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Using ANOVA and Multinomial Logistic Regression to Analyze Defense Acquisition Executive Summary (DAES) and Acquisition Program Baseline (APB) Milestone Estimates to Determine Contributing Factors to Schedule Slips

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Abstract

The process of acquiring Major Defense Acquisition Programs (MDAPs) consumes one of every eight dollars in the Department of Defense budget, costing the Department nearly $90 billion in FY2019. Due to their size and their importance to the warfighter, the success of these programs is paramount to U.S. military dominance for the decades ahead. However, these programs often encounter difficulties, resulting in schedule slips beyond original estimates. During 2014, Under Secretary of Defense for Acquisition, Technology, and Logistics Kendall, instituted the Better Buying Power initiative, which aimed to address the problem of cycle-times and schedule slips. By using analysis of variance (ANOVA) and multinomial logistic regression models to analyze Milestone Current Estimates from Defense Acquisition Executive Summaries (DAES) reports, as well as Milestone Threshold Dates from acquisition program baseline (APB) reports, we seek to determine which factors lead to higher likelihoods of schedule slips. Determining these root causes could inform future acquisition decisions and lead to better original estimates. Our research found that significant mean rank differences exist in all categories and across all schedule slip variables and that as one-month increases occur in the four derive schedule slip variables, there are significant odds that various factor categories are likely to have contributed to that increase in schedule slip.

Key Words: ANOVA, DAES, Logistic Regression, MDAP, Schedule Slip

Introduction

Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L]) Kendall placed an emphasis on reducing cycle-times with his Better Buying Power initiatives, as they are a contributor to program cost growth. As a result of this initiative, many studies have been conducted to examine schedule growth. However, not many utilize ANOVA or logistic regression to analyze the issue. Trudelle, White, Koshnick, Ritschel, and Lucas (2017) utilized logistic regression to determine possible predictors of cost growth and schedule slip. The GAO (2019) investigated causes of schedule slips due to limited use of knowledge base such as maturity of critical technologies, early release of design drawings, and demonstrating that critical manufacturing processes are in statistical control. Light, Leonard, Smith, Wallace, and Arena (2018) created a schedule estimating relationship (SER) based on several MDAP features. Tate (2016) examined reasons that contribute to cycle-times and a possible SER to explain the phenomena.

This research aims to use ANOVA and multinomial logistic regression to determine if there are differences in likelihoods for various features of MDAPs that contribute significantly to schedule slips. We define a "schedule slip" as a deviation in an MDAP's current estimate from its previous estimate. We also derive four measures for analysis. Additionally, we use the DAES data vice data in Selected Acquisition Reports because DAES data is provided more frequently.

Research Questions

- What factors drive schedule slips, and are their mean differences significant?
- Is the likelihood of schedule slips in MDAPs larger due to specific commodity type, service, milestone category, or APB phase categories?

Hypotheses

H_{10}: There is no significant difference in mean schedule slip among MDAPs by APB phase, commodity type, milestone category type, or service type.

H_{1a}: There is a significant difference in mean schedule slip among MDAPs by APB phase, commodity type, milestone category type, or service type.

H_{20}: There is no significant difference in odds of schedule slip among MDAPs by APB phase, commodity type, milestone category type, or service type.

H_{2a}: There is no significant difference in odds of schedule slip among MDAPs by APB phase, commodity type, milestone category type, or service type.

Methodology

We first assemble a DAES and APB data set so that each line represents a specific milestone within a subprogram for a specific DAES report. Next, we manipulate the data to create a schedule slip variable, in months, for each milestone in the subsequent DAES report. Three additional variables were computed rather than taken directly from program characteristics in DAVE/DAMIR. While overarching program characteristics may inform which types of programs and which services are more likely to experience schedule slips, these three variables dive into more granular data encompassing the context in which a milestone event takes place.

The first computed variable, "CE Difference from Current to next DAES," is the primary schedule slip variable of interest and is calculated as the difference, in months, from the current estimate of a specific milestone to the next estimate for the specific milestone. This variable was computed using the Milestone URI field to account for changes in milestone names. Within a specific Milestone URI, we compute the difference in current estimates from the future DAES report back to the current DAES report. An example schematic of the process is displayed in Figure 1.

Milestone URI	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE
DAES Effective Date	1/25/2016	4/25/2016	7/25/2016	10/25/2016	1/25/2017
Current Estimate	Jan-18	Jan-18	Mar-18	Jun-18	Mar-18
Next Current Estimate	Jan-18	Mar-18	Jun-18	Mar-18	
Schedule Slip, months	0	2	3	-3	

Figure 1. CE Difference from Current to Next DAES Schematic

As seen in Figure 2, schedule slips are a rare occurrence. Out of 27,260 observations for which the current estimate exceeded the effective date, 21,664, or almost 80%, of the current estimates did not change.

