defense Acquisition Reform 1960-2009: An Elusive Goal*; Rosalind Lewis et al., *Acquisition Reform Regimes on Their Own Terms: Context, Mechanisms, Effects, and Space Program Impact;* Rhys McCormick, Andrew Hunter, and Gregory Sanders, *Measuring the Outcomes of Acquisition Reform by Major DOD Components;* David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs;* and Andrew Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next."

[19] Peter Levine, *Defense Management Reform: How to Make the Pentagon Work Better and Cost Less*, 148.

[20] Andrew Hunter, "The Cycles of Defense Acquisition Reform and What Comes Next," 39.

[21] David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5; and Thomas Light et al, *Benchmarking Schedules for Major Defense Acquisition,* (Santa Monica, CA: RAND Corporation, 2018), 10, https://www.rand.org/content/dam/rand/pubs/research_reports/RR2100/RR2144/RAND_RR2144.pdf.

[22] David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* v.

[23] Richard H. Van Atta, *Understanding Acquisition Cycle Time: Focusing the Research Problem,* (Alexandria, VA: The Institute for Defense Analyses, 2013), 4, https://www.dau.edu/cop/pm/DAU%20Sponsored%20Documents/Understanding%20Acquisition%20Cycle%20Time%20IDA%20November%202013.pdf.

[24] For example, see: Richard H. Van Atta, *Understanding Acquisition Cycle Time: Focusing the Research Problem;* James V. Monaco and Edward D. White III, "Investigating Schedule Slippage," *Defense Acquisition Review Journal,* https://apps.dtic.mil/dtic/tr/fulltext/u2/a441770.pdf; Jessie Riposo, Megan McKernan, and Chelsea Kaihoi, *Prolonged Cycle Times and Schedule Growth in Defense Acquisition: A Literature Review.* (Santa Monica, CA: RAND Corporation, 2014), https://www.rand.org/pubs/research_reports/RR455.html.

[25] For example, see: Dubos, Saleh, Braun. Technology Readiness Level, Schedule Risk, and Slippage in Spacecraft Design, Journal of Spacecraft and Rockets, Vol. 45, No. 4 (2008))

[26] For example, see Cover, T.M. (1991). Elements of Information Theory. New York: Wiley. And Chaitin, G.J. (1987). Algorithmic Information Theory. Cambridge, UK: Cambridge University

[27] Bearden, David A. "A complexity-based risk assessment of low-cost planetary missions: when is a mission too fast and too cheap?" *Acta Astronautica,* Vol 52, Issues 2-6, January-March 2003, pg. 371-379. Doi: https://doi.org/10.1016/S0094-5765(02)00177-7

[28] For example, see Jessie Riposo, Megan McKernan, and Chelsea Kaihoi, *Prolonged Cycle Times and Schedule Growth in Defense Acquisition: A Literature Review,* 6-7.

[29] David M. Tate, *Acquisition Cycle Time: Defining the Problem (Revised)*, 4.

[30] David M. Tate, *Acquisition Cycle Time: Defining the Problem (Revised)*, 4.

[31] SARs typically provide two schedule estimates: development and production. When it was available, we used the development estimate, which programs make earlier in their lifecycles. When development estimates were unavailable, we deferred to production estimates.

[32] For more information on the databases we used, see: J.M. Jarvaise, J.A. Drezner, and D. Norton, *The Defense System Cost Performance Database: Cost Growth Analysis Using Selected Acquisition Reports* (Santa Monica, CA: RAND Corporation, 1996), https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR625.pdf and Defense Acquisition Programs, *Naval Postgraduate School Dudley Knox Library, https://libguides.nps.edu/acqprog/progcost.*

[33] Statistics quoted in the text and shown in Table 2, Table 3, and Table 4 include all complete MDAPs for which data was available and all active MDAPs initiated prior to FY2015 (cancelled MDAPs are excluded). We used FY2015 as our cut-off date because the most recent data available was from FY2019 and we wished to ensure that all active programs in our sample were at least five years past initiation. This helps eliminate maturity bias, where relatively young, un-fielded programs have optimistic schedule estimates. Our decision to use a five-year cut-off date is based off of an identical assumption made in McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

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[34] For instance, this conference paper appears to have undertaken an approach that assessed schedule in terms of program duration, by measuring duration from initiation to end of production. See: David M. McNicol, "Program Duration, Funding Climate, and Acquisition Policy (Conference Presentation)," *Proceedings of the Seventeenth Annual Acquisition Research Symposium,* https://www.ida.org/-/media/feature/publications/p/pr/program-duration-funding-climate-and-acquisition-policy---conference-presentation/d-13165.ashx.

