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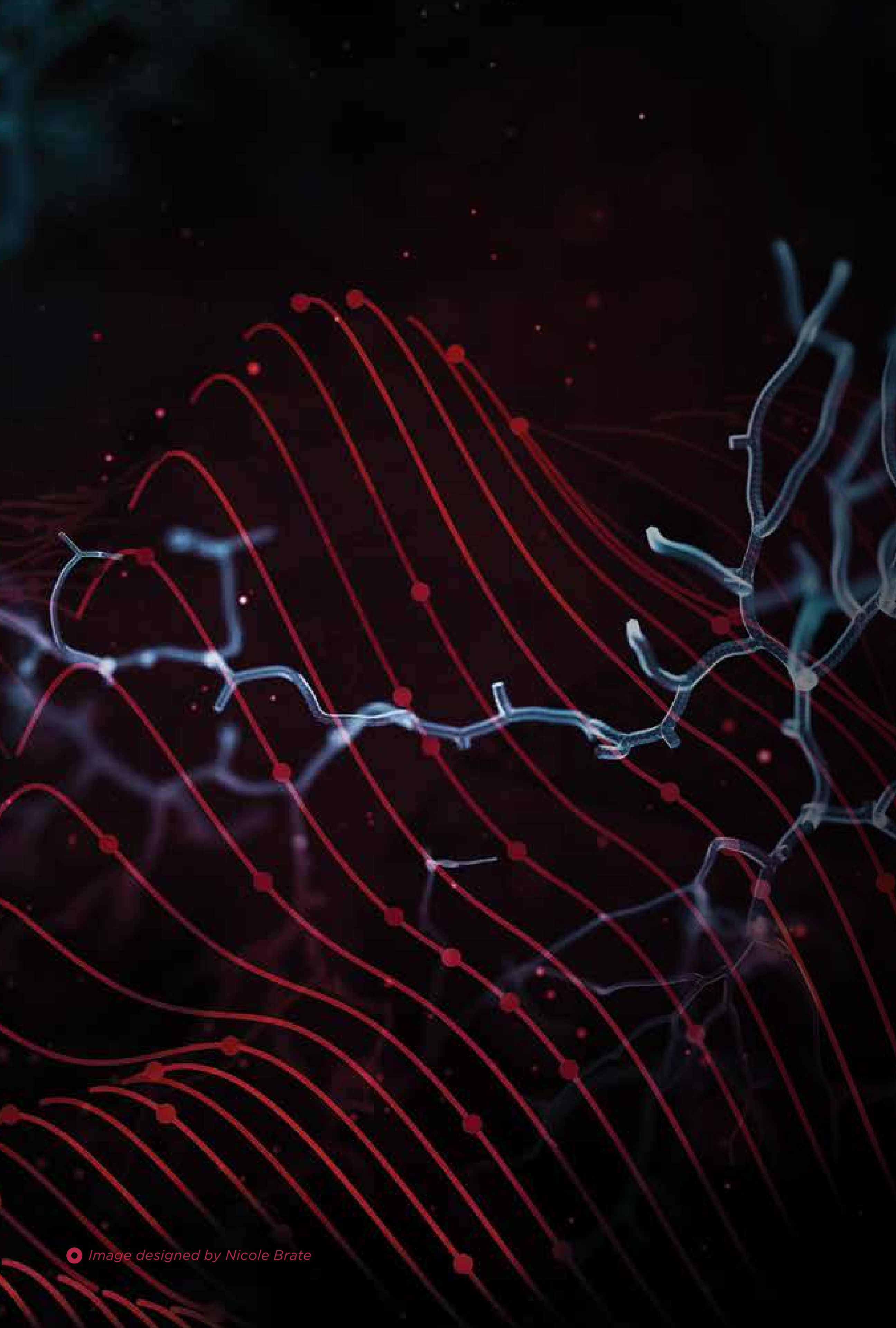

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USE OF FACTORS IN DEVELOPMENT ESTIMATES:

IMPROVING THE COST ANALYST TOOLKIT

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Factor Estimating is a technique commonly used by defense acquisition analysts to develop cost estimations. However, previous studies developing factors for the Engineering and Manufacturing Development (EMD) phase of the life cycle are limited. This research expands the current toolkit for cost analysts by developing cost factors in previously unexplored areas. More specifically, over 400 cost reports are utilized to create new standard cost factors that are delineated by five categories: commodity type, contract type, contractor type, development type, and Service. The factors are developed for those elements that are common in a wide array of projects such as program management, systems engineering, data, or training. This new factor dataset provides cost analysts with the information necessary to appropriately identify and select the most relevant factors to use when developing future cost estimates. Through statistical analysis, the research also helps identify those elements in which more analysts' time and energy should be allocated when developing their estimates.

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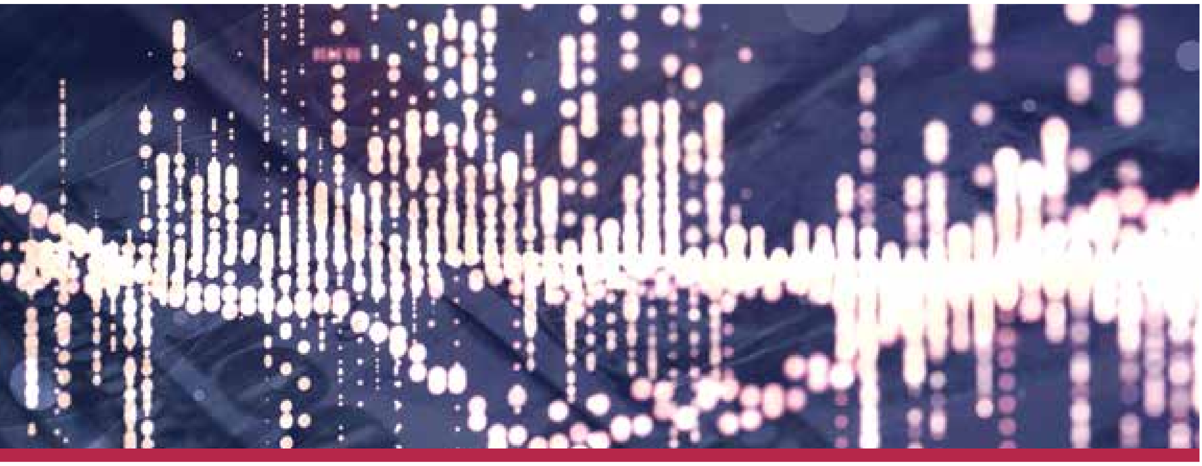
Cost growth in major defense acquisition programs is a well-documented concern (Ritschel et al., 2019; Younossi et al., 2007). This growth is problematic because it crowds out additional programs and leads to an inability to satisfy demands. As a result, cost analysts have conducted numerous studies to determine the causes behind defense program cost growth. Examples of identified causes include decisions by managers to change requirements, externally imposed funding changes, schedule perturbations, and *errors in estimating* or planning (Bolten et al., 2008). This article focuses on refining the cost analyst toolkit in an effort to reduce errors in estimating and thereby improve defense cost estimates and mitigate cost growth. More specifically, this article refines and expands the available set of *cost factors* for estimators to employ in Engineering and Manufacturing Development (EMD) cost estimates.