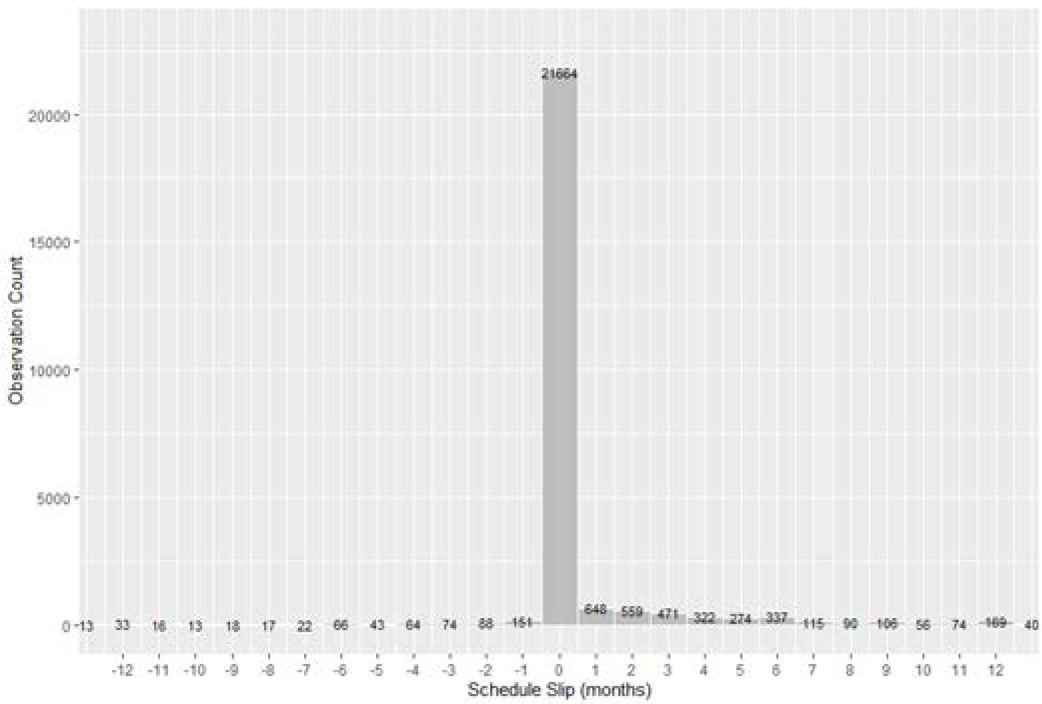

Figure 2. Histogram of CE Difference from Current to Next DAES

A second variable, “CE Difference from Previous to Current DAES,” looks at whether there was a schedule slip between the previous DAES report and the current DAES report. This variable works very similarly to the previously mentioned variable, but looks at the previous DAES report instead of the next DAES report. We hypothesize that this variable may have some impact on future slips because a previous slip indicates that a program is encountering unforeseen difficulties. These unforeseen difficulties may propagate into future additional slips. This variable is essentially a one-period lag from the future slip variable. An example schematic of the process used to calculate this variable is displayed in Figure 3. Notice the difference from the example in Figure 2.

Milestone URI	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE
DAES Effective Date	1/25/2016	4/25/2016	7/25/2016	10/25/2016	1/25/2017
Current Estimate	Jan-18	Jan-18	Mar-18	Jun-18	Mar-18
Previous Current Estimate		Jan-18	Jan-18	Mar-18	Jun-18
Previous Schedule Slip, months		0	2	3	-3

Figure 3. CE Difference from Previous to Current DAES Schematic

Figure 4 illustrates the proportion of milestones that slip given a previous slip. Positive previous slip values indicate milestone slips, while negative previous slip values indicate milestone accelerations. Interestingly, it appears as though larger initial slips correlate with a smaller chance of subsequent slips.

