Aircraft Life Cycle Cost Estimating Methodology – Sample Approach

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Prepared for
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Outline

- **Briefing Assumptions**
- **Aircraft Life Cycle Cost Element Overview**
- **SDD Methodology**
- **Production Methodology**

Assumptions

- **Technical Baseline completed**
- **Work Breakdown Structure (WBS) defined**
- **Acquisition Strategy approved**
- **Cost Analysis Requirements Document (CARD) completed**
- **Data collection plan established and analysis complete**
  - Data is the “key to the Kingdom”

Aircraft Life Cycle Cost Elements and Methodologies Overview

- **System Development and Demonstration (SDD)**
  - Factors
  - Parametric (i.e., Regression equation)
  - Data Sources – CCDR, CPR, Budget Data
- **Production**
  - Parametric
  - Factors
  - Data Sources – CCDR, CPR, Internal Company Data
- **Operating and Support**
  - Parametric
  - Factors
  - Data Source - VAMOSC
- **Disposal**
  - Factors

SDD Methodology - Typical A/C Work Breakdown Structure

WBS Element	Non Rec	Rec
Air Vehicle		
Airframe	X	X
Propulsion	X	X
Avionics	X	X
Software	X	
System Engineering/Project Mgt	X	
System Test & Evaluation	X	
Developmental Test		
Operational Test		
Fatigue Test/ Mockups		
Systems Integration Lab (SIL)		
T&E Support		
Training	X	
Data	X	
Integrated Logistics Support	X	
G&A/Fee	X	

SDD Methodology - Sample SDD Program WBS and Cost Data (CCDR Format)

` (Dollars in 000s)	1. Program: XXX - EM&D Program Total Program	2. Contract No: XXXXXXXX RFP Program Estimate	3. RDT&E X PROCUREMENT	5. Report As Of: 12/31/XX
			4. MULTI YEAR CONTRACT YES X NO	6. FY FUNDED: 19XX

7. Contract Type	8. Contract Price	9. Contract Ce	10. Prime X Associate Subcontractor	11. NAME OF CUSTOMER
CPIF	XXXXXX	XXXXXX	XYZ Company PO Box XXXX XXXX, USA	NAVAIR

CONTRACT LINE ITEM	REPORTING ELEMENTS	ELEMENT CODE	TO DATE COSTS INCURRED NON-RECURRING	TO DATE COSTS INCURRED RECURRING	TO DATE COSTS INCURRED TOTAL	UNITS	AT COMPLETION COSTS INCURRED NON-RECURRING	AT COMPLETION COSTS INCURRED RECURRING	AT COMPLETION COSTS INCURRED TOTAL
0001									
	TOTAL SYSTEM	1	56,420	22,152	78,572		56,852	22,133	78,985
	AIR VEHICLE	11	27,476	19,789	47,265		27,495	19,770	47,265
	AIRFRAMES	111	5,846	12,086	17,932		5,880	12,067	17,947
	FORWARD FUSELAGE ASSEMBLY	1111	4,006	10,520	14,526	2	4,040	10,501	14,541
	CABIN FUSELAGE ASSEMBLY	1112	1,840	1,566	3,406	2	1,840	1,566	3,406
	SYSTEM PROCESS & INTEGRATION	112	21,001	3,031	24,032		20,986	3,031	24,017
	HYDRAULIC SYSTEM	1121	519	235	754	2	519	235	754
	ENGINE SYSTEM	1128	9,137	188	9,325	2	9,076	188	9,264
	AVIONICS SYSTEM	1129	4,568	344	4,912	2	4,242	344	4,586
	INSTRUMENT SYSTEMS	112A	799	0	799	2	823	0	823
	AVIONICS SYSTEM SOFTWARE	112B	1,056	0	1,056	2	1,405	0	1,405
	VENDOR SOFTWARE	112C	4,922	2,264	7,186	2	4,921	2,264	7,185
	DYNAMICS	113	53	28	81	2	53	28	81
	ASSEMBLY & INTEGRATION	114	0	607	607	2	0	607	607
	MODIFICATION	115	576	4,037	4,613		576	4,037	4,613
	SYSTEM TEST AND EVALUATION	12	15,769	0	15,769		16,062	0	16,062
	SYSTEM INTEGRATION LAB	121	3,212	0	3,212	2	3,208	0	3,208
	MOCK UP	122	4,013	0	4,013	2	4,013	0	4,013
	DEV FLIGHT TEST AND DEMO	123	8,544	0	8,544	2	8,841	0	8,841
	SYSTEM AND PROJECT MANAGEMENT	13	7,576	2,363	9,939		7,589	2,363	9,952
	SYSTEM ENG MANAGEMENT	131	1,074	0	1,074	2	1,057	0	1,057
	CONFIG MGMT/DATA MGMT	132	0	0	0		0	0	0
	PROJECT MANAGEMENT	133	3,878	0	3,878	2	3,877	0	3,877
	ANALYTICAL ENGINEERING	134	2,624	0	2,624		2,655	0	2,655
	RELIABILITY ENGINEERING	1341	1,672	0	1,672	2	1,682	0	1,682
	HUMAN FACTORS ENGINEERING	1343	952	0	952	2	973	0	973
	SUSTAINING ENGINEERING	136	0	2,363	2,363	2	0	2,363	2,363
	INTEGRATED LOGISTICS SUPPORT	14	916	0	916		1,001	0	1,001
	ILS PROGRAM MANAGEMENT	141	713	0	713	2	801	0	801
	SERVICE ENGINEERING	146	(5)	0	(5)	2	(4)	0	(4)
	TECHNICAL REPRESENTATIVE	147	208	0	208	2	204	0	204
	GROUND SUPPORT EQUIP	15	141	0	141		157	0	157
	PECULIAR SUPPORT EQUIPMENT	151	114	0	114	2	134	0	134
	COMMON SUPPORT	152	27	0	27	2	23	0	23
	TRAINING	16	965	0	965		964	0	964
	EQUIPMENT/TRAINING	161	965	0	965	2	964	0	964
	DATA	17	3,082	0	3,082		3,069	0	3,069
	TECHNICAL PUBLICATIONS DATA	171	2,581	0	2,581	2	2,578	0	2,578
	ENGINEERING DATA	172	501	0	501	2	491	0	491
	SPARES	18	495	0	495		515	0	515
	ASSEMBLY & CHECKOUT SPARES	182	495	0	495	2	515	0	515
	OVERHEAD ADJUSTMENTS		$0	$0	$0		$0	$0	$0
	COST (LESS G & A)		$56,420	$22,152	$78,572		$56,852	$22,133	$78,985
	GENERAL & ADMINISTRATION		$9,455	$2,881	$12,336		$9,517	$2,877	$12,394
	COST OF MONEY		$0	$0	$0		$0	$0	$0
	UNDISTRIBUTED BUDGET		$0	$0	$0		$0	$0	$0
	MANAGEMENT RESERVE		$0	$0	$0		$0	$0	$0
	** TARGET FEE		$0	$0	$0		$0	$0	$0
	TOTAL CPAF		$ 65,877	$ 25,035	$ 90,912		$ 66,369	$ 25,012	$ 91,381