Defense cost analysts have a range of models and techniques they utilize to estimate program resources. One of these tools is the application of standard cost factors. Factors are traditionally used as primary and/or as cross-check methodologies when estimating major defense acquisition program (MDAP) "common" cost elements such as program management, systems engineering, training, site activation, and spare part costs.

Given that factors are just one of several cost-estimating techniques and that cost-estimating errors account for only a portion of program cost growth, one may question the magnitude of the impact that improvements in cost factors can provide. Research by Miller (2020) illuminates the potential impacts. To ascertain the estimating techniques used by cost analysts, Miller examines a sample of 60 defense development programs from 2003–2018. He finds the factor technique mean value across the 60 programs to be 16.9%. In other words, factor estimating is utilized to determine 16.9% of total cost in EMD cost estimates. The total dollar value of the 60 programs in Miller's (2020) sample is $48.8 billion. Therefore, even small (for example 1–2%) improvements in the accuracy of cost factors employed can result in millions of dollars of estimating error reductions.

> **This article focuses on refining the cost analyst toolkit in an effort to reduce errors in estimating and thereby improve defense cost estimates and mitigate cost growth.**

In what ways can extant factors be improved? What gaps exist? Currently, the research division of the Air Force Life Cycle Management Center (AFLCMC) periodically publishes standard cost factor tables for aircraft EMD that capture prime contractor data for a selection of clean-sheet design aircraft programs. Despite the utility of the AFLCMC-published tables, additional data exist that can assist in refining these factors, as well as developing new factors to include Army, Navy, and Joint programs. Other identified gaps in currently published EMD factors include neglected commodity categories (e.g., electronic/automated software, missiles, ordnance, space, and Unmanned Aerial Vehicles [UAVs]), development types (e.g., modification programs), and subcontractor data. Each additional category of data enables estimators to accomplish more in-depth analysis based on the type of program in question. Thus, expanding and refining factors for EMD programs gives estimators a more robust tool set to draw upon, ultimately leading to more precise estimates.

Literature Review

Several key documents designate and define the cost estimating methodologies utilized within the Department of Defense (DoD), including the *Air Force Cost Analysis Handbook* (AFCAH) and the *Government Accountability Office Cost Estimating and Assessment Guide*. These publications assist in setting a baseline for program offices and cost analysts to craft credible and consistent cost estimates. They also satisfy an overarching requirement for the DoD to have policies in place to safeguard the billions of taxpayer dollars allocated to MDAPs each year (U.S. Government Accountability Office, 2009). While the documents define the acceptable estimating methodologies, they do not represent an all-encompassing guidebook, as every MDAP presents unique challenges. The four primary techniques outlined in the AFCAH are analogy and factor, parametric, build-up (engineering), and expert opinion (subject matter expert) (Department of the Air Force, 2007). While each technique represents a different approach to cost estimating, with associated benefits and drawbacks, the merit of using multiple strategies to achieve greater confidence in an estimate cannot be overstated. The introduction of more than one estimating technique provides cost analysts with the ability to triangulate a point estimate that considers levels of detail not fully captured by individual techniques or estimates. Furthermore, this approach serves as a cross-check to ensure that estimates fall within percentage bounds set by the analyst.

Cost factor creation necessitates an understanding of Work Breakdown Structures (WBS). The WBS concept in MDAPs has remained relatively constant over the past several decades (DoD, 2005). It is a decomposition of a project into smaller, more manageable components, sometimes referred to as the management blueprint for the project (Mislick & Nussbaum, 2015). The WBS is mandated and governed by MIL-STD-881D, ultimately fulfilling broader requirements set forth in DoD Instruction 5000.2; this DoD publication aims to maintain uniformity in definition and consistency of approach for programs developing a WBS (DoD, 2018). For the sake of consistency, the DoD has revised and updated guidance regarding the WBS only when major technological advances or changes in the acquisition process warranted such action (DoD, 2005).

> **“While each technique represents a different approach to cost estimating, with associated benefits and drawbacks, the merit of using multiple strategies to achieve greater confidence in an estimate cannot be overstated.**

The WBS consists of three primary hierarchical levels, with a fourth and fifth sometimes included in expanded forms; for this article, only the second level is addressed. Level two of the WBS captures major elements subordinate to the system identified by level one and consists of prime mission products, including all hardware and software elements. Level two also includes combinations of system-level services applicable to the program, including the following elements common to most programs: integration and assembly, system test and evaluation (ST&E), systems engineering/program management (SE/PM), common support equipment (CSE), peculiar support equipment (PSE), training, data, operational/site activation, and initial spares and repair parts (DoD, 2018). These common elements at level two of the WBS are the focus for developing factors in this article. Benefits

of the WBS mandated by MIL-STD-881D include ease of normalization of data and information across a variety of commodity types and DoD agencies, and the ability to reference past and current MDAPs to better understand and forecast their own costs, schedules, and overall program.

Research on MDAP cost factors in cost estimating is insufficient to fully and efficiently utilize the technique. The Air Force acquisition cost analyst community has conducted unpublished cost factor studies by Wren (1998) and Otte (2015) specific to MDAPs in the EMD phase. These studies, however, are very narrow in scope and apply solely to a limited subset of aircraft programs. Wren (1998) focused solely on developing factors relevant to common factors in 20 aircraft aviation programs. Otte (2015) updated the work of Wren, but his analysis remained narrowly focused on clean-sheet design aircraft programs. The efforts of Wren and Otte represent a sizable stepping stone towards an exhaustive reference table of factors for DoD analysts, but lack the breadth required to make the studies applicable to more than a specific set of programs based at Wright Patterson Air Force Base. Large gaps in cost factor creation exist for additional (e.g., nonaircraft) commodity types, modification programs, subcontractor data, and contract type.

Database

In an effort to reduce defense program cost growth, Congress enacted Pub. L. 111-23, Weapon Systems Acquisition Reform Act of 2009. This act created a Pentagon office—Office of Cost Assessment and Program Evaluation (CAPE). CAPE is chartered to provide independent analysis of resource allocation to deliver the optimal portfolio of defense capability through efficient and effective use of public funds (Office of the Secretary of

Defense [OSD], n.d.). CAPE initiated the development of the Cost Assessment Data Enterprise (CADE) system to help achieve its mission. CADE serves as an integrated web-based application for defense acquisition program cost, schedule, and technical data (OSD, n.d.). Within CADE are Cost Data Summary Reports (CDSR), which contain the data used in this analysis. EMD data were chosen as the only life-cycle phase to be analyzed based on the identified literature gap.

Contractor submittal of CDSRs is mandatory for all major contracts and subcontracts (regardless of contract type) valued at $50 million or more in programs designated as Acquisition Category I (DoD, 2011). The threshold for Acquisition Category I designation is *total* expenditures of $480 million in Research, Development, Test and Evaluation (RDT&E) fiscal year 2014 constant dollars or $2.79 billion in procurement (DoD, 2015). Due to these thresholds, no contracts under $50 million are used in the analysis.

Cost information in CDSRs is reported through a standardized WBS as governed by MIL-STD 881D. The level two WBS elements include system-level services applicable to the program, including elements common to most programs as shown in Table 1. These eight "common" WBS elements in Table 1 are the focus for analyzing factors in this article.