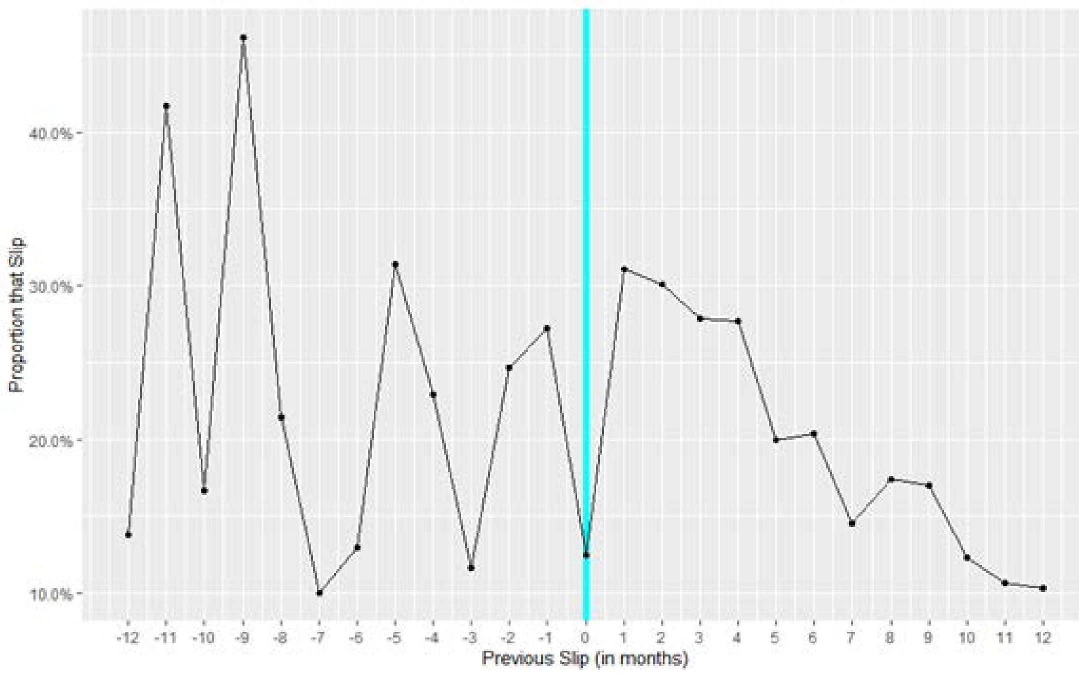

Figure 4. Previous Slip Impact on Future Slips

A third variable, “Months to Threshold,” analyzes schedule behavior as a current estimate approaches the APB Threshold. Programs are incentivized to avoid breaching APB Thresholds, as a breached threshold requires a program to submit a Program Deviation Report (PDR) to its Milestone Decision Authority (MDA). This variable could provide insight into whether programs get better at managing schedules or make tradeoffs in performance or cost in order to meet a schedule threshold. An example schematic for how this variable was calculated is displayed in Figure 5.

Milestone URI	SAMPLE	SAMPLE	SAMPLE	SAMPLE	SAMPLE
DAES Effective Date	1/25/2016 →	4/25/2016 →	7/25/2016 →	10/25/2016 →	1/25/2017
APB Threshold	Mar-18	Mar-18	Mar-18	Mar-18	Mar-18
Current Estimate	Jan-18	Jan-18	Mar-18	Jun-18	Mar-18
Months to Threshold	2	2	0	-3	0

Figure 5. Months to Threshold Schematic

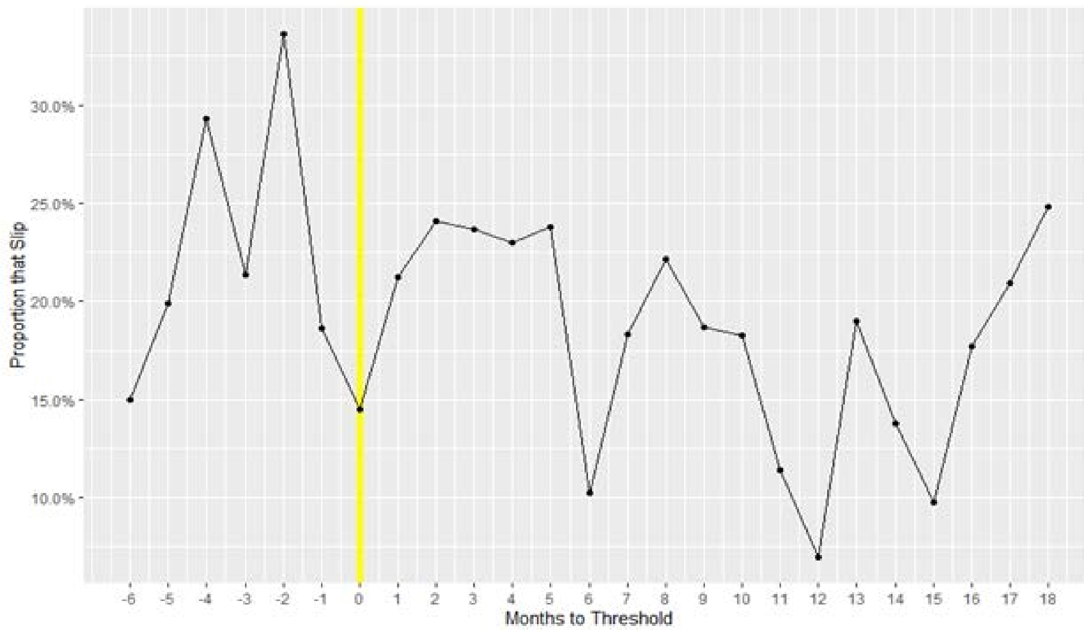

Figure 6. Months to Threshold vs Proportion that Slip

Figure 6 displays the proportion of milestones that slip at each calculated month-to-threshold. A positive number of months to the threshold indicates that a milestone has not breached and that the current estimate is that the milestone will be completed before the threshold. A negative number of months to the threshold indicates breached milestones whose current estimate is that the milestone will be completed after the threshold. Most APB Objective dates are either six months or 12 months before the threshold, so most of the observations in this graph are at +6 months and +12 months. Notice the dip in the graph as the “Months to Threshold” variable approaches 0. This indicates that a smaller proportion of milestones are slipping near the APB threshold.

