PARAMETERS IN PARAMETRIC COST ESTIMATING

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Introduction and Purpose

- A parametric estimating method is one of the most desirable and is a high creditable estimating method available because this method used actual hours to estimate the weapon system development effort.
- Parametric estimating methods have a commercial estimating systems such as, Price System and SEER System, regression method, and factor methods.
- These commercial estimating systems have a universal parameter.
  - First, in order to use either system, the estimators have to calibrate the parameters to meet the industrial environments of there company.
  - Second, the system produces a high level estimate rather than low level of discipline.
- The purpose of this paper is to study how to create a parametric estimating model in a weapon system, especially in an aircraft system.
- A cargo aircraft system engineering organization will be utilized for generating an estimating model.

Methodology

- The first step in a parametric model build-up is to find parameters in engineering performance activities in the engineering organization.

- The second step is to find a relationship among the parameters in the engineering performing groups in order to build a parametric estimating method.

- The engineering organization can be divided into the following three categories based on the engineering performance activities.
  - *Engineering Design (ED) Group:* The main efforts of this group are design structures and engineering system design
  - *Engineering Design Support (EDS) Group:* The primary efforts of this group are supporting only the ED group
  - *Engineering Support (ES) Group:* The ES group supports the Total Engineering Group which consists of the Engineering Design Group and the Avionics/Flight Controls (AVFC) Group

Parameters in Engineering Groups

- *Estimating parameter in ED Group*. Engineering drawing is a primary parameter of this group. Engineering drawings are required in order to complete the structures and engineering system design according to the specification and requirement of the weapons system.

- *Estimating parameter in EDS Group*. Two parameters belong to this EDS group: engineering drawings and ED group hours. Engineering drawings, which are produced from the ED group, have a relationship with the Engineering Release (ER) group. Further the ED group hours have a relationship with Technical Design Service (TDS) group’s hours.

- *Estimating parameter in ES Group*. ED group and AVFC hours are the primary parameter in this group. The primary efforts of the ES group are to support the ED group and AVFC. If the ED group and AVFC have no effort, then the ES group also will have no effort.

Model Development Process

1. Identify parametric opportunity

- Feasibility study
- Management Support
- Set up team

2. Preliminary model design

- Scope/defining
- Assumption
- Interfaces
- Developing

3. Data collection & analysis

- Cost drivers
- Data sources
- Collecting
- Normalizing
- Analyzing

4. Model development

- Refine scope
- Modeling approaches
- Estimating methods
- Calibration

5. Approval process

- Technical buy-in
- Management buy-in
- Update estimating system policy & procedures
- DCMA. DCAA agreement
- Training

6. Model maintenance

- New data
- Technology or process shift
- Periodic recalibration

Parametric Model Build Up

- The parametric estimating model explains an appropriate and valid relationship between independent variables and dependent variable.

- Independent Variables and Definition
  - *Engineering Order (IR & AIR).* Based on the engineering design performance, the drawing, in general, can be divided into Initial Release (IR) and After Initial Release (AIR). Engineering Order (EO) means IR plus AIR. Drawings and EO have the same meaning in this paper.
  - *Engineering Design Group Hours*. Engineering hours accrued from engineering design group.
  - *Total Engineering Hours*. Engineering design hours plus Avionics and Flight Control Group hours.

- Dependent Variables and Definition
  - The dependent variables in this study are the cost estimate hours, such as Engineering Design Group, Engineering Design Support Group, and Engineering Support Group.

Hypotheses and Research Models

- The three hypotheses described are the key for the model to be developed for this study. The three models based on the hypotheses can be delineated as follows:

- ***Research Model 1***
  - Hypothesis 1: There is a positive relationship between the Engineering Orders (EO) and Engineering Design hours.

    Model 1: EDG Hours = $\beta 0 + \beta 1 EO + \varepsilon$

- ***Research Model 2***
  - Ha-1: There is a relationship between numbers of EO and the ER hours.
  - Ha-2: There is a relationship between Engineering Design hours and the TDS hours.