SDD Methodology – Air Vehicle

- **Non Recurring – Design and developmental of the airframe and integration of components, engines, avionics, and weapon systems into the airframe**
  - Factor based on Production 1st Unit Cost (i.e., NRE = factor x T-1 $'s)
  - Factor based on NRE cost per pound AUW (i.e., NRE = factor x AUW)
  - CER developed from other similar programs

- **Recurring – flight test articles (airframe, engines, avionics, and weapon systems)**
  - SDD 1st Unit cost typically derived as a step-up factor from Production T-1 cost
  - After SDD T-1 established, use learning/rate curve to estimate recurring cost of SSD test articles

SDD Methodology – Non Recurring Airframe and Air Vehicle Factor Analysis

TACAIR NONRECURRING AIRFRAME

PROGRAM	FY06$M NREC A/F	REC A/F	EMD QTY	LOT MIDPT	UNIT AVG RECUR	T-1 90% LC	NREC A/F RATIO TO T	EMD MOS SD/EMD AWD TO END IOTE	AUW K lbs	NRE Per LB AUW	Comp Wt %	Titanium Wt %	Alum/ Other Wt %
USN A	xxx $	xxx $	11	4.66	xxx $	xxx $	15.65	61	14.85	89.56	7.6	10	82.4
USAF B	xxx $	xxx $	8	3.66	xxx $	xxx $	13.58	35	7.99	45.81	3.1	1.6	95.3
USAF C	xxx $	xxx $	20	7.49	xxx $	xxx $	14.32	70	18.05	56.18	1.4	27.8	70.8
USN D	xxx $	xxx $	12	4.98	xxx $	xxx $	9.99	57	24.98	39.47	0.7	30	69.3
USN E	xxx $	xxx $	4	2.25	xxx $	xxx $	9.15	60	7.35	58.10	17.6	5.4	77
USAF F	xxx $	xxx $	6	2.97	xxx $	xxx $	8.76	32	15.02	16.51	0	10	90
USAF G	xxx $	xxx $	11	4.66	xxx $	xxx $	19.61	156	28.95	127.67	24	42	34
USN H	xxx $	xxx $	7	3.32	xxx $	xxx $	16.31	84	21.64	26.62	15.6	12	72.4

Avg All Programs	13.42
Avg All less high/low	13.17
Avg USN Only	12.77
Avg Most Recent	17.96

TACAIR NONRECUR AIR VEHICLE (Includes A/F Nrec Dev, Engine Integration, and Avionics Integration)