The fourth variable, “Previous Milestone Slips,” orders milestones within a DAES report by current estimate, then extracts the previous milestone’s schedule slip, in months. This variable reaches across milestone URIs to attempt to create a critical milestone path. One big assumption for this variable is that the milestone path is linear and that the closest previous milestone leads directly to the current milestone. Programs whose milestones follow this assumption have a critical path as displayed in Figure 7.

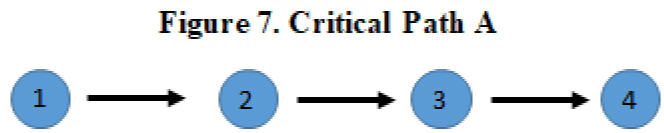

Figure 7. Critical Path A

Programs whose milestones do not follow this assumption might have a critical path as displayed in Figure 8.

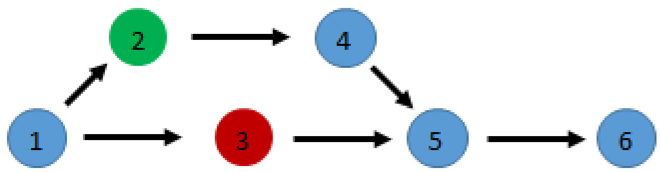

Figure 8. Critical Path B

Notice how the green milestone is the closest previous milestone to the red milestone yet has no direct bearing on the red milestone. Our assumption in using this variable is that most programs follow Critical Path A. If most programs, or even a large minority of programs, follow Critical Path B, then this variable will underestimate the impact the previous milestone's schedule slip has on the current milestone's schedule slip. An example schematic for how this variable is calculated is displayed in Figure 9.

Milestone URI	1	2	3	4
DAES Effective Date	1/25/2016	1/25/2016	1/25/2016	1/25/2016
Current Estimate	Jan-18	Feb-18	May-18	Sep-18
Previous Current Estimate	Jan-18	Jan-18	Mar-18	Aug-18
Previous Schedule Slip, months	0	1	2	1
Previous Milestone Slip		0	1	2

Figure 9. Previous Milestone Slip Variable Schematic

We next perform parametric ANOVA or nonparametric ANOVA analysis on each of the four continuous derived schedule slip variables to determine if there are significant differences between commodity type, service, milestone category, and APB Phase factor groups of MDAPs. Dean and Voss (1999) and Rutherford (2011) state that the assumptions of parametric ANOVA must be met for this analysis method to be valid. These assumptions are normality of the distribution of the various schedule slip variables, equality of variance among various factor groups, and finally, independence of observations. If these assumptions are not met, then nonparametric ANOVA methods such as the Kruskal-Wallis test will be used to determine if significant differences in mean ranks exist among factor groups. If so, the post hoc Kruskal-Nemenyi test will be used to determine if significant pairwise difference comparisons exist.

Finally, multinomial logistic regression of the dependent variables commodity type, service, milestone category, and APB Phase on the four derived schedule slip independent variables will be conducted to determine if the likelihood/odds of one group is larger than another as unit increases in each schedule slip variable occur.

Data Collection

DAES and APB data from the Defense Acquisition Management Information Retrieval (DAMIR) system were merged to create a final data set that contained 105,690 rows of unique milestone-DAES report entries. This data set was culled to include only MDAP programs. The original milestone category variable was transformed to create a revised milestone category variable that included only the initial operational capability (IOC), milestone B (MSB), milestone C (MSC), and an “Other” category. The original commodity type variable was also transformed to group 28 categories down to 11 to facilitate ANOVA and logistic regression analysis. The final data set contained 95,312 observations and 39 variables.

Exploratory Data Analysis

The summary statistics for the four schedule slip variables can be found in Figure 10. The mean of the “Months to Threshold” variable is centered near 4.2 months, while the remaining variables’ means are centered near 0.3. Figures 11–14 illustrate the schedule slip variables’ distribution. All of the variables will have difficulties with achieving the normality assumption, as the skew and kurtosis of their distributions are greater than +/- 2 months for each of those statistics, respectively. Therefore, nonparametric ANOVA techniques will be utilized.