    Model 2-1: ER Hours = $\beta 0 + \beta 1 EOs + \varepsilon$

    Model 2-2: EDSG Hours = $\beta 0 + \beta 1$EDG Hours $+ \varepsilon$

- ***Research Model 3***
  - Hypothesis 3: There is a relationship between Total Engineering (TE) hours and the ES group hours.

    Model 3: ES Group Hours = $\beta 0 + \beta 1$TE Hours $+ \varepsilon$

Assumptions and Limitations

1. The Research method and procedures used in the conduct of this study are appropriate.
2. The Producibility Enhancement and Performance Improvement (PE/PI) projects that issued drawings are selected for this study.
3. For the regression analysis, the data set should be more than eight.
4. If the regression analyses are not appropriated, then a factor method will be used.
5. Outliers in the data set are omitted.

PE/PI PROJECT

- The PE/PI effort incorporates new design, modifies the aircraft systems, and updates new technology for the First Flight aircraft (T-1) after first flight test.
- A PE/PI contract can be summarized as (a) Perform studies and analyses, (b) Design, develop, test, and prototype weapon system improvement and enhancement, (c) System engineering investigation for software block upgrade analyses, studies, and plans final design including software lab infrastructure, and (d) Flight test maintains testing capability.
- The PE/PI projects, therefore, operate separately with the production of aircraft.
- The outcomes of PE/PI projects applied to the T1 are incorporated into the production.

Three Phases of Aircraft PE/PI

- The cargo aircraft PE/PI program has spanned more than 15 years after four years of the first flight September 15, 1991.

- The engineering character of PE/PI contracts can be categorized in three phases in view of aircraft system development modification.
  - Phase 1 (August 1995 – December 2000)
  - Phase 2 (January 2001 – December 2004)
  - Phase 3 (January 2005 – June 2010)

- The aircraft system development and modification can be explained by engineering drawings (EO) in Chart 1 and 2

- Chart 2 shows all combined EOs produced from the ED group except the Electrical engineering group

Three Phases of Aircraft System PE/PI

- Phase 1 (August 1995 – December 2000)
  - The first phase had structure oriented contracts.
  - Therefore, engineering design groups, such as Fuselage, Wing Structure Mission Systems, Propulsion/Environment, Hydraulic/Mechanical Engineering including Electrical Engineering were heavily involved in the first phase

- Phase 2 (January 2001 – December 2004)
  - In the second phase, the engineering design effort slowly declined and the Avionics and Flight Controls group's effort started to grow.

- Phase 3 (January 2005 – June 2010)
  - In the third phase, projects of the Avionics and Flight Control's activity were had a very high volume, along with electrical engineering group, which supporting Avionics/Flight Control's boxes or instruments.