TABLE 1. WBS ELEMENTS

Level 2 Common WBS Elements
Systems Engineering/Program Management (SE/PM)
System Test and Evaluation (ST&E)
Training
Data
Peculiar Support Equipment (PSE)
Common Support Equipment (CSE)
Site Activation
Spares

The final dataset consists of programs spanning from 1961 to 2017, representing a broad range of programs across numerous commodity types and military services. The common WBS mandated by MIL-STD-881D enables consistency in data collection and normalization. The complete dataset within CADE contained 189 programs; however, only 102 of those programs fit the criteria for inclusion in the final dataset (see Appendix A for final program list). Table 2 depicts the exclusion criteria and remaining programs utilized for factor development.

TABLE 2. DATABASE EXCLUSIONS

Category	Number Removed	Remaining Programs
Available Programs in CADE		189
Excluded Commodity Types	35	154
No EMD Data	25	129
CCDR File Format Not .XLS	27	102
Final Dataset for Analysis		102

Several commodity types, such as system of systems, are excluded because they lie outside the scope of this analysis. Additionally, 25 programs lacked associated EMD phase costs and are excluded. Twenty-seven programs contained EMD data but have no accessible files within CADE, resulting in the entire program's exclusion from the dataset. These are primarily older programs with manually transcribed data from the 1980s or earlier, and in many instances the data are illegible.

Methods

The methodological approach has two stages. The first stage is creation of individual factors. The factors are calculated as a ratio of individual level two WBS elements from Table 1 to a base cost. The base cost is the program's Prime Mission Equipment (PME) value, which does not include the contractor's fee or miscellaneous expenses (general and administrative, undistributed budget, management reserve, or facilities capital cost of money). The general form of the calculation is shown in Equation 1.

$$\frac{WBS\ Level\ 2\ Element_{ij}}{PME_j} = Cost\ Factor_{ij}$$

where i = SE/PM, ST&E, Training, Data, PSE, CSE, Spares, and Site Activation

j = individual programs

After establishing cost factors for the level two WBS elements, it is possible to develop composite factors for a myriad of unique categories. Specific level two WBS elements can be examined in groupings to establish aggregate values that represent an average or percentage that can be used in formulating estimates. These groupings allow for analysis at several levels, such as fixed wing aircraft, rotary wing aircraft, a specified contractor for radar modifications, a specified contractor's role in a program (prime versus sub), a specified period for a certain commodity type, and many more.

Once the factors are established for each program, the mean, median, and standard deviation values for the various program groupings are calculated. In addition, interquartile ranges are calculated to examine variability among factors. This allows for descriptive analysis and provides a basis from which the programs are grouped and analyzed to compare differences.

The second stage of analysis subdivides the cost factors into categories for statistical testing to aid the cost analyst in determining appropriate levels of aggregation for practical use. The categories were determined through discussions with cost analyst practitioners in the field. These categories represent the way cost analysts may consider grouping or filtering their data when developing an estimate. The categories are Commodity Type, Service, Contractor Designation, Development Type, and Contract Type, with associated subcategories shown in Table 3.

TABLE 3. CATEGORIES FOR COMPARISON ANALYSIS

Categories				
Service	**Commodity Type**	**Contractor Designation**	**Contract Type**	**Development Type**
Army	Aircraft	Prime	CPAF (Cost Plus Award Fee)	Modification
Navy (includes Marine Corps)	Electronic/ Automated Software	Sub	CPFF (Cost Plus Fixed Fee)	New Design
Air Force	Missile		CPIF (Cost Plus Incentive Fee)	Prototype
Multiple	Ordnance		Cost-Other (Other than CPAF, CPFF, CPIF)	Subsystem
	Space		FFP (Firm Fixed Price)	New Mission Design Series (MDS) Designator
	Unmanned Aerial Vehicle (UAV)		FPI (Fixed Price Incentive)	Commercial Derivative
			FPIF (Fixed Price Incentive Firm Target)	
			Fixed - Other	
			Unknown	

For each of the categorical comparisons, hypothesis tests are used to identify differences in the elements detailed in Table 3. For example, differences in cost factors are tested based on whether the work was completed by a

> **The Kruskal-Wallis test is a rank-based nonparametric test to determine whether statistically significant differences exist between two or more groups of an independent variable on a continuous dependent variable.**

prime contractor or subcontractor (shown in the Contractor Designation column of Table 3). One of the most widely used hypothesis test techniques is a parametric test, such as the *t*-test. However, an underlying assumption of parametric tests is that the data are normally distributed. Therefore, a Shapiro-Wilk test was conducted to determine whether or not the data were normally distributed. The results of the test showed that the data were not normally distributed, thereby indicating parametric techniques should not be used.

As a result, nonparametric tests (which do not require the assumption of normality) are utilized throughout the remainder of the analysis. Specific nonparametric tests used include the Kruskal-Wallis and Steel-Dwass tests, which are similar to ANOVA and *t*-tests. The Kruskal-Wallis test is a rank-based nonparametric test to determine whether statistically significant differences exist between two or more groups of an independent variable on a continuous dependent variable. The dependent variable is the numerical cost factor value, while the independent variables are the various groups. For example, contractor type (prime versus subcontractor) is the independent variable, while the cost factor values are the dependent variable. Because the Kruskal-Wallis test does not identify where within the subcategory comparison differences occur, the Steel-Dwass test is employed. The Steel-Dwass multiple comparison test identifies which rank orders of the tested groups are statistically different for each instance of

subcategory comparison. The definition of statistical significance used throughout the analysis will be in reference to an $\alpha = 0.05$ level. This means that in order for the results to be deemed statistically significant, there is less than a 5% chance of concluding that a difference exists where there is no actual difference.

Results

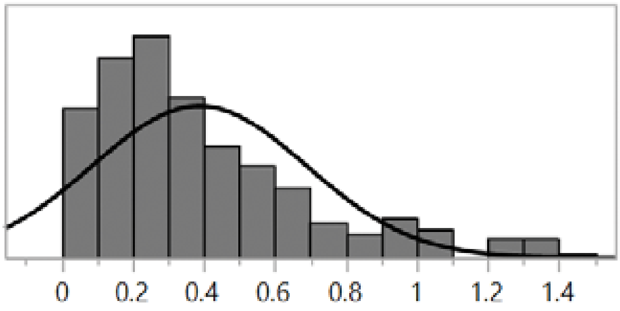
Factor development in stage one of the analysis applies Equation 1 to the dataset. More specifically, the eight level two WBS elements identified in Table 1 are combined with the final 102 program dataset. For example, a factor for ST&E (one of the WBS elements identified in Table 1) is developed for the C-17 program (one of the 102 programs identified in Appendix A) utilizing Equation 1. It is important to note that within an individual program, there may be multiple Cost Data Summary Reports (CDSR) reported in the CADE database. These reports serve as the primary means within the DoD to collect actual data reported by contractors in performing acquisition contracts. Therefore, the 102 programs used for analysis expands to 443 individual cost reports from which new, unique cost factors are created across the eight common WBS elements.