[35] We used FY2015 as our cut-off date because the most recent data available was from FY2019 and we wished to ensure that all active programs in our sample were at least five years past initiation. This helps eliminate maturity bias, where relatively young, un-fielded programs have optimistic schedule estimates. Our decision to use a five-year cut-off date is based off of an identical assumption made in McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[36] David M Tate, *Acquisition Cycle Time: Defining the Problem,* 1-3

[37] Tim Grayson, *Mosaic Warfare* (Arlington, VA: DARPA, 2018), https://www.darpa.mil/attachments/STO-Mosaic-Distro-A.pdf.

[38] Ibid.

[39] For example, see: Andrea Gilli and Mauro Gilli, "Why China Has Not Caught Up Yet: Military-Technological Superiority and the Limits of Imitation, Reverse Engineering, and Cyber Espionage," *International Security* 43, no. 3 (Winter 2018/2019): 141-189, doi:10.1162/ISEC_a_00337.

[40] "The Chinese People's Liberation Army Air Force. (Briefs).(rolls out program for the development of a new stealth fighter, the J-X)," *Journal of Electronic Defense,* January 1, 2003, https://web.archive.org/web/20150924165623/http://www.highbeam.com/doc/1G1-97131209.html; For example, see: Gilli and Gilli, "Why China Has Not Caught Up Yet," 179; Minnie Chan, "Why China's first stealth fighter was rushed into service with inferior engines," *South China Morning Post*, February 10, 2018, https://www.scmp.com/news/china/diplomacy-defence/article/2130718/why-chinas-first-stealth-fighter-was-rushed-service; Dave Majumdar, "China's New J-20 Stealth Fighter Has Officially Entered Service," *National Interest*, September 28, 2017, https://nationalinterest.org/blog/the-buzz/chinas-new-j-20-stealth-fighter-has-officially-entered-22529; Wendell Minnick, "China Reports Y-20 Aircraft IOC in 2017," Defense News, March 1, 2016, https://www.defensenews.com/breaking-news/2016/03/01/china-reports-y-20-aircraft-ioc-in-2017; and Sebastien Roblin, "Forget about China's stealth fighter or aircraft carriers. This is the plane America needs to worry about," *National Interest*, September 15, 2018, https://nationalinterest.org/blog/buzz/forget-about-chinas-stealth-fighter-or-aircraft-carriers-plane-america-needs-worry-about.

[41] Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century* (Washington, DC: 2015), 16, https://www.oni.navy.mil/Portals/12/Intel%20agencies/China_Media/2015_PLA_NAVY_PUB_Interactive.pdf?ver=2015-12-02-081058-483; "Luyang-III Class/Type 052 Destroyers," Naval Technology, 2020, https://www.naval-technology.com/projects/luyang-052d-destroyers; "Type 052 Luhu Class," Sino Defense, September 3, 2017, http://sinodefence.com/type-052-luhu-class/; and "Type 052 *Luhu*-class Multirole Destroyer," Global Security, last modified October 14, 2019, https://www.globalsecurity.org/military/world/china/luhu.htm.

[42] China Power Team, "What do we know (so far) about China's second aircraft carrier?," CSIS, December 17, 2017, https://chinapower.csis.org/china-aircraft-carrier-type-001a/; Kristen Huang, "China's Type 001A aircraft carrier sets off on latest sea trial as navy prepares to commission ship 'within months'," *South China Morning Post*, October 17, 2019, https://www.scmp.com/news/china/military/article/3033392/chinas-type-001a-aircraft-carrier-sets-latest-sea-trial-navy; Rick Joe, "A Mid-2019 Guide to Chinese Aircraft Carriers: What is the future trajectory of the Chinese People's Liberation Navy carrier program?," *The Diplomat*, July 18, 2019, https://thediplomat.com/2019/06/a-mid-2019-guide-to-chinese-aircraft-carriers/; and Ben Blanchard, "China's new aircraft carrier enters service at South China Sea base," Reuters, December 17, 2019, https://www.reuters.com/article/us-china-defence-carrier/chinas-new-aircraft-carrier-enters-service-at-south-china-sea-base-idUSKBN1YL136.

[43] For some comparisons between DOD and PLA capabilities, please see: Gilli and Gilli, "Why China Has Not Caught Up Yet," 180,182; Roblin, "Forget about China's stealth fighter or aircraft carriers"; Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century,* 22; Toshi Yoshihara and James R. Holmes, "The Master 'PLAN': China's New Guided Missile Destroyer," *The Diplomat*, September 4, 2012, https://thediplomat.com/2012/09/the-master-plan-chinas-new-guided-missile-destroyer/; Minnie Chan, "China Just Launched 2 More Advanced Destroyers – Here's How They Stack Up Against the US Navy's Arleigh Burke-Class

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[44] Budget cycle start date is defined by the start of available data. Budget cycle end date is derived from: David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[45] For a discussion of the "decade of neglect" see: Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II,* (Santa Monica: RAND Corporation, 1990), 32, https://apps.dtic.mil/dtic/tr/fulltext/u2/a238854.pdf. Budget cycle start and end dates are derived from: David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[46] For a discussion of the policies associated with this budget cycle, see: Kevin N. Lewis, *National Security Spending and Budget Trends Since World War II,* 5. Budget cycle start and end dates are derived from: David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[47] Budget cycle discussion, as well as start and end dates are derived from: David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[48] Budget cycle start date is derived from David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.