Chart 1: EO produced by ED Group for PE/PI

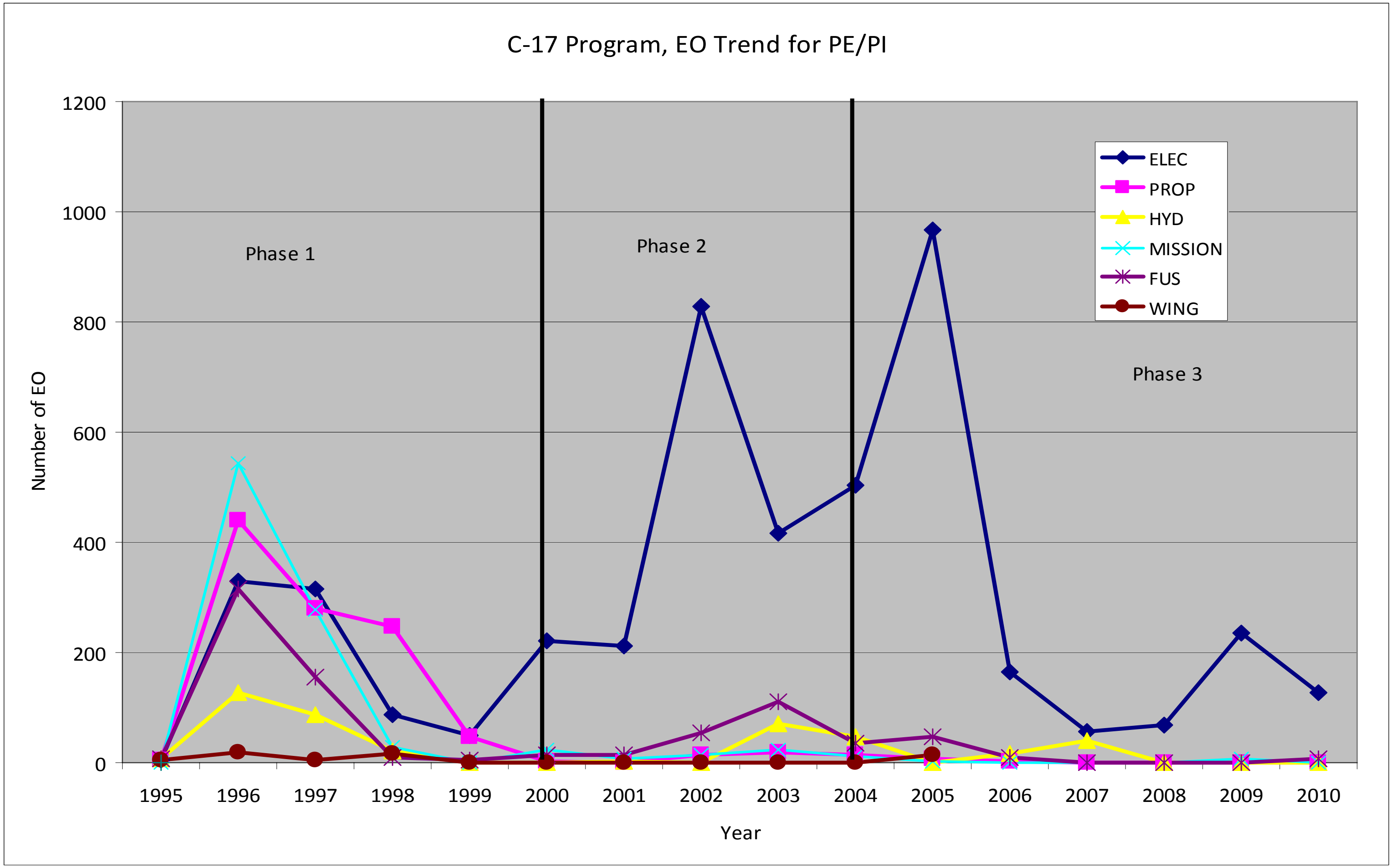
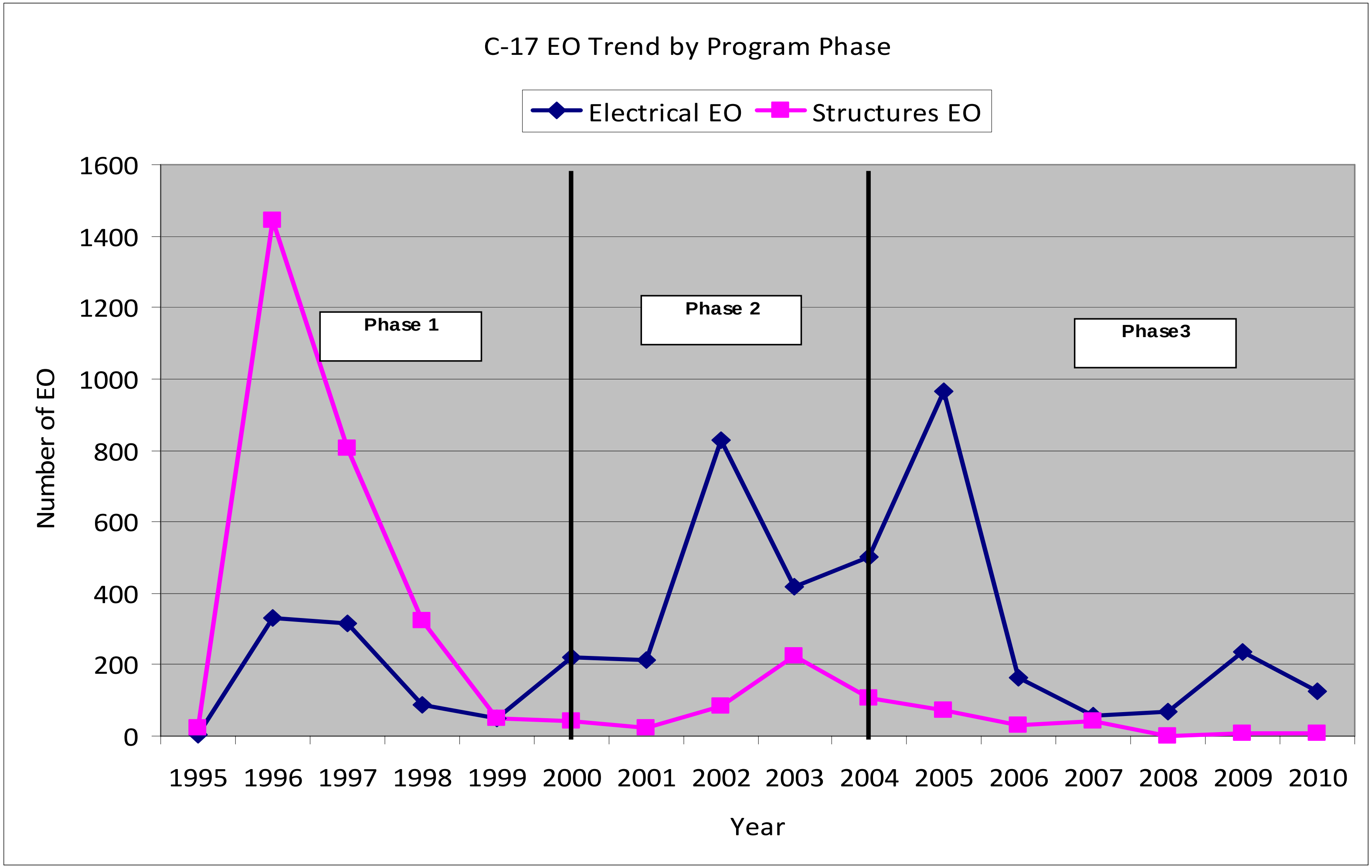