TABLE 4. FACTORS BY CATEGORY TYPE

Category	Total	Category	Total	Category	Total
Unique Factors Created	443	**Development Type**		**Contract Type**	
Commodity Type		Commercial Derivative	4	CPAF	74
Aircraft	245	Modification	135	CPFF	39
Electronic/ Automated Software	118	New Design	150	CPIF	66
Missile	22	Prototype	9	Cost-Other	135
Ordnance	12	Subsystem	105	FFP	27
Space	36	New Mission Design Series (MDS) Designator	40	FPI	20
Unmanned Aerial Vehicle (UAV)	10	**Service**		FPIF	19
Contractor Type		Air Force	196	Fixed-Other	6
Prime	308	Army	94	Unknown	57
Subcontractor	135	Multiple	24		
		Navy (includes Marine Corps)	129		

Individual factors from a CDSR, relevant only to the peculiarities of a specific program, are of limited utility to cost analysts. For example, the ST&E factor from the C-17 is undoubtedly useful to the C-17 program office; but relying on this single factor as the basis for analysis on a different program inserts additional uncertainty into that estimate. The credibility of a cost estimate is only as good as the data from which it is developed. Basing an estimate off a single data point goes against cost-estimating best practices. Therefore, the individual factors developed from the 443 CDSRs are mapped into composite factors. These composite factors are created according to the subcategories in Table 4, and descriptive statistics including mean, median, and standard deviation are calculated. (See Appendix B for the descriptive statistics for each of the eight common WBS elements.)

FIGURE. SE/PM SHAPIRO-WILK TEST



Goodness-of-Fit Test

	W	Prob<W
Shapiro-Wilk W Test	0.8855	<.0001*

The subcategories in Table 4 primarily represent subcategories established within the data hierarchy of the CADE database. These subcategories can be statistically tested to identify where differences exist. If differences are not found between the subcategories, then analysts can use composite factors comprising a wider dataset. However, if differences exist, then analysts should only use factors comprising programs within that unique subcategory. First, normality of the eight common WBS elements is tested with the Shapiro-Wilk test at an $\alpha = 0.05$ threshold. Results for the first element tested, SE/PM, are shown in the Figure.

As shown in the Figure, the null hypothesis is rejected with a p-value of less than 0.0001. (Note: The null hypothesis states that there is no significant difference between a normal distribution and the data; a rejection of the null therefore indicates that differences are present and the data are not normally distributed.) Similar Shapiro-Wilk test results for the subsequent seven WBS elements (not shown) rejected the null hypothesis, necessitating nonparametric testing throughout the remainder of the analysis. Nonparametric testing identifies similarities of locations in the data elements analyzed. Histograms of the data in this analysis reveal a consistent right-skewed profile. Due to the similarities in the shape of the histograms, the nonparametric tests can be considered to be testing medians (Hollander et al., 2014). Therefore, subsequent discussion of nonparametric results will focus on differences in the medians of the data.

Commodity Type

The first category analyzed is commodity type. The Kruskal-Wallis test reveals statistical differences between WBS element median values (Table 5). Specific differences are identified within the SE/PM, ST&E, and Site Activation WBS elements.

TABLE 5. KRUSKAL-WALLIS RESULTS FOR COMMODITY TYPE

WBS Element	Alpha	N	Chi-Square	*P*-value	Null Hypothesis Test Result
SE/PM	0.05	406	49.2441	<0.0001	Reject
ST&E	0.05	374	32.3203	<0.0001	Reject
Training	0.05	192	6.9636	0.2234	Do Not Reject
Data	0.05	267	6.1052	0.2961	Do Not Reject
PSE	0.05	149	2.2603	0.8121	Do Not Reject
CSE	0.05	50	1.0203	0.9609	Do Not Reject
Site Activation	0.05	47	14.4899	0.0059	Reject
Spares	0.05	84	3.7434	0.2905	Do Not Reject

TABLE 6. COMMODITY DIFFERENCES SUMMARY

	Aircraft	Electronic/ Automated Software	Missile	Ordnance	Space	UAV
SE/PM	2	1	1	0	0	0
ST&E	2	1	1	0	3	1
Site Activation	1	1	0	0	0	0

After determining that statistical differences exist, the Steel-Dwass multiple comparison test is employed to identify which commodity types exhibited differences. The identification of differences through the statistical tests tells the analyst that utilizing the more readily available aggregated factors is ill-advised. Rather, it indicates that the analysts should take more time to refine and narrow the dataset to account for the differences and isolate the relevant data. Table 6 summarizes the findings for each WBS element with the number of differences annotated by commodity type. The aircraft commodity type contains the most statistical differences, with five instances where the WBS median values were statistically different from the other subcategories (for example, the median SE/PM cost factor for aircraft is different than both the SE/PM cost factor for electronic/automated software systems and missiles). The space and electronic/automated software contain the second most statistical differences with three each. For the WBS elements, SE/PM and ST&E contain 85.7% of all differences. The implications for practical usage are that standard factors for SE/PM and ST&E should be careful to ensure delineation by commodity type and not modeled at aggregated levels. This is especially important for these two WBS elements, as they have the highest factor values with respect to PME among all the elements. In other words, these two elements have the largest cost impacts of all the WBS elements. Thus, taking the extra time and effort to refine the cost factor by commodity type is suggested in these areas.

Contract Type

The second category analyzed is contract type. Contract types are designated on the Contractor Cost Data Reporting (CCDR) system. There are two broad categories of contract type: cost reimbursable contracts and fixed price contracts. Further subdivision of these categories ranges from firm-fixed-price, in which the contractor has full responsibility for the performance costs and resulting profit (or loss), to cost plus-fixed-fee, in which the contractor has minimal responsibility for the performance costs and the negotiated profit is fixed. In between are the various incentive contracts where the contractor's responsibility for the performance costs and the profit or fee incentives offered are tailored to the uncertainties involved in contract performance. Examples include cost plus award fee or cost plus incentive fee.

> **“The identification of differences through the statistical tests tells the analyst that utilizing the more readily available aggregated factors is ill-advised. Rather, it indicates that the analysts should take more time to refine and narrow the dataset to account for the differences and isolate the relevant data.**

The Kruskal-Wallis test results in rejection of the null hypothesis in four areas. Differences in median values are found for SE/PM, ST&E, Data, and Peculiar Support Equipment (PSE) (Table 7).

Conducting the Steel-Dwass multiple comparison test across all contract types reveals statistically significant differences across all but one contract type (Table 8). Fixed Price Incentive (FPI) contracts display the most statistical differences with eight. Any project expecting an FPI contract should place increased scrutiny on the programs that contribute to the composite factor calculation and the specific contract type utilized. Additionally, SE/PM and ST&E find 10 differences each. The concentration of differences in the SE/PM and ST&E WBS elements suggests estimators should afford extra time and research for estimates in those areas. [Note that the PSE WBS element displays statistical differences according to the Kruskal-Wallis test in Table 7, but no individual pair differences are found with the Steel-Dwass test. This is due to the extremely low *n* values for several subcategories.]