[49] For a similar assumption, see McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy*, 4.

[50] McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs.*

[51] Ibid., v-vi.

[52] David L. McNicol and Linda Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Program,* vii, 14.

[53] Richard H. Van Atta, *Understanding Acquisition Cycle Time: Focusing the Research Problem,* (Alexandria, VA: The Institute for Defense Analyses, 2013), 4, https://www.dau.edu/cop/pm/DAU%20Sponsored%20Documents/Understanding%20Acquisition%20Cycle%20Time%20IDA%20November%202013.pdf.

[54] One approach is described here: David M. McNicol, "Program Duration, Funding Climate, and Acquisition Policy (Conference Presentation),"

[55] For example, see NDAA 2016, Sec. 804.

[56] For example, see NDAA 2017, Sec. 901.

[57] Government Accountability Office, *Acquisition Reform: DOD Should Streamline Its Decision-Making Process for Weapon Systems to Reduce Inefficiencies* (Washington, DC: 2015), 6, https://www.gao.gov/assets/670/668629.pdf.

[58] Jeffrey A. Drezner et al., *Measuring the Statutory and Regulatory Constraints on Department of Defense Acquisition* (Santa Monica, CA: RAND Corporation, 2007), xii, https://www.rand.org/pubs/monographs/MG569.html.

[59] Samantha Brainard and Zoe Szajnfarber, "Understanding the burden of government oversight on engineering work: Adding empirical data to the debate," *Space Policy* 42 (November 2017): 70, https://doi.org/10.1016/j.spacepol.2017.07.001.

[60] For additional discussion about oversight centralization and decentralization in the context of historic acquisition reforms, please see: Levine, *Defense Management Reform*; Fox, *Defense Acquisition Reform 1960-2009*; Lewis et al., *Acquisition Reform Regimes on Their Own Terms*; and Hunter, "Cycles of Defense Acquisition Reform." Further, we also note that, in addition to characterizing reform cycles in terms of oversight centralization and decentralization, it is also possible to characterize reform cycles according to their focus on regulation or deregulation, their preference for commercial products and processes, and their use of specific contract types and

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approaches. Levine, *Defense Management Reform*, 83. Although we focus on cycles of centralization and decentralization here, we acknowledge that reform cycles come in many types, each of which warrant further study.

[61] For additional discussion of the centralization that occurred during this cycle, please see: Fox, *Defense Acquisition Reform 1960-2009*, 35-36. We derived the cycle start date from the start of Secretary McNamara's tenure at the Pentagon, see: Ibid.

[62] For additional discussion of the decentralization that occurred during this cycle, please see: Fox, *Defense Acquisition Reform 1960-2009*, 47-61. We derived the cycle start date from an analogous cycle identified by McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 3.

[63] For additional discussion of the centralization that occurred during this cycle, please see: Fox, *Defense Acquisition Reform 1960-2009*, 95, 99; and Edward C. Keefer, *Harold Brown Offsetting the Soviet Military Challenge 1977-1981* (Washington, D.C., Historical Office, Office of the Secretary of Defense, 2017), https://history.defense.gov/Portals/70/Documents/secretaryofdefense/OSDSeries_Vol9.pdf, 14. We derived the cycle start date from Fox, *Defense Acquisition Reform 1960-2009, 95.* Note also that Secretary Brown left office in January 1981. We kept the end date of this cycle as FY1982 to be consistent with McNicol and Wu's subsequent cycle, which started in FY1983 and which represented further decentralization of OSD's control in response to Brown's tenure; see Fox, *Defense Acquisition Reform 1960-2009*, 95, 99 and McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 3.

[64] For additional discussion of the decentralization that occurred during this cycle, please see Fox, *Defense Acquisition Reform 1960-2009*, 99. We derived the cycle start date from an analogous cycle identified by McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 3.

[65] For an additional discussion of the centralization that occurred during this cycle, please see: Fox, *Defense Acquisition Reform, 1960-2009,* 129 and Levine, *Defense Management Reform*, 109. We derived the cycle start date from an analogous cycle identified by McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 3.

[66] Fox, *Defense Acquisition Reform, 1960-2009*,134.