Chart 2: Engineering Orders (EO) for PE/PI



Statistical Analysis

- For the research analysis, the major inferential statistics for regression model analysis included Analysis of Variance (ANOVA) and coefficients analysis.

- An ANOVA table presents five statistical indicators (a) correlation coefficient, (b) R-squared, (c) Adjusted R-square, (d) standard error, and (e) F-value.

- Correlation coefficient of (Pearson's r) measured the strength of the linear relationship between two variables, IV and DV.

- Level of Significance: The level of significance used for this study was 0.05 with a one-tail rejection region (Mendenhall & Sincich, 2003).

Model 1 Test Results by Phases

Research Model 1: ED Hours = β0 + β1EO + ε

- Phase 1
  - Table 1: Model 1 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Electrical Engineering	13	52.4%	27.4%	20.8%	7,825.9	4.16
Fuselage	8	94.4%	89.2%	87.4%	29,530.0	49.37

  - Table 2: Model 1 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Electrical Engineering	(2,886.1)	189.6	5,314.9	93.0	(0.54)	2.04	0.66	0.07
Fuselage	2,335.0	81.5	1,241.2	11.6	1.88	7.03	0.11	0.00

- In summary, only the Fuselage model is statistically significant in the Phase 1. The usable Fuselage cost estimating model is
  - Fuselage Hours = 81.5 * EO + 2,335.0