PROGRAM	FY06$M NR AVEH	REC A/F AVEH	EMD QTY	LOT MIDPT	UNIT RECUR	T-1 90% LC	NREC AVEH RATIO TO T	EMD MOS SD/EMD AWD TO END IOTE
USN A	xxx $	xxx $	11	4.66	xxx $	xxx $	19.64	61
USAF C	xxx $	xxx $	20	7.49	xxx $	xxx $	23.47	70
USN H	xxx $	xxx $	7	3.32	xxx $	xxx $	19.75	84
USAF G	xxx $	xxx $	11	4.66	xxx $	xxx $	33.02	156

Avg All Programs	23.97
Avg less USAF G	20.95
Avg USN only	19.69

SDD Methodology - Non Recurring SDD Factor & CER Analysis

NON RECURRING AIR VEHICLE (LESS SOFTWARE) DATA

EMD/SSD PROG	TY$ NREC A/F	SDD REC A/F	A/C QTY	MIDPT	ESC MP	TY-FY07	FY07-FY06	FY06$ NREC A/F	SDD REC A/F	UNIT REC	NRE FACT AUREC	SDD T1 90% LC	NRE FACT REC T1	EMD/SDD DURATION	ATT HELO	SOURCE
USA A (ADV DEV)	xxx $	xxx $	3	1.866	FY76	0.3409	0.9756	xxx $	xxx $	xxx $	9.11	xxx $	8.28	42	1	CCDR
USN B	xxx $	xxx $	4	2.25	FY97	0.848	0.9756	xxx $	xxx $	xxx $	8.04	xxx $	7.11			CCDR
USA C	xxx $	xxx $	2	1.457	FY99	0.8655	0.9756	xxx $	xxx $	xxx $	2.42	xxx $	2.28	72	0	CCDR
USN D	xxx $	xxx $	3	1.866	FY01	0.8907	0.9756	xxx $	xxx $	xxx $	2.05	xxx $	1.86	118	1	CCDR
USN E	xxx $	xxx $	2	1.457	FY01	0.8907	0.9756	xxx $	xxx $	xxx $	3.18	xxx $	3.00	118		CCDR
USN F (Mod)	xxx $	xxx $	5	2.618	FY79	0.4328	0.9756	xxx $	xxx $	xxx $	4.42	xxx $	3.82	69	0	CCDR
USN G	xxx $	xxx $	2	1.457	FY77	0.3656	0.9756	xxx $	xxx $	xxx $	2.68	xxx $	2.53	48	0	CCDR
USA H (Mod)	xxx $	xxx $	5	2.618	FY83	0.5896	0.9756	xxx $	xxx $	xxx $	8.53	xxx $	7.37	60	1	CCDR
USA I (DemVal)	xxx $	xxx $	2	1.457	FY96	0.8375	0.9756	xxx $	xxx $	xxx $	15.46	xxx $	14.60	108	1	CCDR

Avg less High/Low	4.47
Avg High Risk =	8.21
Avg Low Risk =	3.17
Avg Company A Programs	6.06
Avg Company B Programs	5.89
Avg Company C Programs	3.17

TOT NONREC ENGINEERING CERS (ALL FY06$M) (LESS ST&E, ILS, TRAIN, DATA, G&A, FEE)

TOT NRE = .993 x (REC AIR VEH SDD T-1$M)^ 1.401 x (2.26)(Dummy if Attack Helo)

R SQ = .99 SEE = +19.7%, -16.5%

ABOVE CER INCLUDES NR A/F, NR ENGINE INTEGRATION, NR AVX INTEGRATION

SDD Methodology - Recurring Airframe Step-Up Factor & CER Analysis

FY06$M

Program	Test Airframe	Qty	MIDPT	Avg Unit	DEV T-1 90% LC	1st Lot Airframe	Qty	MIDPT	Avg Unit	1ST LOT T-1, 90% LC	AVG UNIT Ratio	T-1 RATIO	EW
USA Prog A	xxx $	2	1.457	xxx $	xxx $	xxx $	110	32.994	xxx $	xxx $	3.42	2.13	6.6
USA Prog B	xxx $	9	4.000	xxx $	xxx $	xxx $	48	15.714	xxx $	xxx $	1.89	1.53	11.39
USN Prog C	xxx $	6	2.975	xxx $	xxx $	xxx $	44	14.567	xxx $	xxx $	1.66	1.30	12.41
OSA Prog D	xxx $	7	3.323	xxx $	xxx $	xxx $	18	6.871	xxx $	xxx $	1.73	1.55	23.09
USN Prog E	xxx $	3	1.866	xxx $	xxx $	xxx $	76	23.609	xxx $	xxx $	4.85	3.30	7.75
USN Prog F	xxx $	9	4.000	xxx $	xxx $	xxx $	20	7.486	xxx $	xxx $	1.76	1.60	11.3
USA Prog G	xxx $	9	4.000	xxx $	xxx $	xxx $	9	4.000	xxx $	xxx $	1.89	1.89	3.79
USA Prog H	xxx $	3	1.866	xxx $	xxx $	xxx $	15	5.936	xxx $	xxx $	3.25	2.73	10.6
USN Prog I	xxx $	5	2.618	xxx $	xxx $	xxx $	9	4.000	xxx $	xxx $	2.87	2.69	12.07
								Avg All Data			2.59	2.08	
								Exclude High and Low			2.40	2.02	