Schedule Slip Variable Summary Statistics

Schedule Slip Variable	N	Mean	Standard Deviation	Median	Min	Max	Skew	Kurtosisis
CE Diff Current to Next DAES	92036	0.24	3.83	0	-304	304	10.02	1316.37
CE Diff Previous to Current DAES	92036	0.24	3.83	0	-304	304	10.02	1316.37
Months to Threshold	90147	4.27	10.83	6	-168	234	1.24	42.5
Previous Milestone Slips	84735	0.17	3.23	0	-304	124	-4.31	1262.45

Figure 10. Schedule Slip Statistics

Analysis

Parametric ANOVA

We began to examine the mean differences in the four derived schedule slip variables based on various factors such as APB phase, commodity type, milestone category type, and service type. However, after checking to determine if the assumptions for using ANOVA held, we found that the distributions of all four variables were not normal, and four individual Bartlett’s tests confirmed there wasn’t equivalence of variance in the factor groups. Two of the assumptions for using the ANOVA technique did not hold, so we used the Kruskal-Wallis nonparametric ANOVA method to examine mean rank differences and the Kruskal-Nemenyi nonparametric post-hoc test method for pairwise mean rank group comparisons.

Nonparametric ANOVA

Kruskal-Wallis nonparametric ANOVA tests for all four schedule slip variables found that there was very strong evidence of a difference (p-value < 0.05) between the mean ranks of at least one pair of groups for the factors (APB phase, commodity type, milestone category type, and service type). Table 1 in Appendix A illustrates the findings for the Difference Current to Next DAES schedule slip variable.

Post-Hoc Analysis

Next, pairwise comparisons were conducted to see which group pairs were significantly different at alpha less than or equal to 0.05. Tables 2–8 display the results of post hoc Kruskal-Nemenyi tests for pairwise comparisons for a few schedule slip variables for some factors. Not enough space was available in the appendix to place all of the analysis tables, as we were limited to 20 pages for this study. There seems to be a trend of the pairwise comparisons for each factor with respect to all schedule slip variables. Regarding the milestone category factor, all pairwise comparisons were significant except for the MSC-IOC and MSC-Other pairs. With respect to the service category there are significant pairwise differences in DoD-Air Force and DoD-Navy pairs. For the Months to Threshold variable, all service category pairwise comparisons were significant. Regarding APB Phase, there are significant pairwise differences in the Production-Concept and Production-Development pairs. Regarding commodity type, there are significant pairwise differences in the Missile-Ship and Missile-Satellite pairs for all the variables. However, for the Months to Threshold variable, the majority of pairs were significant except for the Other-Aircraft, Other-Ground Combat Vehicle, Satellite-Radar, Ship-C3I, and Missile-Submarine pairs.

Logistic Regression

Agresti (2007) and Hilbe (2009) state that the assumptions for multinomial logistic regression are (1) nominal dependent variables; (2) a continuous, nominal, or ordinal independent variable; (3) independence of observations; and (4) no multicollinearity. These assumptions were checked and met, so the model was used for this dataset. A reference level must be chosen for each dependent variable when conducting multinomial logistic regression. IOC, Air Force, Aircraft, and Concept were chosen as reference levels for the Milestone Category Revised, Service, Commodity Type Revised, and APB Phase dependent variables, respectively. Tables 10–20 of Appendix B contain results of the multinomial logistic regression analyses. In general, the multinomial logistic models behaved similarly for the Difference from Current to Next DAES, Difference from Previous to Current DAES, and the Previous Milestone Slip variables when examining the various factors. As such, we only provided tables for the Difference from Current to Next DAES and the Months to Threshold variables. We did, however, provide the actual results later. Only odds with p-values less than 0.05 are considered significant for this analysis.

Table 10 shows that the odds of MDAPs are 0.9%–2.75% higher to be in the IOC milestone category than the MSB, MSC, and Other category as one unit increases in the schedule slip variables CE Difference from Current to Next DAES, CE Difference from Previous to Current DAES, and Previous Milestone Slips occur. Table 11 shows that as Months to Threshold increases one month, the odds of an MDAP are 1.1% higher to be MSB than the IOC milestone category.

Tables 12 shows that as one month increases in the Difference from Current to Next DAES and Difference from Previous to Current DAES variables occur, the odds of an MDAP belonging to the service Air Force are 9% higher than belonging to the DoD. Table 13 shows that as one month increases in the Months to Threshold variable occur, the odds of an MDAP belonging to the service Army is 1.1 % higher than the Air Force. Table 14 shows that as one month increases in the Previous Milestone Slip variable occur, the odds of an MDAP belonging to the service Navy is 1.1 % higher than the Air Force.

Table 15 shows that as one month increases in the Difference from Current to Next DAES, Difference from Previous to Current DAES, and Previous Milestone Slip variables occur, the odds of an MDAP belonging to the APB Phase factor reference level Concept vice Development are 2.5%, 2.2%, and 2.6% higher, respectively. Table 16 shows that as one month increases in the Milestone Threshold variable occur, the odds of an MDAP belonging to the APB Phase factor Production are 4.1% higher than reference level Concept.