Model 1 Test Results by Phases (cont'd)

- Phase 2
  - Table 3: Model 1 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Electrical Engineering	13	79.5%	63.1%	59.8%	11,526.8	18.86

  - Table 4: Model 1 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Electrical Engineering	2,235.0	146.9	3,790.0	33.8	0.59	4.34	0.57	0.00

- In summary, the electrical engineering model is statistically significant in the Phase 2. The p-value of intercept, 0.57, is greater than 0.02, therefore, the intercept of 2,235.0 does not strongly support the Electrical parametric model. The usable Electrical engineering estimating model is:
  - Electrical Hours = 146.9 * EO + 2,235.0

Model 1 Test Results by Phases (cont'd)

- Phase 3
  - Table 5: Model 1 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Electrical Engineering	8	98.1%	96.3%	95.7%	5,171.3	157.2

  - Table 6: Model 1 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Electrical Engineering	609.1	105.9	2,226.5	8.5	0.27	12.50	0.79	0.00

- In summary, the parametric equation for the electrical engineering cost estimating is:
  - Electrical Engineering Hours = 105.9 * EO + 609.1

Model 2 Test Results by Phases

Model 2: 2-1: ER Hours = β0 + β1EOs + ε and Model 2-2: EDSG Hours = β0 + β1EDG Hours + ε

- Phase 1
  - Table 7: Model 2 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Release	25	56.3%	31.7%	28.7%	1,970.4	10.66
Technical Design Service	17	70.6%	49.8%	46.4%	394.2	14.87

  - Table 8: Model 2 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Engineering Release	864.6	7.1	458.2	2.2	1.89	3.27	0.07	0.00

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EDG	Intercept	EDG	Intercept	EDG	Intercept	EDG
Technical Design Service	(122.5)	0.0	144.3	0.0	(0.85)	0.39	0.41	0.00

- In summary, both groups are not acceptable in Phase 1 as can be seen in Tables 7 and 8.

Model 2 Test Results by Phases (cont'd)

- Phase 2
  - Table 9: Model 2 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Release	10	82.2%	67.6%	63.5%	5765.9	16.66
Technical Design Service	8	86.8%	75.3%	71.2%	2,798.10	18.3

  - Table 10: Model 2 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Engineering Release	(2,146.2)	28.0	2,294.2	6.9	(0.94)	4.08	0.38	0.00

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EDG	Intercept	EDG	Intercept	EDG	Intercept	EDG
Technical Design Service	(426.8)	0.1	1,368.2	0.0	(0.31)	4.28	0.77	0.01

- In summary, TDS is acceptable, but ER is unacceptable as can be seen in Tables 9 and 10. The acceptable equation for the TDS:
  - TDS Hours = 0.1*EDG Hours - 426.8

Model 2 Test Results by Phases (cont'd)

- Phase 3
  - Table 11: Model 2 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Release	12	88.8%	78.8%	76.7%	452.3	37.3
Technical Design Service	16	59.5%	35.5%	30.8%	1,888.5	7.7

  - Table 12: Model 2 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	EO	Intercept	EO	Intercept	EO	Intercept	EO
Engineering Release	(255.4)	3.4	192.1	0.6	(11.70)	6.10	0.27	0.00

- Both groups have statistical data but the ER is more acceptable than TDS to use as parametric estimating tool. Engineering Release group's statistics are acceptable based on the statistics of Table 12.

- In summary, the parametric equation for the Engineering Release cost estimating is:
  - Engineering Release hours = 3.4 * EO – 255.4

Model 3 Test Results by Phases

Model 3: Model 3: ES Group Hours = β0 + β1TE Hours + ε

- Phase 1
  - Table 13: Model 3 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Support	11	57.2%	32.8%	25.3%	585.9	4.38

  - Table 14: Model 3 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total
Engineering Support	351.2	0.0	217.6	0.0	1.61	2.09	0.14	0.07

- In summary, the engineering support group is unacceptable in Model 3 as can be seen in the tables 13 and 14.