TABLE 7. KRUSKAL-WALLIS RESULTS FOR CONTRACT TYPE

WBS Element	Alpha	N	Chi-Square	*P*-value	Null Hypothesis Test Result
SE/PM	0.05	406	32.8151	<0.0001	Reject
ST&E	0.05	374	34.4853	<0.0001	Reject
Training	0.05	192	5.6801	0.683	Do Not Reject
Data	0.05	267	19.4757	0.0125	Reject
PSE	0.05	149	18.7037	0.0165	Reject
CSE	0.05	50	6.8419	0.4455	Do Not Reject
Site Activation	0.05	47	9.8514	0.1972	Do Not Reject
Spares	0.05	84	9.4857	0.2196	Do Not Reject

TABLE 8. CONTRACT TYPE DIFFERENCES SUMMARY

	CFAP	CPFF	CPIF	Cost-Other	FFP	EPI	FPIF	Unknown
SE/PM	2	2	0	1	2	3	0	0
ST&E	1	1	0	1	1	5	0	1
Data	0	0	1	0	0	0	0	1

Development Type

The third category analyzed is development type consisting of six subcategories. New Design programs are those with capabilities new to the DoD, while Modifications are defined as programs undergoing a major change to core capabilities or performance. Prototypes are programs intended to test an emerging capability for future utilization. The New Mission Design Series (MDS) Designator subcategory captures existing major programs undergoing minor changes, such as the F-16B, which accommodates two pilots, instead of one, for training purposes. Commercial Derivatives are defined as programs initiated in the commercial market that are adapted for subsequent military use. Lastly, the Subsystem designation is assigned to those programs whose efforts are accomplished independent of the primary project, such as an engine upgrade. The Kruskal-Wallis test reveals differences in five WBS areas: SE/PM, ST&E, Data, PSE, and Spares (Table 9).

TABLE 9. KRUSKAL-WALLIS RESULTS FOR DEVELOPMENT TYPE

WBS Element	Alpha	N	Chi-Square	*P*-value	Null Hypothesis Test Result
SE/PM	0.05	406	18.3391	0.0026	Reject
ST&E	0.05	374	15.3905	0.0088	Reject
Training	0.05	192	6.7041	0.2436	Do Not Reject
Data	0.05	267	13.8759	0.0164	Reject
PSE	0.05	149	11.4644	0.0429	Reject
CSE	0.05	50	6.3575	0.273	Do Not Reject
Site Activation	0.05	47	8.5601	0.128	Do Not Reject
Spares	0.05	84	13.0157	0.0232	Reject

TABLE 10. DEVELOPMENT TYPE DIFFERENCES SUMMARY

	Modification	New Design	Prototype	Subsystem	New MDS Designator	Commercial Derivative
SE/PM	1	2	0	0	1	0
ST&E	0	0	0	1	1	0
Data	0	0	1	0	1	0
PSE	1	0	0	0	1	0
Spares	1	1	0	0	0	0

The Steel-Dwass test identifies median value statistical differences for each development category (Table 10). All development categories have at least one statistically significant difference except for commercial derivatives, which is the smallest category comprising less than 1% of the dataset. The new MDS designator and new design subcategories have the most differences at four and three, respectively. Projects in these two subcategories should ensure factor development does not have other development types in its composite factors.

Contractor Type

The fourth category analyzed is contractor type. The CCDR dataset consisted of prime contractor data and subcontractor data. The majority of the data—69.5%—is prime data. Because the fourth category had only two subcategories, the Steel-Dwass test is not needed. The identification of differences through the Kruskal-Wallis test is sufficient. Results are shown in Table 11.

Differences in the contractor type category are found for only two WBS elements: ST&E and PSE. The small number of differences suggests that composite factor development does not require large amounts of time and effort dedicated to determining whether the data are from the prime or a sub. Rather, aggregated factor models consisting of both contractor types may be sufficient.

TABLE 11. KRUSKAL-WALLIS RESULTS FOR CONTRACTOR TYPE

WBS Element	Alpha	N	Chi-Square	*P*-value	Null Hypothesis Test Result
SE/PM	0.05	406	0.7777	0.3778	Do Not Reject
ST&E	0.05	374	12.064	0.0005	Reject
Training	0.05	192	0.0811	0.7759	Do Not Reject
Data	0.05	267	2.66	0.1029	Do Not Reject
PSE	0.05	149	5.3186	0.0211	Reject
CSE	0.05	50	1.6912	0.1934	Do Not Reject
Site Activation	0.05	47	0.0571	0.8111	Do Not Reject
Spares	0.05	84	0.087	0.768	Do Not Reject

Service

The last category analyzed is military service. The data are subcategorized by Air Force, Army, Navy, and Multiple as designated on the CCDRs. The Kruskal-Wallis test for the Service category identifies statistically different median values in two areas: SE/PM and ST&E (Table 12).

Despite only two WBS elements containing statistical differences in median values, the Steel-Dwass multiple comparison test is able to identify a total of 12 statistically significant instances (Table 13). The Army SE/PM factor is found to be different from all other Services, while the ST&E factor for multiple Services is also different from all others. For these two WBS elements, practitioners should ensure delineation by Service in composite factor development.

TABLE 12. KRUSKAL-WALLIS RESULTS FOR SERVICE

WBS Element	Alpha	N	Chi-Square	*P*-value	Null Hypothesis Test Result
SE/PM	0.05	406	20.1146	0.0002	Reject
ST&E	0.05	374	9.1187	0.0278	Reject
Training	0.05	192	3.7819	0.286	Do Not Reject
Data	0.05	267	1.6337	0.6518	Do Not Reject
PSE	0.05	149	2.666	0.446	Do Not Reject
CSE	0.05	50	2.1053	0.5508	Do Not Reject
Site Activation	0.05	47	1.222	0.7477	Do Not Reject
Spares	0.05	84	1.0621	0.588	Do Not Reject

TABLE 13. SERVICE DIFFERENCES SUMMARY

	Air Force	Army	Navy	Multiple
SE/PM	1	3	1	1
Spares	1	1	1	3

Timeframe-Specific Analysis

The initial dataset exclusion criteria (Table 2) removed 27 programs due to inaccessible files or illegible data entries. These excluded programs are primarily from the 1980s or earlier. Exclusion of these programs may raise concerns of bias in the analysis. To determine whether the exclusion of these older programs has an effect on the factors developed, a timeframe-specific analysis on a subset of the data spanning the past two decades is accomplished using 1998 as the cut-off date. Table 14 displays the descriptive statistics for the SE/PM WBS element for the original dataset, as well as the revised dataset spanning from 1998 to 2017.

TABLE 14. SE/PM DESCRIPTIVE STATISTICS COMPARISON

Commodity	Original Mean	1998–Present Mean	Original Median	1998–Present Median
Aircraft	0.3025	0.3433	0.2292	0.2727
Electronic/Automated Software	0.5463	0.5479	0.4875	0.4875
Missile	0.5014	0.5014	0.3897	0.3897
Ordnance	0.3426	0.3484	0.285	0.3409
Space	0.3825	0.4059	0.3109	0.3109
UAV	0.4913	0.5154	0.3655	0.3887

The descriptive statistics of the subset of data for SE/PM are similar in most cases, and identical in some, to the original dataset. Analysis of other WBS elements (not shown) yields similar results. The consistency displayed between the subset and original dataset leads to the conclusion that the 27 programs excluded due to inaccessible files or illegible entries are unlikely to affect the descriptive statistics or statistical analysis results.