Table 20 shows that as one month increases in the Difference from Current to Next DAES, Difference from Previous to Current DAES, and Previous Milestone Slip variables occur, the odds of an MDAP belonging to the Commodity Type factor Ground Combat Vehicle vice reference level Aircraft are 1.5%, 1.5%, and 1.7% higher, respectively. Table 21 shows that as one month increases in the Milestone Threshold variable occur, the odds of an MDAP belonging to the Commodity Type factor "Other" are 2.4% higher than reference level Aircraft.

Results

Based on the results of the Kruskal-Wallis tests, we reject the null hypothesis and conclude there are statistical mean rank differences in schedule slip in MDAPs based on commodity type, service, milestone category, and APB Phase.

Based on the results of the multinomial logistic regressions, we reject the null hypothesis and conclude there is a likelihood/odds of schedule slip in MDAPs based on a specific commodity type, service, milestone category, or APB Phase.

Conclusion

The primary schedule slip variable, "Difference from Current to Next DAES," the secondary schedule slip variable, "Difference from Previous to Current DAES," and the fourth derived schedule slip variable, "Previous Milestone Slip," appear to be affected similarly when acted upon by the same factors. The Months to Threshold variable does not typically behave similarly to the other three derived schedule slips.

Regarding non parametric ANOVA pairwise comparisons, significant mean rank differences exist in all categories and across all schedule slip variables in the same trend. Significant mean rank differences occur as follows:

Service

- DoD–Air Force and DoD–Navy pairs

Milestone Category

- MSB–MSC and MSB–IOC pairs

APB Phase

- Production–Concept and Production–Development pairs

Commodity Type

- Missile–C3I, Missile–Satellite, and Missile–Ship pairs

The above pairs should be examined in more detail for all schedule slip variables as the trend is systematic across all four schedule slip types.

All multinomial logistic regression models provided odds that were significant for unit increases in all schedule slip variables when modeling the service, milestone category, APB phase, and commodity type factors. In general, the multinomial logistic models behaved similarly for the Difference from Current to Next DAES, Difference from Previous to Current DAES, and the Previous Milestone Slip variables when examining the various factors.

Service

- The Air Force is more likely to exhibit slips as one unit increases in the Difference from Current to Next DAES and Difference from Previous to Current DAES variables occur.
- The Army is more likely to exhibit slips as one unit increases in the Months to Threshold variable occur.
- The Navy is more likely to exhibit slips as one unit increases in the Previous Milestone Slips variable occur.

Milestone Category

- IOC is more likely to exhibit slips as one unit increases in all schedule slip variables except Months to Threshold occur.
- MSB is more likely to exhibit slips as one unit increases in Months to Threshold occur.

APB Phase

- The Concept Phase is more likely to exhibit slips as one unit increases in the Difference from Current to Next DAES, Difference from Previous to Current DAES, and Previous Milestone Slip variables occur.
- The Production Phase is more likely to exhibit slips as one unit increases in the Months to Threshold variable occur.

Commodity Type

- The Ground Combat Vehicle commodity type is more likely to exhibit slips as one unit increases in the Current to Next DAES, Difference from Previous to Current DAES, and Previous Milestone Slip variables occur.
- The Other commodity type is more likely to exhibit slips for the Months to Threshold variable.

Limitations of Study

One limitation of this study is that parametric ANOVA was not able to be conducted due to normality and equivalence of variance assumptions. It is more robust than the nonparametric methods utilized in this research. Transforming the original commodity type variable is another limitation, as we may have lumped too many non-similar commodity types and may have provided significant odds in the multinomial logistic regression analysis, where the original groupings would provide the true representation of reality.

Future Research

Examining different eras/time periods in acquisition is interesting. Future research will break the data set into different acquisition epochs to examine the effects of changes in leadership and policy using the methodology from this study. We will also examine further those significant pairwise differences in category groupings. Regression discontinuity models are novel for understanding the impacts of policies on various processes in an organization. We can use a regression discontinuity model to see how the implementation of various acquisition policies affect milestone slips. Finally, we will examine why various APB Phases, milestone categories, service types, and commodity types are more likely to occur in the four schedule slips.

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Appendix A

Kruskal-Wallis and Post-Hoc Kruskal Nemenyi Tests

Table 1. Kruskal Wallis Test
Difference from Current to Next DAES

Factor	DF	Chi-Sq	p-value
APB Phase	3	1107.6	<0.001
Commodity Type	10	280.65	<0.001
Milestone Category Revised	3	161.15	<0.001
Service	3	130.01	<0.001

-

Table 2. Post Hoc Pair-Wise Kruskal-Nemenyi Milestone Category Revised Difference from Current to Next DAES

	Other	IOC	MSB
IOC	0.011		
MSB	0.011	<0.001	
MSC	0.883	0.096	0.02

Table 3. Post Hoc Pair-Wise Kruskal-Nemenyi Service Difference from Current to Next DAES