Model 3 Test Results by Phases (cont'd)

- Phase 2
  - Table 15: Model 3 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Support	12	89.2%	79.6%	77.6%	1,080.7	39.12

  - Table 16: Model 3 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total
Engineering Support	863.3	0.02	384.9	0.00	2.24	6.25	0.05	0.00

- In summary, the parametric model of the engineering support group is acceptable in Model 3 as can be seen in Table 15 and 16.

- The engineering support group's cost estimating model is:
  - ✓ ES group Hours = 0.02 * ET hours + 863.3

Model 3 Test Results by Phases (cont'd)

- Phase 3
  - Table 17: Model 3 Regression Statistics and ANOVA

Department Name	Obs	Multiple R	R-square	Adj R-square	SE	F-value
Engineering Support	19	59.0%	34.8%	31.0%	2,483.9	9.08

  - Table 18: Model 3 Coefficients

	Coefficient		SE		t-stat		P-value	
Department Name	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total	Intercept	Eng Total
Engineering Support	2,162.6	0.02	798.5	0.01	2.71	3.01	0.01	0.01

- In summary, the parametric model of the Engineering Support group is unacceptable in Model 3 as can be seen in Tables 17 and 18

Discussion of Research Findings by Model

- Engineering parametric models produced 4 equations by 3 models in the 3 phases.
- In Model 1, only the fuselage engineering among 6 departments had acceptable statistical results in Phase 1, however, the electrical engineering had good statistical value in the Phases 2 and 3.
- In Model 2, both groups are acceptable in Phase 2, however, TDS model is stronger than ER cost estimating equation. The ER cost estimating equation was acceptable in the Phase 3.
- In Model 3, only the engineering support group had a strong regression relationship in Phase 2.

Discussion of Research Findings by Phases

- In conclusion, as predicted, each phase has a unique character of engineering performance in various groups.
- In Phase 1, only the fuselage engineering (Model 1) had significant engineering effort in order to modify or improve the T1 aircraft.
- In Phase 2, only electrical engineering cost model is useable in Model 1 and TDS model also has a significant statistical value to use a cost estimating tool in Model 2. Also ES Group model in Model 3 is good tool to use . In phase 2, the engineering effort continued to grow along with the electrical groups and other design support groups, such as engineering release group, technical design service, and engineering support group. Furthermore, Avionics and Flight Controls had a strong start in engineering performance because of technical changes.
- In Phase 3, only electrical engineering cost estimating model in Model 1 and the engineering release dept in Model 2 have a good statistics for cost estimating tool.

Conclusion

- In conclusion, although this research explored, identifiable characteristics and engineering performance in engineering environment, this paper supports and establishes the relative degree of importance between engineering hours and engineering parameters through simple regression.

- As practical use of an estimating tool, the method should use all estimates, not only partial use.

- In reviewing all models in the three phases, the partial parametric estimating tool cannot be used to estimate PE/PI projects.

- The answer for this solution is to use a factor method. The factor estimating method is the most desirable estimating method in detail and will be explained in the next section.

Factor Estimating Method

- The factor estimating method can provide a good estimate for each department in a project cost development in the development phase for a weapon system.
- This factor estimating method uses historical data in developing projects by applying a valid relationship among engineering groups.
- The relationship among the three engineering functional areas was described in the Hypotheses Test and Research Models section.
  - The first factor method in engineering design group is hours per EO.
  - The second factor method is a piggyback factor method between the engineering design group and the engineering design support group.
  - The last method is another piggyback factor method for the total engineering effort and the engineering support group.
- The prepared factor method in the three phases of the aircraft weapon program as an example can be seen in Table 19. The factor method of three areas of engineering organization and how to apply to the cost estimates will be explained in the next section.