SDD HELO T-1 COST (FY06$M)

SDD T-1 = 7.75 x (SDD QTY)^ -.4375 x (1ST PROD LOT T-1)^1.017 x (1ST PROD LOT QTY)^-.2235

R SQ = .97 SEE = +16.9%, -14.5%

SDD Methodology – Propulsion Development Factor Analysis

- **SDD propulsion involves integration costs only, unless a new engine is to be used in aircraft being developed. New engine typically involves a separate SSD program and estimate.**

Turbofan Engine Development Data

MODEL	FY06$M SDD	ENGINE WEIGHT	SDD PER LB	Eng 1st Proc t-1	SDD to T-1 ratio
F404	$ 1,080	2161	0.500	6.38	169.28
F-119	$ 3,220	3900	0.826	17.3	186.13
F-135	$ 6,640	6405	1.037	27.19	244.21
F-414	$ 1,200	2501	0.480	9.29	129.17
				Avg	**182**

Turboshaft Engine Development Data

T-64-GE-6	$ 298			2.67	111.61
T58-GE-1	$ 246			1.03	238.83
T-700	$ 346			1.6	216.25
				Avg	**189**

CER: Jet Engine
EMD ENGINE COST = 11.554 x AIR^.531 x THR / WT^.853 x e^(.0116 x deltaTOA)
Source: IDA, FY1990
R Sq = .95
SEE = +12.2%, -10.8%
Database - 11 Engines, type unknown

CER: Turboshaft Engine
ENG EMD(FY83$M) = .0000337 x DRY WT^.4943 x SHP/LB^1.273 x TIT^1.417
Source: SPA Derived (FY1995)
R Sq = .97
SEE = +11.4%, -10.2%
DATABASE - T-53, T-55, T-56, T-58, T-63, T-64. T-73, T-700

SDD Methodology – Avionics Non Recurring and Recurring

- **Non Recurring**
  - Integration estimated by of historical program integration costs as a factor of either SDD or Production 1st unit recurring costs similar to airframe integration.
  - Factor typically much higher than airframe (typically 20 to 40 times 1st unit)
  - New avionics systems developed under separate SDD contract as per new Propulsion system
  - Typical Avionics systems SDD methodologies
    - Similar system actual SDD adjusted for technology/functionality
    - Commercial Models – SEER, PRICE
    - Other models – IDA, RAND studies

- **Recurring**
  - If legacy system used, use current pricing
  - New systems (Radars, ECM, etc.) – same methodologies as Non recurring above

SDD Methodology – Avionics Development and Recurring Cost CER Examples

DEVELOPMENT

ALT 1

CER: DCOST = 3.33 x INPUT^1.10 x 1.0204^(WDENS)

SOURCE: IDA STUDY (1991)
R Sq = .91 SEE = +53.7%, - 34.9%
N = 22
DATABASE INCLUDES RADARS AND ECM SYSTEMS, CAN BE USED TO ESTIMATE BOTH

DCOST = Development Cost in FY90$ K
INPUT = Maximum Input Power in kilowatts
WDENS = Weight Density Measure (= Unistalled Wt in lbs divided by Volume in cubic ft)

ALT 2

CER: DCOST = 132.3 x C100^1.31

SOURCE: IDA STUDY (1991)
R Sq = .86 SEE = +60.0%, - 37.5%
N = 12
DATABASE INCLUDES RADARS AND ECM SYSTEMS, CAN BE USED TO ESTIMATE BOTH

DCOST = Development Cost in FY90$ K
C100 = Est 100th unit Cost, FY90$ K

PRODUCTION:

	COMP LC	LC Exp
Fire Control Radar:		
FCR 100 = 2.32 x WT ^ .87 x LOI ^ .17 x e ^ .49(NEW)	**0.88**	**-0.1844**
R Sq = .77 SEE = +64.8%, - 39.3%		
Controls and Displays:		
C&D 100 = 1.46 x WT ^ 1.06 x LOI ^ .04 x e ^ .53(NEW)	**0.98**	**-0.0291**
R Sq = .92 SEE = +53.7%, - 34.9%		

SDD Methodology – Software Development

- **Numerous Models available**
- **Critical steps is to estimate the most accurate ESLOC count, productivity factor, and schedule**
- **More detailed methodology discussion subject of future training session**