Discussion and Conclusions

This article sought to improve the current state of cost estimating with a focus on furthering EMD cost factors. These improvements are achieved through several avenues. First, new standard cost factors were created from a diverse set of program types comprising over 400 CDSRs. The development and publication of these new factors are useful on their own merit. But additional gains in cost estimation accuracy are possible by determining which factors should be used in various circumstances. This second benefit is determined through statistical testing of relevant categorical grouping (commodity, contract type, development type, contractor, and

Service). When statistical testing *does not* reveal differences in categories, then aggregated composite factors are sufficient. However, when differences *are detected*, then analysts should allocate more time and effort to ensure properly refined composite factors are utilized, rather than relying on the readily available aggregated factors.

The following example illustrates the potential gains to be achieved. In this hypothetical scenario, the analyst is estimating SE/PM for an aircraft. The mean SE/PM cost factor value for the aggregated dataset is 0.3802. While this is a good starting point, the analyst knows through the statistical testing results in this article that SE/PM is frequently found to be unique in a multitude of categories. If only the commodity type of aircraft is known, then the mean SE/PM aircraft cost factor value of 0.3025 would be the value chosen. But perhaps the analyst also knows the type of contract is CPAF. The results in this article indicate that the SE/PM cost factor has statistically different values based on contract type. The analysts, therefore, would be advised to allocate further effort to refining the dataset to include only those programs composed of aircraft with CPAF contracts. In this hypothetical example, the final cost factor value would be 0.2945. The refining of criteria in this example led to a 22.5% difference in mean values of included data points, which if examined in the context of a $30 million program, reflects a $2.57 million difference in the estimate for SE/PM.

Each MDAP presents unique characteristics that must be explored and understood to make the inclusion of its data truly meaningful in the context of constructing a cost estimate.

As shown in the example, each MDAP presents unique characteristics that must be explored and understood to make the inclusion of its data truly meaningful in the context of constructing a cost estimate. Generic composite factors represent a starting point for analysts in instances where MDAP characteristics may be unrefined. Once a program's requirements have been solidified and the manner in which they will be accomplished is well-defined, analysts can refine their dataset to MDAPs with direct application to their program.

As reviewed at the beginning of this article, Miller (2020) found the cost factor technique is commonly used for EMD programs. Thus, even small improvements in the accuracy of cost factors employed can have positive impacts. These better estimates should lead to better program outcomes. As a result, the cost growth due to estimating inaccuracies, as identified by Bolten et al. (2008), should be reduced.

While the discussion thus far has focused on an illustrative example and potential program-level impacts, some specific findings deserve increased attention and can impact where cost analysts allocate effort in refining cost factors germane to their specific estimate. First, knowledge of contract type is highly desirable, as the contract type category contained the highest number of statistical differences between the subcategories. While it would be most advantageous to develop composite factors based on the *precise* contract type (e.g., cost plus award fee), even broader classifications into the *two general categories* of cost reimbursable or fixed price contracts are useful. Second, the commodity type category was found to have the second most differences in median values after contract type. Commodity information should be readily available for any project, allowing for ease of analyst calibration. The results also indicate those areas where analysts should economize their time. Specifically, the results showed fewer differences in the contractor type category. The implication is that deriving the factor from prime or subcontract data has little effect.

> **“Future research should focus not only on factor development in other phases of the life cycle, but also on those elements of cost growth that are not attributable to estimator toolkit deficiencies.**

Lastly, the statistical testing also illuminates which of the eight individual WBS elements deserve the most attention from cost analysts. Interestingly, the SE/PM and ST&E elements were flagged in virtually every categorical test. Making the distinction more compelling is the fact that these two elements typically have the highest in raw dollar value of the WBS elements analyzed. Coupling the high dollar value with the statistical testing results suggests that analysts should spend their time and energy on these areas.

In contrast, elements such as data and training were rarely flagged with statistically significant differences. Aggregated factors are therefore likely to be sufficient in these areas.

Several limitations to this study are noted. First, the analysis applies only to development projects. Projects in the production stage are likely to have different factors. Future research is recommended in this area. Second, the CCDR database that was utilized contained only contract values greater than $50 million. Smaller projects were not considered. Third, 27 older programs could not be analyzed due to inaccessible files or illegible data. Timeframe testing was conducted to analyze the effect with results showing little potential for bias. Lastly, an anonymous reviewer suggested exploring the effects of dollar-weighted factors, rather than equal weighting of individual contracts. This is an area to explore in future research.

The cost factor development and analysis presented here is one step toward improving public procurement in the DoD. Future research should focus not only on factor development in other phases of the life cycle, but also on those elements of cost growth that are not attributable to estimator toolkit deficiencies. Ultimately, it will be the combination of improvements in all these areas that is necessary to achieving efficiency gains in public procurement.

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APPENDIX A

List of Programs

AIRCRAFT

A-6A Full Scale Development
A-6E Full Scale Development
AH-64E Apache (Formerly AB3)
ARH – Armed Reconnaissance Helicopter
B-1 CMUP – B-1 LANCER Penetrating Bomber Conventional Mission Upgrade Program
B-1B Integrated Battle Station (IBS)
B-2 DMS: Defensive Management System
B-2 EHF SATCOM AND COMPUTER INCREMENT I – B-2 Advanced Extremely High Frequency SatCom Capability
B-2 RMP – B-2 Radar Modernization Program
B-52 Combat Network Communications Technology (CONECT)
B-58A Full Scale Development
BLACK HAWK UPGRADE (UH-60M) – Utility Helicopter Upgrade Program
C-130 AMP – C-130 Aircraft Avionics Modernization Program
C-130J – HERCULES Cargo Aircraft Program
C-17A – GLOBEMASTER III Advanced Cargo Aircraft Program
C-5 AMP – C-5 Aircraft Avionics Modernization Program
C-5 RERP – C-5 Aircraft Reliability Enhancement and Re-engineering Program
CH-47F – Cargo Helicopter. CH-47D Helicopter Upgrade Program
CH-53K – Heavy Lift Replacement Program
Comanche – Reconnaissance Attack Helicopter (RAH-66)
CRH – Combat Rescue Helicopter
E-10 – Multi-Sensor Command and Control Aircraft Program
E-2D AHE – E-2D Advanced Hawkeye
F/A-18E/F – SUPER HORNET Naval Strike Fighter
F-22 – RAPTOR Advanced Tactical Fighter
F-22A Increment 3.2B
F-117A Full Scale Development
F-35 – Lightning II Joint Strike Fighter (JSF) Program
H-1 UPGRADES (4BW/4BN) – United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter
JSTARS – Joint Surveillance Target Attack Radar System
KC-135A Full Scale Development
MH-60R – Multi-Mission Helicopter Upgrade
MH-60S – Multi-Mission Combat Support Helicopter
P-8A – Poseidon Program
RQ-4A/B Full Scale Development
V-22 – OSPREY Joint Advanced Vertical Lift Aircraft
VH 71 – Presidential Helicopter Fleet Replacement Program
VH-92A Presidential Helicopter
YA-10 Development

ELECTRONIC/AUTOMATED SOFTWARE

3DELRR – Three-Dimensional Expeditionary Long-Range Radar
ADS (AN/WQR-3) – Advanced Deployable System
AMDR – Air & Missile Defense Radar
AMF JTRS – Joint Tactical Radio System Airborne & Maritime/Fixed Station
AOC-WS – Air and Space Operations Center-Weapon System
CAC2S – Common Aviation Command and Control System
CANES – Consolidated Afloat Network Enterprise Services
CEC – Cooperative Engagement Capability
CIRCM – Common Infrared Countermeasures
DCGS ARMY – Distributed Common Ground System Army
F-15 EPAWSS – Eagle Passive Active Warning Survivability System