Factor Estimating Method (cont'd)

Table 19

	1995 - 2000			2001 - 2004			2005 - 2010		
Department Name	Hours	EOs	Hours/EO	Hours	EOs	Hours/EO	Hours	EOs	Hours/EO
Wing Structure	2,545.4	25	**101.8**	5,606.5	20	**280.3**	6,992.3	13	**537.9**
Electrical	102,103.4	713	**143.2**	143,947.3	782	**184.1**	203,834.5	2,810	**72.5**
Fuselage	84,346.8	487	**173.2**	42,000.6	188	**223.4**	18,933.5	92	**205.8**
Final/Mission Systems	101,750.2	841	**121.0**	24,492.7	72	**340.2**	12,510.5	25	**500.4**
Hyrdro Mechanical	22,374.0	213	**105.0**	7,821.3	36	**217.3**	24,101.9	121	**199.2**
Propulsion/Environmental System	33,951.3	293	**115.9**	129,312.9	751	**172.2**	12,088.2	32	**377.8**
Eng Design (ED) Group Total (A)	**347,071.1**	**2,572**		**353,181.3**	**1,849**		**278,460.9**	**3,093**	
Standards		32			34			51	
Avionics/Flight Controls		109			23			92	
Others		20			154			179	
	Total EOs	**2,733**		**Total EOs**	**2,060**		**Total EOs**	**3,415**	
		% to EDG	**Hours/EO**		**% to EDG**	**Hours/EO**		**% to EDG**	**Hours/EO**
Engineering Release	41,446.4		**15.2**	35,419.0		**17.2**	7,776.2		**2.3**
M & P /Standards	2,595.5	0.7%		7,403.3	2.1%		17,930.1	6.4%	
Design Assurance	810.6	0.2%		10,656.1	3.0%		15,276.7	5.5%	
UG II Support	1,687.0	0.5%		7,238.2	2.0%		0.0	0.0%	
Design Integration	167.5	0.0%		[illegible]	1.1%		30,728.9	11.0%	
Design Support Total	**5,260.6**	**1.5%**		[illegible]	[illegible]		**63,935.7**	**23.0%**	
Avionics	175,991.0			[illegible]			190,331.2		
Flight Controls	22,820.5			[illegible]			85,583.8		
Core Integration Processor	244,148.8			[illegible]			764,583.2		
Avionics System & Integration	0.0			[illegible]			337,470.5		
Sumulators	27,544.7			[illegible]			1.0		
AV/FLT Integration	3,065.4			7,692.0			9,636.1		
Avionics/Flight Controls Total (B)	**473,570.4**			**496,030.5**			**1,387,605.8**		
Total Engineering (A + B)	**820,641.5**			**849,211.8**			**1,666,066.7**		
		% to Eng Base			**% to Eng Base**			**% to Eng Base**	
Contract Compliance	718.6	**0.1%**		7,474.9	**0.9%**		4,403.0	**0.3%**	
Configuration Management	4,266.3	**0.5%**		6,616.0	**0.8%**		14,108.7	**0.8%**	
System Engineering	n/a			5,120.6	**0.6%**		44,080.7	**2.6%**	
Performance	840.4	**0.1%**		8,196.3	**1.0%**		10,975.6	**0.7%**	
Sub Total	5,825.3	**0.7%**		27,407.8	**3.2%**		73,568.0	**4.4%**	
Department Name	**IR**	**AIR**	**IR vs AIR Ratio**	**IR**	**AIR**	**IR vs AIR Ratio**	**IR**	**AIR**	**IR vs AIR Ratio**
Wing Structure	24	1.0	**0.04**	20	0	**0.00**	12	1	**0.08**
Electrical	513	200.0	**0.39**	511	271	**0.53**	1,980	830	**0.42**
Fuselage	318	169.0	**0.53**	119	69	**0.58**	77	15	**0.19**
Final/Mission Systems	488	353.0	**0.72**	62	10	**0.16**	20	5	**0.25**
Hyrdro Mechanical	80	133.0	**1.66**	18	18	**1.00**	81	40	**0.49**
Propulsion/Environmental System	169	124.0	**0.73**	253	498	**1.97**	27	5	**0.19**

Sample

Factor Estimating Method – ED Group

Hours per EO.