SDD Methodology – System Engineering and Project Management (SE/PM)

- **Typical estimating methods**
  - Annual headcount times labor rate based on historical programs (usually requires company internal cost data)
  - SE/PM percent of total Air Vehicle costs based on historical programs (latest average is 15-20 percent)
  - Personally developed or other Study CERs

Example RAND CER:
SE/PM Dev (FY03$K) = .01524 x (CAFF)$^{1.431}$ x (TDEVLSEPM)(FY03$K) $^{.7766}$

CAFF = contract award to first flight in months
TDEVLSEPM = total development cost less SE/PM
R Sq = .95
SE = $167.98M

SDD Methodology – System Test and Evaluation (ST&E)

- **Typical estimating methods**
  - Cost per flight hour for entire ST&E program based on past similar programs
  - Cost per flight hour of flight test only and ground test portion estimated separately as percent of flight test based on past similar programs
  - Personally developed or other Study CERs

Example RAND Study ST&E Program CER (FY2001 $ M):

GND TEST = 94.84 + 1.54(T)
R Sq = .97 SE = +/- 21%
ST/FAT TEST = 37.21 + .001573(WE)
R Sq = .97 SE = +/- 19%
FLT TEST = -311.7 + 1.736(AC Mo) + 5.268(DUR)
R Sq = .91 SE = +/- 20%
OTH TEST = -134.5 + .5041(GND + FLT TEST)
R Sq = .96 SE = +/- 27%

T = 1st Unit Cost of Flt Test A/C
WE = Empty weight of Flt Test A/C
AC Mo = total time in months each Flt Test A/C is avail for flt test in DT
DUR – est time in months from 1st flight to end of DT

SDD Methodology – System Test and Evaluation (ST&E)

Program	F-22	F/A-18E/F	F-14A	F/A-18A/B	F-16A/B	F-15A/B	AV-8B	A-10	WTD Avg	Adj Avg	Raw Avg	Adj Raw
Prototype Prior	Yes	Yes	No	Yes	Yes	No	Yes	Yes				
Type Dollars	FY08$	FY08$	FY08$	FY08$	FY08$	FY08$	FY08$	FY08$				
Total Air Vehicle $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M				
SEPM $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M				
ST&E $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M				
Flt Test Only $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M				
Flt Test Hrs	x Hrs K	x Hrs K	x Hrs K	x Hrs K	x Hrs K	x Hrs K	x Hrs K	x Hrs K				
EW (Development)	31.67	30.56	37.78	22.38	14.61	26.77	12.75	20.491				
SEPM % Air Veh	22.7%	20.5%	15.3%	7.6%	17.8%	3.3%	9.2%	16.6%	**14.5%**	**18.2%**	**14.1%**	**16.7%**
ST&E % Air Veh	10.8%	54.9%	43.5%	27.1%	45.5%	18.0%	43.1%	54.0%	**22.6%**	**30.5%**	**37.1%**	**40.9%**
Flt Test % ST&E	24.1%	49.7%	47.1%	43.4%	52.6%	38.6%	37.4%	40.2%	**40.2%**	**44.1%**	**41.6%**	**44.1%**
ST&E Cost Per FH	0.228	0.133	0.481	0.218	0.138	0.389	0.167	0.217	**0.232**	**0.210**	**0.246**	**0.213**
ST&E/FH/EW	0.0072	0.0044	0.0127	0.0097	0.0095	0.0145	0.0131	0.0106	**0.0102**	**0.0117**	**0.010**	**0.0117**
Flt Test Cost Per FH	0.055	0.066	0.227	0.095	0.073	0.150	0.062	0.087	**0.093**	**0.081**	**0.102**	**0.084**
Flt Test/FH/EW	0.0017	0.0022	0.0060	0.0042	0.0050	0.0056	0.0049	0.0043	**0.0042**	**0.0050**	**0.004**	**0.0050**
Other Test % ST&E	75.9%	50.3%	52.9%	56.6%	47.4%	61.4%	62.6%	59.8%	**59.8%**	**NA**	**58.4%**	**NA**
Source	CCDR(1921)	CCDR(1921)	IDA Study	IDA Study	IDA Study	IDA Study	IDA Study	IDA Study				