FAB-T – Family of Beyond Line-of-Sight Terminals
FBCB2 – Force XXI Battle Command Brigade and Below Program
G/ATOR – Ground/Air Task Oriented Radar
GCSS ARMY – Global Combat Support System Army
GSE – Ground Soldier Ensemble
IAMD – Integrated Air & Missile Defense
ITEP – Improved Turbine Engine Program
JATAS – Joint and Allied Threat Awareness System
JLENS – Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
JPALS – Joint Precision Approach and Landing System
JTRS GMR – Joint Tactical Radio System Ground Mobile Radio
JTRS NED – Joint Tactical Radio System Network Enterprise Domain
Land Warrior – Integrated Soldier Fighting System for the Infantryman
LMP – Logistics Modernization Program
MIDS – Multi-Functional Information Distribution System (Includes Low Volume Terminal and JTRS)
MP RTIP – Multi-Platform Radar Technology Insertion Program
MPS – Mission Planning System
NGJ – Next Generation Jammer
NMT – Navy Multiband Terminal
Space Fence Inc. 1 – Space Fence Ground-Based Radar System Increment 1
WIN-T – Warfighter Information Network-Tactical

MISSILE

APKWS – Advanced Precision Kill Weapon System
AGM-88E AARGM – AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program
AIM-9X – Air-to-Air Missile Upgrade
GMLRS/GMLRS AW – Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket System Alternative Warhead
ICBM – Fuse Modernization Program
JAGM – Joint Air-to-Ground Missile
JASSM (JASSM/JASSM-ER) – Joint Air-to-Surface Standoff Missile
JCM – AGM-169 Joint Common Missile
Offensive Anti-Surface Warfare Increment 1 (Long Range Anti-Ship Missile)
Patriot PAC-3 – Patriot Advanced Capability 3
SM-6 – Standard Missile-6

ORDNANCE

B61 Mod 12 Life Extension Program Toolkit Assembly
ERM – Extended Range Munition
EXCALIBUR – Family of Precision, 155 mm Projectiles
SDB I – Small Diameter Bomb Increment I
SDB II – Small Diameter Bomb, Increment II

SPACE

AEHF – Advanced Extremely High Frequency (AEHF) Satellite Program
EPS – Enhanced Polar System
AIM-9X – Air-to-Air Missile Upgrade
GPS OCX – Global Positioning Satellite Next Generation Control Segment
GPS-IIIA – Global Positioning Satellite III
MUOS – Mobile User Objective System
NAVSTAR GPS – Global Positioning System
NPOESS – National Polar-Orbiting Operational Environmental Satellite System
SBIRS HIGH – Space-Based Infrared System Program, High Component
TSAT – Transformational Satellite Communications System

UAV

GLOBAL HAWK (RQ-4A/B) – High Altitude Endurance Unmanned Aircraft System
MQ-1C Gray Eagle
MQ-4C Triton (formerly Broad Area Maritime Surveillance - BAMS)
NAVY UCAS – Navy Unmanned Combat Air System
REAPER (MQ-9 UAS) – Unmanned Aircraft System
VTUAV – Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)

APPENDIX B

Summary Tables

	Training Summary Table				Data Summary Table			
	Mean	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**
Service								
Air Force	0.0319	0.0093	0.0643	95	0.0385	0.0217	0.0608	126
Army	0.0398	0.0148	0.0673	45	0.0405	0.0180	0.0646	50
Navy	0.0329	0.0071	0.0653	50	0.0319	0.0148	0.0473	85
Multiple	0.0482	0.0482	0.0647	2	0.0194	0.0189	0.0103	6
Development Type								
Modification	0.0245	0.0051	0.0406	64	0.0448	0.0243	0.0664	84
New Design	0.0395	0.0166	0.0772	76	0.0297	0.0134	0.0457	85
Prototype	0.0029	0.0029	0.0019	2	0.0060	0.0042	0.0065	6
Subsystem	0.0277	0.0063	0.0475	23	0.0333	0.0180	0.0616	54
Variant	0.0543	0.0166	0.0886	24	0.0441	0.0269	0.0543	34
Commercial Derivative	0.0134	0.0133	0.0118	3	0.0240	0.0152	0.0187	4
Contractor Type								
Prime	0.0344	0.0100	0.0406	163	0.0384	0.0205	0.0572	206
Subcontractor	0.0329	0.0109	0.0772	29	0.0296	0.0175	0.0555	61
Commodity Type								
Aircraft	0.0307	0.0055	0.0544	111	0.0355	0.0206	0.0498	174
Electronic/Automated Software	0.0527	0.0254	0.0922	53	0.0407	0.0164	0.0736	59
Missile	0.0117	0.0079	0.0122	7	0.0418	0.0107	0.0861	12
Ordnance	0.0081	0.0062	0.0039	6	0.0100	0.0071	0.0109	4
Space	0.0142	0.0146	0.0119	9	0.0240	0.0076	0.0291	10
UAV	0.0176	0.0123	0.0180	6	0.0449	0.0280	0.0534	8
Contract Type								
CPAF	0.0468	0.0275	0.0785	30	0.0376	0.0217	0.0635	39
CPFF	0.0491	0.0167	0.0981	18	0.0362	0.0246	0.0401	19
CPIF	0.0371	0.0079	0.0736	27	0.0243	0.0092	0.0409	43
Cost-Other	0.0313	0.0065	0.0608	59	0.0351	0.0206	0.0571	74
FFP	0.0526	0.0178	0.0640	8	0.0262	0.0133	0.0396	18
FPI	0.0142	0.0159	0.0124	15	0.0358	0.0333	0.0251	19
FPIF	0.0266	0.0102	0.0554	13	0.0691	0.0167	0.1041	16
Fixed-Other	0.0016	0.0016	-	1	0.0060	0.0049	0.0040	4
Unknown	0.0210	0.0047	0.0271	21	0.0468	0.0294	0.0631	35