- All six design departments are using hours per EO for a project estimates.

Application.

- First, when a project requires estimates, the estimator prepares to find out the required drawings which are initial release (IR) for the project. Then, the estimator calculates the EO (IR+AIR) by applying "IR vs AIR" ratio as shown in the Table 19.

- Second, the estimator applies the department's hours/EO to the calculated EO. However, a new project is not similar to the old projects because the project is a development related project. For that reason, the estimator establishes a "complexity factor" by comparing the requirements between the old project and new project.

- Finally, the estimator applies the calculated EO to hours/EO with applied the "complexity factor" if it is necessary for the project estimates.

Factor Estimating Method – EDS Group

Hours per EO.

- The Engineering Release group uses hours per EO, which is all drawings produced in engineering departments including AVFC, Standards, and M&P Engineering.

Percent to ED.

- M&P engineering, Design Assurance, and Design integration department use certain percent to ED.

Application.

- Determine the total required drawings for the project and apply hours per EO for the engineering release department. Other groups in engineering design support group apply the related group percent to the engineering drawing groups' total hours.

Factor Estimating Method – ES Group

Percent to Total Engineering.

- All supporting groups' estimates are a certain percent to total engineering estimates which is total of engineering drawing groups' estimate and AFVC's estimates.

Application.

- All groups' estimates calculated using the related group's percent to the total engineering hours.

- By reviewing the factor table, the engineering factors were increasing along with the phases. The reason could be that the company requires keeping a certain level of employees while workloads are declining. That might increase the factors.

Approval Process

- Responsibility of estimator to brief internal and external customers on estimate
  - Integrated Product Team (IPT) Leads
  - Program Management
  - Financial Management
  - DCAA/DCMC
  - Procuring Authority
- May included all of the detailed documentation discussed on previous chart
- Complete estimating system policy and procedures
- Complete estimating system manual

Model Maintenance

- New data
- Technology or process shift
- Periodic recalibration

Recommendation For Future Research

- This study opens another avenue of opportunity in quantitative research toward not only engineering groups but also manufacturing groups.
- For further study, there is an argument about how much the other engineering group use parametric estimate or factor method.
- Some recommendation for future study subjects are discussed in the followings.

Recommendation For Future Research (cont'd)

Avionics/Flight Controls (AVFC), Software Engineering Group:

- *Software Engineering Model.*

  Software Engineering Hours = f (hours per SLOC)

  Software Engineering Hours = $\beta 0 + \beta 1$SLOC Hours + ε

  - Note: Effective SLOC = New SLOC + (Reused SLOC * (X1% * %Redesign) + (X2% * X3% Recode) + (X4% * Retest)))

- *Avionics/Flight Controls Test Lab*

  Avionics/Flight Controls Test Lab Model.

  AV/FC Lab Hours = f (AVFC Lab Hours)

  AVFC Lab Hours = $\beta 0 + \beta 1$AVFC Hours + ε

Recommendation For Future Research (cont'd)

Flight Test

- *Flight Test Model.*

  Flight Test Hours = f (# of flight test and the hours associated with the flight test)

  FT Hours = $\beta 0 + \beta 1$Number of Flight Test + ε

Business Management (BM) Group

- *BM Group Model.*

  BM Group Hours = f (number of business control account and the period of account)

  BM Group Hours = $\beta 0 + \beta 1$Numer of CA + $\beta 2$Months of CA + ε

Recommendation For Future Research (cont'd)

- The above model may require multiple regressions and the Engineering Design group can add another parameter, project period of time associated the project.
  - Engineering Design Group Hours = $\beta0 + \beta1EO + \beta2Months\ of\ Project + \varepsilon$

- In a multiple regression two independent variables, such as the number of EO and the length of the project period in a project, may have multicollinearity, a case of multiple regression in which the independent variables are themselves highly correlated.

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