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Program Type Program	V-22 Mod	SH-60B Mod	CH-47F Mod	AH-1Z/UH-1Y New	UH-1H Comp Blade Mod	MH-47 SOF Mod	CH-47 Modernize Mod	OH-58D AHIP Mod	CH-53E New	WTD Avg	Adj Avg	RQ-8A	Raw Avg	Adj Raw
Prototype Prior	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			No		
Type Dollars	FY08$	FY08$	FY08$	FY08$	TY$	TY$	FY08$	FY08$	FY08$			FY08$	No	No
Total Air Vehicle $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M			xxx $M	Include	Include
SEPM $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M			xxx $M	RQ-8A	RQ-8A
ST&E $'s	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M	xxx $M			xxx $M		
Flt Test Only $'s	xxx $M	xxx $M	xxx $M	xxx $M			xxx $M	xxx $M	xxx $M			xxx $M		
Flt Test Hrs	x Hrs K		x Hrs	x Hrs K					x Hrs			x Hrs		
EW (Development)	33.14		23.401	12.05					33.226					
SEPM % Air Veh	24.9%	27.4%	21.0%	20.1%			38.5%	5.4%	5.8%	**23.7%**	**25.2%**	**41.5%**	**20.4%**	**26.4%**
ST&E % Air Veh	40.2%	50.0%	32.7%	29.7%			39.6%	15.1%	26.1%	**40.4%**		**38.5%**	**33.4%**	**38.5%**
Flt Test % ST&E	87.4%	31.6%	55.0%	95.8%			63.0%	92.4%	50.2%	**66.0%**	**34.0%**	**52.7%**	**67.9%**	**50.0%**
ST&E Cost Per FH	0.397		0.083	0.080					0.145	**0.237**	**0.089**	**0.077**	**0.176**	**0.103**
ST&E/FH/EW	0.0120		0.0035	0.0067					0.0044					
Flt Test Cost Per FH	0.346		0.046	0.077					0.073	**0.205**	**0.074**	**0.041**	**0.135**	**0.065**
Flt Test/FH/EW	0.0105		0.0019	0.0064					0.0022					
Other Test % ST&E	12.6%	68.4%	45.0%	4.2%	NA	NA	37.0%	7.6%	49.8%	**34.0%**	**NA**	**47.3%**	32.1%	NA
Source	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)	CCDR(1921)			CCDR(1921)		

SDD Methodology – Training, Data, Integrated Logistics Support

- **Typically estimated as a percent of Air Vehicle or Total Development Cost less Training, Data,ILS**
- **Sample Helo programs below**

PERCENT TOTAL AIR VEHICLE

SDD PROGRAM	DEVELOPER	SEPM	DATA	TRAINING	PSE	SPARES	ST&E	SEPM % of AIRVEH+ST&E
Helo A	A Company	5.44%	6.54%	0.42%	0.79%	1.53%	15.67%	4.70%
Helo B, USN	A Company	10.31%	1.65%	0.00%	0.97%	2.61%	50.37%	6.86%
Helo C	**C Company**	**44.65%**	**5.27%**	**12.50%**	**3.47%**	**0.00%**	**75.11%**	**25.50%**
Helo D	D Company	10.89%	2.55%	0.00%	0.00%	0.00%	44.59%	7.53%
Helo E USN	**B Company**	**15.56%**	**4.01%**	**1.34%**	**0.22%**	**4.55%**	**11.72%**	**13.93%**
Helo F Mod	A Company	27.43%	7.44%	0.00%	0.00%	0.00%	54.99%	17.70%
Helo G	D Company	21.13%	3.60%	0.87%	0.00%	0.00%	23.95%	17.05%
Helo H Mod	**B Company**	**21.06%**	**6.49%**	**2.04%**	**0.33%**	**1.09%**	**33.98%**	**15.72%**
Helo I	**A-B Company**	**25.14%**	**0.04%**	**0.43%**	**0.91%**	**0.00%**	**25.89%**	**19.97%**
Helo J USN	A Company	15.65%	11.28%	15.94%	0.06%	0.01%	1.39%	15.44%
Helo K USN	**D Company**	**20.16%**	**0.39%**	**0.30%**	**1.54%**	**0.00%**	**30.50%**	**15.45%**
Helo L USN	**B-D Company**	**24.87%**	**2.92%**	**0.37%**	**0.03%**	**0.00%**	**41.07%**	**17.63%**
WTD AVERAGE		**24.54%**	**2.59%**	**0.79%**	**0.55%**	**0.11%**	**36.97%**	**17.92%**
AVERAGE		**20.19%**	**4.35%**	**3.80%**	**0.93%**	**2.44%**	**34.10%**	**14.79%**
AVERAGE MOST RECENT		**25.24%**	**3.19%**	**2.83%**	**1.08%**	**2.82%**	**36.38%**	**18.03%**
AVERAGE NAVY		**19.68%**	**4.74%**	**3.32%**	**0.65%**	**1.31%**	**35.66%**	**14.61%**
RED MOST RECENT SDD								

SDD Methodology - Summary

- Why not just accept the contractor cost estimate in most cases ?