	SE/PM Summary Table				ST&E Summary Table			
	Mean	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**
Service								
Air Force	0.3685	0.2972	0.2755	177	0.2251	0.1672	0.2074	166
Army	0.5080	0.4426	0.3372	91	0.2157	0.1992	0.1915	80
Navy	0.3393	0.2551	0.3039	115	0.2201	0.1582	0.2150	105
Multiple	0.3142	0.2699	0.2053	23	0.1059	0.0642	0.1027	23
Development Type								
Modification	0.3484	0.2845	0.2555	124	0.2155	0.1396	0.2193	119
New Design	0.4738	0.3759	0.3472	131	0.2143	0.1817	0.1880	114
Prototype	0.1906	0.1783	0.1472	8	0.2673	0.2820	0.1028	9
Subsystem	0.3730	0.2793	0.2816	101	0.1744	0.1038	0.1883	89
Variant	0.3249	0.2517	0.2924	39	0.2934	0.2456	0.2281	39
Commercial Derivative	0.1840	0.2128	0.1011	3	0.1804	0.1585	0.1432	4
Contractor Type								
Prime	0.3849	0.2947	0.3068	284	0.2294	0.1838	0.2019	274
Subcontractor	0.3966	0.3336	0.2898	122	0.1733	0.0999	0.2001	100
Commodity Type								
Aircraft	0.3025	0.2292	0.2385	227	0.2498	0.2036	0.2139	225
Electronic/Automated Software	0.5463	0.4875	0.3511	107	0.1702	0.1038	0.1924	88
Missile	0.5014	0.3897	0.3297	20	0.2041	0.1842	0.1772	18
Ordnance	0.3426	0.2850	0.1737	11	0.1513	0.0961	0.0998	11
Space	0.3825	0.3109	0.3093	31	0.0778	0.0448	0.0879	23
UAV	0.4913	0.3655	0.3217	10	0.2068	0.1893	0.01273	9
Contract Type								
CPAF	0.4128	0.3649	0.2641	66	0.1802	0.1072	0.1964	63
CPFF	0.5189	0.4233	0.3896	37	0.1671	0.0791	0.2095	31
CPIF	0.3905	0.2729	0.2987	61	0.2586	0.1997	0.2200	55
Cost-Other	0.4082	0.3175	0.3103	126	0.1824	0.1277	0.1748	113
FFP	0.2457	0.1560	0.2531	25	0.1777	0.1300	0.1503	20
FPI	0.2118	0.1694	0.2232	17	0.3907	0.3267	0.1991	20
FPIF	0.4203	0.3931	0.2811	19	0.2876	0.2167	0.2168	17
Fixed-Other	0.5720	0.5427	0.2327	2	0.2714	0.2227	0.2483	4
Unknown	0.3131	0.2430	0.2573	51	0.2248	0.1608	0.2163	51
Averages	**0.3802**	**0.3121**	**0.2732**	**75.1852**	**0.2117**	**0.1621**	**0.1822**	**69.2593**

	Training Summary Table				Data Summary Table			
	Mean	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**
Service								
Air Force	0.0646	0.0282	0.0922	79	0.0136	0.0014	0.0313	22
Army	0.0399	0.0115	0.0626	28	0.0211	0.0088	0.0331	14
Navy	0.0592	0.0177	0.0917	40	0.01186	0.0011	0.0224	13
Multiple	0.0593	0.0593	0.0565	2	0.0063	0.0063	-	1
Development Type								
Modification	0.0477	0.0177	0.0880	60	0.0129	0.0013	0.0319	19
New Design	0.0573	0.0286	0.0770	46	0.0148	0.0067	0.0206	18
Prototype	0.0118	0.0090	0.0049	3	0.0001	0.0001	0.0001	2
Subsystem	0.0485	0.0194	0.0609	13	0.0378	0.0063	0.0537	5
Variant	0.0978	0.0481	0.1070	26	0.0108	0.0038	0.0171	5
Commercial Derivative	0.0039	0.0039	-	1	0.0018	0.0018	-	1
Contractor Type								
Prime	0.0497	0.0186	0.0778	120	0.0133	0.0015	0.0268	41
Subcontractor	0.0945	0.0545	0.1110	29	0.0235	0.0095	0.0390	9
Commodity Type								
Aircraft	0.0549	0.216	0.0789	98	0.0125	0.0018	0.0309	31
Electronic/Automated Software	0.0468	0.0094	0.0565	12	0.0149	0.0015	0.0280	7
Missile	0.0716	0.0085	0.0993	11	0.0218	0.0202	0.0212	6
Ordnance	0.0235	0.0182	0.0193	9	0.0353	0.0353	0.0493	2
Space	0.01247	0.0477	0.1673	11	0.0013	0.0013	-	1
UAV	0.0496	0.0213	0.0632	8	0.0209	0.021	0.0327	3
Contract Type								
CPAF	0.0540	0.0347	0.0637	14	0.0069	0.0024	0.0103	10
CPFF	0.0203	0.0092	0.0279	13	0.0365	0.0365	0.0301	2
CPIF	0.0398	0.0214	0.0542	28	0.0215	0.0081	0.0404	9
Cost-Other	0.0699	0.0186	0.1099	44	0.0103	0.0017	0.0193	14
FFP	0.0238	0.0175	0.0249	11	0.0004	0.0006	0.0002	3
FPI	0.1098	0.0619	0.1167	14	0.0028	0.0028	-	1
FPIF	0.0338	0.0042	0.0686	9	0.0290	0.0018	0.0459	9
Fixed-Other	0.0041	0.0041	-	1	-	-	-	-
Unknown	0.0929	0.0798	0.0925	15	0.0057	0.0057	0.0064	2

	Site Activation Summary Table				Spares Summary Table			
	Mean	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**
Service								
Air Force	0.0490	0.0235	0.0798	23	0.0430	0.0113	0.0558	33
Army	0.0299	0.0250	0.0319	4	0.0221	0.0107	0.0259	10
Navy	0.0309	0.0020	0.0686	18	0.0341	0.0225	0.0347	41
Multiple	0.0065	0.0065	0.0049	2	-	-	-	-
Development Type								
Modification	0.0495	0.0141	0.0968	12	0.0222	0.0046	0.0479	25
New Design	0.0500	0.0241	0.0590	19	0.0438	0.0332	0.0394	34
Prototype	0.0040	0.0040	-	1	0.0279	0.0279	-	1
Subsystem	0.0046	0.0410	0.0040	4	0.0283	0.0225	0.0288	7
Variant	0.0276	0.0013	0.07878	9	0.0504	0.0303	0.0493	15
Commercial Derivative	0.0001	0.0001	<0.0001	2	0.0054	0.0054	0.0069	2
Contractor Type								
Prime	0.0405	0.0042	0.0737	40	0.0372	0.0174	0.0468	62
Subcontractor	0.0277	0.0030	0.0519	7	0.0331	0.0195	0.0336	22
Commodity Type								
Aircraft	0.0186	0.0015	0.0476	26	0.0397	0.0168	0.0498	52
Electronic/Automated Software	0.0917	0.0687	0.1018	11	0.0239	0.0152	0.0284	21
Missile	0.0009	0.0009	-	1	-	-	-	-
Ordnance	-	-	-	-	-	-	-	-
Space	0.0602	0.0494	0.0591	6	0.0356	0.0250	0.0304	6
UAV	0.0024	0.0028	0.0017	3	0.0519	0.0302	0.0353	5
Contract Type								
CPAF	0.0498	0.04260	0.0511	5	0.0255	0.0113	0.0298	17
CPFF	0.0277	0.0152	0.0316	6	0.0045	0.0012	0.0074	4
CPIF	0.0723	0.0649	0.0777	6	0.0255	0.0275	0.0192	11
Cost-Other	0.0355	0.0040	0.06750	15	0.0439	0.0226	0.0438	18
FFP	0.0008	0.0005	0.0009	3	0.0410	0.0047	0.0824	7
FPI	0.0023	0.0004	0.0040	4	0.0593	0.0432	0.0545	10
FPIF	0.0090	0.0002	0.0152	3	0.0152	0.0092	0.0195	4
Fixed-Other	-	-	-	-	-	-	-	-
Unknown	0.0790	0.0044	0.1505	5	0.0440	0.0236	0.0428	13

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