[67] For additional discussion of the decentralization that occurred during this cycle, please see: Obaid Younossi et al.,
Improving the Cost Estimation of Space Systems: Past Lessons and Future Recommendations (Santa Monica, CA: RAND Corporation, 2008), 72-81,
https://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG690.pdf; and Levine, *Defense Management Reform,* 116-120, 124-129. We derived the cycle start date from an analogous cycle identified by McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 3.

[68] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Report of the Defense Science Board / Air Force Scientific Advisory Board Joint Task Force on Acquisition of National Security Space Programs* (Washington, D.C., 2003), 3, https://apps.dtic.mil/dtic/tr/fulltext/u2/a429180.pdf; Younossi et al., *Improving the Cost Estimation of Space Systems*, 72-81; and Levine, *Defense Management Reform,* 123.

[69] For additional discussion of the centralization that occurred during this cycle, please see: Levine, *Defense Management Reform*, 131-133. We derived the cycle start date from an analogous cycle identified by Rosalind Lewis et al., *Acquisition Reform Regimes on Their Own Terms: Context, Mechanisms, Effects, and Space Program Impact,* 15.

[70] Ibid., 134

[71] For an additional discussion of the decentralization that occurred during this cycle, please see: Levine, *Defense Management Reform*, 145. We derived the cycle start date from the date that AT&L formally split (Feb. 1, 2018), see: Aaron Mehta, "The Pentagon's acquisition office is gone. Here's what the next 120 days bring," *Defense News,* February 1, 2018, https://www.defensenews.com/pentagon/2018/02/01/the-pentagons-acquisition-office-is-gone-heres-what-the-next-120-days-bring/.

[72] For a similar assumption, see McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy*, 4.

[73] McNicol provides an excellent analogy to illustrate the relationship between OSD and the military services in terms of speed limit enforcement, where the military services tend to speed (i.e., be optimistic about costs) and

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various OSD components serve as traffic cops or courts. The same dynamic likely occurs for schedule estimates as well. For more description, see David L. McNicol, "Cost Growth in Major Weapon Procurement Programs," Institute for Defense Analyses, IDA Paper P-3832, 2004, 41, https://catalyst.library.jhu.edu/catalog/bib_2681939; or see a summary of McNicol's discussion in, Levine, *Defense Management Reform,* 109-110.

[74] Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (Washington, DC, 2018), 10, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

[75] McNicol provides an excellent analogy to illustrate the relationship between OSD and the military services in terms of speed limit enforcement, where the military services tend to speed (i.e., be optimistic about costs) and various OSD components serve as traffic cops or courts. The same dynamic likely occurs for schedule estimates as well. For more description, see David L. McNicol, "Cost Growth in Major Weapon Procurement Programs," Institute for Defense Analyses, IDA Paper P-3832, 2004, 41, https://catalyst.library.jhu.edu/catalog/bib_2681939; or see a summary of McNicol's discussion in, Levine, *Defense Management Reform,* 109-110.

[76] David M. Tate, *Acquisition Cycle Time: Defining the Problem,* 4.

[77] Ibid.

[78] David M Tate, *Acquisition Cycle Time: Defining the Problem,* 4.

[79] Ibid.

[80] McNicol provides an excellent analogy to illustrate the relationship between OSD and the military services in terms of speed limit enforcement, where the military services tend to speed (i.e., be optimistic about costs) and various OSD components serve as traffic cops or courts. The same dynamic likely occurs for schedule estimates as well. For more description, see David L. McNicol, "Cost Growth in Major Weapon Procurement Programs," Institute for Defense Analyses, IDA Paper P-3832, 2004, 41, https://catalyst.library.jhu.edu/catalog/bib_2681939; or see a summary of McNicol's discussion in, Levine, *Defense Management Reform,* 109-110.

[81] See a similar point made in Levine, 146

[82] This analysis followed the procedure suggested in: Thomas Light et al, *Benchmarking Schedules for Major Defense Acquisition.*

[83] David M Tate, *Acquisition Cycle Time: Defining the Problem,* 4.

[84] Statistics quoted in the text and shown in Table 2, Table 3, and Table 4 include all complete MDAPs for which data was available and all active MDAPs initiated prior to FY2015 (cancelled MDAPs are excluded). We used FY2015 as our cut-off date because the most recent data available was from FY2019 and we wished to ensure that all active programs in our sample were at least five years past initiation. This helps eliminate maturity bias, where relatively young, un-fielded programs have optimistic schedule estimates. Our decision to use a five-year cut-off date is based off of an identical assumption made in McNicol and Wu, *Evidence on the Effect of DoD Acquisition Policy and Process on Cost Growth of Major Defense Acquisition Programs,* 5.