AoA ALT	CONTRACTOR	CONTRACTOR SDD FY06$M	COST TEAM SDD FY06$ M	DELTA
SYS A	Company A	NA	91	NA
SYS B	Company B	32	368	1150%
SYS C	Company B	58	342	590%
SYS D	Company C	201	732	364%
SYS E	Company D	500	1123	225%
SYS F	Company E	500 - 700	3714	531%

Note: Contractor Costs based on original and follow-on RFI responses

Production Methodology - WBS

WBS Element	Non Rec	Rec
Air Vehicle		
Airframe		X
Propulsion		X
Avionics (CFE & GFE)		X
Engineering Change Orders		X
SE/PM		X
ALL ABOVE = RECURRING FLYAWAY		
Ancillary Equipment		X
Non Recurring Flyaway	X	
TOT REC FLYAWAY + ANCILL + NON REC = TOTAL FLYAWAY		
Support		
A/F, Engine, Avionics Test Equipment		X
Publications/Technical Data		X
Production Engineering Support		X
Program Management		X
Other ILS		X
TOTAL FLYAWAY + SUPPORT = WEAPON SYSTEMS		
Initial Spares		X

Production Methodology – Example WBS and Cost Estimate

ELEMENT OF COST	TOTAL COST IN MILLIONS								
	Prior Years	FY 2008		FY 2009		FY 2010		FY 2011	
	Total Cost	Unit Cost	Total Cost	Unit Cost	Total Cost	Unit Cost	Total Cost	Unit Cost	Total Cost
Quantity		6		8		20		34	
Airframe/CFE		120.398	722.387	97.888	783.107	97.382	1,947.636	85.974	2,923.099
CFE Electronics		35.942	215.654	31.350	250.800	27.714	554.270	22.898	778.546
GFE Electronics									
Engines/Eng Acc		29.599	177.596	27.556	220.447	25.878	517.550	21.773	740.282
Armament									
Other GFE									
Rec Flyaway ECO		10.268	61.610	5.996	47.970	3.278	65.565	2.831	96.241
Rec Flyaway Cost	0.000	196.208	1,177.248	162.791	1,302.325	154.251	3,085.021	133.476	4,538.168
Non-Recur Cost			12.876		264.019		707.764		847.768
Ancillary Equip			27.327		32.203		97.292		148.841
Other									
Total Flyaway	0.000	202.908	1,217.451	199.818	1,598.547	194.504	3,890.077	162.788	5,534.777
Airframe PGSE			1.886		0.517		50.301		63.934
Engine PGSE			0.364		0.000		26.363		32.716
Avionics PGSE			0.473		0.000		69.782		111.669
Pec Trng Eq			5.643		52.241		82.789		92.945
Pub/Tech Eq			0.779		5.823		17.377		19.109
Prod Eng Supt			2.608		52.326		85.993		205.354
Other ILS			0.164		11.401		50.600		149.468
Miscellaneous Support							7.107		8.870
Support Cost	0.000		11.916		122.308		390.311		684.065
Gross P-1 Cost	0.000		1,229.367		1,720.855		4,280.388		6,218.842
Adv Proc Credit			-124.498		-118.771		-258.814		-612.026
Net P-1 Cost	0.000		1,104.869		1,602.084		4,021.574		5,606.816
Adv Proc CY	124.498		118.771		258.814		612.026		784.365
Wpn Syst Cost	124.498		1,223.640		1,860.898		4,633.600		6,391.181
Initial Spares	0.000		0.000		35.128		296.783		356.475
Procurement Cost	124.498		1,223.640		1,896.026		4,930.383		6,747.656

Production Methodology - Airframe

- **Typically estimated by labor hour categories**
  - Functional – Engineering, Tooling, Quality Control, Manufacturing
  - Raw Material and Purchased Parts (RM/PP) – estimated separately
- **Select an analogous A/C system that has sufficient historical data for calculating labor hours and learn/rate curves for new A/C (e.g., Use F/A-18A/B data to estimate F/A-18E/F)**
- **Calculate new A/C labor category T-1's by adjusting for weight and material composition percentages**
  - Composites/titanium generally require higher number of labor hours compared to aluminum
  - RM/PP additionally more expensive
- **Calculate total hours required for each production lot for each labor category using standard learning/rate curve equation**
  - Avg Lot Hrs = T1 x Lot Midpt $^{LC\ EXP}$ x Lot Qty RC ^{EXP}
  - Total Lot Hours = Avg Lot Hrs x Qty
- **Calculate total lot costs**
  - Total Lot Cost = Total Lot Hrs for each labor category x Wrap Rate
  - WRAP = fully burdened rate (Direct + Overhead + G&A + Profit)

Production Methodology Airframe– Sample Production CCDR Format

12. WBS ELEMENT CODE	PART I. FUNCTIONAL COST-HOUR REPORT					
	14. COST TYPE		15. QUANTITY		16. APPROPRIATION	
AIRFRAME		RECURRING	TO DATE	17		RDT&E
13. REPORTING ELEMENT	X	NONRECURRING	AT COMPLETION	17	X	PROCUREMENT
	X	TOTAL				