	Air Force	Army	DoD
Army	0.0493		
DoD	0.0019	0.2442	
Nsvy	0.9002	0.1078	0.0042

Table 4. Post Hoc Pair-Wise Kruskal-Nemenyi Service Months to Threshold

	Air Force	Army	DoD
Army	<0.001		
DoD	<0.001	<0.001	
Navy	<0.001	<0.001	<0.001

Table 5. Post Hoc Pair-Wise Kruskal-Nemenyi Milestone Category Revised Previous Milestone Slip

	Air Force	Army	DoD
Army	0.348		
DoD	0.033	0.363	
Navy	1	0.161	0.013

Table 6. Post Hoc Pair-Wise Kruskal-Nemenyi Milestone APB Phase Difference from Current to Next DAES

	Other	Concept	Development
Concept	0.112536		
Development	0.31421	0.47198	
Production	0.22673	0.00067	<0.001

Table 7. Post Hoc Pair-Wise Kruskal-Nemenyi APB Phase Months to Threshold

	Other	Concept	Development
Concept			
Development		<0.001	
Production		<0.001	<0.001

Table 8. Post Hoc Pair-Wise Kruskal-Nemenyi Commodity Type Revised Difference from Current to Next DAES

	Aircraft	C3I-2	Electronics	Ground Combat Vehicle	Helicopter	Missile	Other	Radar	Satellite	Ship
C3I-2	0.9960									
Electronics	1.0000	0.9959								
Ground Combat Vehicle	0.9999	1.0000	0.9991							
Helicopter	1.0000	0.9907	1.0000	0.9995						
Missile	0.3990	0.0504	0.9984	0.2684	0.6764					
Other	0.7468	0.1525	1.0000	0.5442	0.9324	0.9998				
Radar	0.5510	0.7500	0.5336	0.7344	0.5193	0.1538	0.2306			
Satellite	0.4275	0.8939	0.6743	0.9016	0.4033	0.0044	0.0140	0.9853		
Ship	0.6366	0.9885	0.8750	0.9882	0.6105	0.0044	0.0150	0.9365	1.0000	
Submarine	0.9969	0.9426	1.0000	0.9742	0.9900	1.0000	1.0000	0.3697	0.4699	0.6602

Table 9. Post Hoc Pair-Wise Kruskal-Nemenyi Commodity Type Revised Months to Threshold

	Aircraft	C3I-2	Electronics	Ground Combat Vehicle	Helicopter	Missile	Other	Radar	Satellite	Ship
C3I-2	0.021									
Electronics	<0.001	<0.001								
Ground Combat Vehicle	0.001	<0.001	<0.001							
Helicopter	<0.001	<0.001	<0.001	0.000						
Missile	<0.001	<0.001	<0.001	<0.001	<0.001					
Other	0.236	<0.001	<0.001	0.445	<0.001	<0.001				
Radar	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Satellite	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.000		
Ship	0.001	0.976	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	
Submarine	<0.001	<0.001	<0.001	<0.001	<0.001	0.567	<0.001	<0.001	<0.001	<0.001

Appendix B. Logistic Regression Odds/Relative Risk Output

Table 10. Logistic Regression Output of Milestone Category Against CE Difference from Current to Next DAES: IOC

	Dependent Variable		
	MSB	MSC	Other
CE Difference from current to next DAES	0.992***	0.975***	0.988***
	0.002	0.004	0.003
Constant	4.196***	0.511***	1.163***
	0.01	0.015	0.012
Akaike Inf. Crit.	197,941.40	197,941.40	197,941.40
	*p<0.10;	**p<0.05;	***p<0.01

Table 11. Logistic Regression Output of Milestone Category Against Months to Threshold: IOC Reference Group

	Dependent Variable		
	MSB	MSC	Other
Months.to.Threshold	1.011***	1.005***	1.009***
	0.001	0.001	0.001
Constant	3.927***	0.503***	1.163***
	0.01	0.016	0.013
Akaike Inf. Crit.	194,798.80	194,798.80	197,950.70
	*p<0.10;	**p<0.05;	***p<0.01

Table 12. Logistic Regression Output of Service Against CE Difference from Current to Next DAES: Air Force Reference Group

	Dependent Variable		
	Army	DoD	Navy
CE Difference from current to next DAES	0.997	0.991**	1.002
	0.003	0.004	0.002
Constant	1.622***	0.461***	1.892***
	0.009	0.015	0.012
Akaike Inf. Crit.	234,837.80	234,837.80	234,837.80
	*p<0.10;	**p<0.05;	***p<0.01

Table 13. Logistic Regression Output of Service Against Months to Threshold: Air Force Reference Group

	Dependent Variable		
	Army	DoD	Navy
Months to Threshold	1.011***	1.005***	1.009***
	0.001	0.001	0.001
Constant	3.927***	0.503***	1.104***
	0.01	0.016	0.013
Akaike Inf. Crit.	194,798.80	194,798.80	194,798.80
	*p<0.10;	**p<0.05;	***p<0.01

Table 14. Logistic Regression Output of Service Against Previous Milestone Slip: Air Force Reference Group

	Dependent Variable		
	Army	DoD	Navy
Previous.Milestone.Slip	1	0.995	1.010***
	0.003	0.004	0.002
Constant	1.650***	0.495***	1.959***
	0.01	0.014	0.01
Akaike Inf. Crit.	234,837.80	234,837.80	234,837.80
	*p<0.10;	**p<0.05;	***p<0.01

Table 15. Logistic Regression Output of APB Phase Against CE Difference from Current to Next DAES: Concept Phase Is Reference Group

	Dependent Variable		
	Development	Production	Other
CE Difference from current to next DAES	0.975***	0.994	0.956***
	0.009	0.005	0.005
Constant	2.372***	37.996***	70.903***
	0.042	0.035	0.035
Akaike Inf. Crit.	143,702.10	143,702.10	143,702.10

Table 16. Logistic Regression Output of APB Phase Against Months to Threshold: Concept Phase Is Reference Group

	Dependent Variable	
	Development	**Production**
Months to Threshold	1.023***	1.041***
	0.002	0.002
Constant	35.245***	60.920***
	0.035	0.035
Akaike Inf. Crit.	124,591.70	124,591.70
	*p<0.10;	**p<0.05; ***p<0.01

Table 17. Logistic Regression Output of APB Phase Against Milestone Slip: Concept Phase Is Reference Group

Table 17. Logistic Regression Output of APB Phase against Previous Milestone Slip: Concept Phase is

	Dependent Variable		
	Development	**Production**	**Other**
Previous.Milestone.Slip	0.974**	0.987*	0.941***
	0.011	0.007	0.007
Constant	2.627***	40.258***	79.265***
	0.045	0.039	0.038
Akaike Inf. Crit.	130,588.70	130,588.70	130,588.70
	*p<0.10;	**p<0.05;	***p<0.01

Table 18. Logistic Regression Output of APB Phase Against CE Difference From Current to Next DAES

	Dependent Variable		
	Development	**Production**	**Other**
CE Difference from current to next DAES	0.975***	0.994	0.956***
	0.009	0.005	0.005
Constant	2.372***	37.996***	70.903***
	0.042	0.035	0.035
Akaike Inf. Crit.	143,702.10	143,702.10	143,702.10
	*p<0.10;	**p<0.05;	***p<0.01

Table 19. Logistic Regression Output of APB Phase Against CE Difference From Previous to Current DAES

	Dependent Variable		
	Development	Production	Other
CE Difference from previous to current DAES	0.978***	0.994	0.958***
	0.009	0.005	0.005
Constant	2.396***	38.567***	74.214***
	0.042	0.036	0.036
Akaike Inf. Crit.	142,412.00	142,412.00	142,412.00
	*p<0.10;	**p<0.05;	***p<0.01

Table 20. Logistic Regression Output of Commodity Type Revised Against CE Difference From Current to Next DAES: Aircraft Is Reference Group

	Dependent Variable									
	C3I-2	Electronic	Ground Combat Vehicle	Helicopto	Missile	Other	Radar	Satellite	Ship	Submarin
CE Difference from current to next DAES	1.007**	1.005	1.014***	1.005	0.990***	0.992**	1.003	1.012***	1.007*	0.999
	0.003	0.006	0.004	0.004	0.004	0.003	0.012	0.004	0.004	0.008
Constant	0.878***	0.170***	0.475***	0.693***	0.770***	0.039***	0.039***	0.312***	0.525***	0.117***
	0.012	0.021	0.014	0.013	0.012	0.042	0.042	0.017	0.014	0.025
Akaike Inf. Crit.	398,469.80	398,469.80	398,469.80	398469.8	398,469.80	398,469.80	398,469.80	398,469.80	398,469.80	398,469.80

*p<0.10; **p<0.05; ***p<0.01

Table 21. Logistic Regression Output of Commodity Type Revised Against Months to Threshold: Aircraft Is Reference Group

	Dependent Variable									
	C3I-2	Electronics	Ground Combat Vehicle	Helicoptor	Missile	Other	Radar	Satellite	Ship	Submarine
Months to Threshold	0.989***	0.968***	0.990***	0.995***	1.012***	1.024***	0.995	0.973***	0.978***	1.016***
	0.001	0.002	0.002	0.001	0.001	0.001	0.005	0.002	0.001	0.002
Constant	0.922***	0.137***	0.465***	0.736***	0.762***	0.998	0.043***	0.360***	0.596***	0.113***
	0.013	0.025	0.016	0.014	0.014	0.013	0.045	0.017	0.015	0.028
Akaike Inf. Crit.	386,668.50	386,668.50	386,668.50	386668.5	386,668.50	386,668.50	386,668.50	386,668.50	386,668.50	386,668.50

*p<0.10; **p<0.05; ***p<0.01

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