AIRFRAME	REPORTING CONTRACTOR		SUBCONTRACT OR OUTSIDE PRODUCTION AND SERVICES		TOTAL	
DATA ELEMENTS	**TO DATE A**	**AT COMPLETION B**	**TO DATE C**	**AT COMPLETION D**	**TO DATE E**	**AT COMPLETION F**
ENGINEERING						
1. DIRECT LABOR HOURS	198.5	202.5	0.0	0.0	198.5	202.5
2. DIRECT LABOR DOLLARS	13,882.0	14,050.0	0.0	0.0	13,882.0	14,050.0
3. OVERHEAD	8,200.8	8,500.2	0.0	0.0	8,200.8	8,500.2
4. MATERIAL	1,200.0	1,250.0	0.0	0.0	1,200.0	1,250.0
5. OTHER DIRECT CHARGES *(Specify)*	87.0	89.0	0.0	0.0	87.0	89.0
6. TOTAL ENGINEERING DOLLARS	23,369.8	23,889.2	0.0	0.0	23,369.8	23,889.2
TOOLING						
7. DIRECT LABOR HOURS	175.0	176.0	0.0	0.0	175.0	176.0
8. DIRECT LABOR DOLLARS	8,500.8	8,600.0	0.0	0.0	8,500.8	8,600.0
9. OVERHEAD	13,500.0	13,590.8	0.0	0.0	13,500.0	13,590.8
10. MATERIAL AND PURCHASED TOOLS	9,000.0	9,089.0	0.0	0.0	9,000.0	9,089.0
11. OTHER DIRECT CHARGES *(Specify)*	0.0	0.0	0.0	0.0	0.0	0.0
12. TOTAL TOOLING DOLLARS	31,000.8	31,279.8	0.0	0.0	31,000.8	31,279.8
QUALITY CONTROL						
13. DIRECT LABOR HOURS	646.5	648.0	0.0	0.0	646.5	648.0
14. DIRECT LABOR DOLLARS	17,779.6	17,820.0	0.0	0.0	17,779.6	17,820.0
15. OVERHEAD	32,181.0	32,254.2	0.0	0.0	32,181.0	32,254.2
16. OTHER DIRECT CHARGES *(Specify)*	0.0	0.0	0.0	0.0	0.0	0.0
17. TOTAL QUALITY CONTROL DOLLARS	49,960.6	50,074.2	0.0	0.0	49,960.6	50,074.2
MANUFACTURING						
18. DIRECT LABOR HOURS	2,811.0	2,953.8	0.0	0.0	2,811.0	2,953.8
19. DIRECT LABOR DOLLARS	87,843.8	92,306.3	0.0	0.0	87,843.8	92,306.3
20. OVERHEAD	131,765.6	138,459.4	0.0	0.0	131,765.6	138,459.4
21. MATERIALS AND PURCHASED PARTS	52,357.0	54,451.3	0.0	0.0	52,357.0	54,451.3
22. OTHER DIRECT CHARGES *(Specify)*	9,850.0	9,860.0	0.0	0.0	9,850.0	9,860.0
23. TOTAL MANUFACTURING DOLLARS	392,311.9	392,944.5	0.0	0.0	392,311.9	392,944.5
OTHER COSTS						
24. PURCHASED EQUIPMENT	205,103.0	210,433.0	0.0	0.0	205,103.0	210,433.0
25. MATERIAL OVERHEAD	222,536.8	228,319.8	0.0	0.0	222,536.8	228,319.8
26. OTHER COSTS NOT SHOWN ELSEWHERE *(Specify)*	63,575.0	65,988.0	0.0	0.0	63,575.0	65,988.0
SUMMARY						
27. TOTAL COST (Direct and Overhead)	987,857.9	1,002,928.5	0.0	0.0	987,857.9	1,002,928.5

Production Methodology Airframe – Calculation of Functional Labor T-1's and Learn/Rate Curves

FY	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
LOT QTY	6	12	16	24	27	32	30
MID PT	2.975	11.862	25.958	45.778	71.408	100.905	132.102
AUW	28950	28970	28978	29001	29015		29042
AVG HRS PER A/C:			K HOURS				
ENG	138	82.5	52	41	41		34.7
TOOL	183	59.8	41.7	40.5	33.2		27
QC	89.5	62.1	58	52.7	38.6		29.2
MFG	500.1	410.7	370.9	345.8	310.7		249.5

AVG AUW
28993

HRS PER LBS AUW: HRS K

ENG	0.00477	0.00285	0.00179	0.00141	0.00141		0.00119
TOOL	0.00632	0.00206	0.00144	0.00140	0.00114		0.00093
QC	0.00309	0.00214	0.00200	0.00182	0.00133		0.00101
MFG	0.01727	0.01418	0.01280	0.01192	0.01071		0.00859

MAT/PE TY$M	163.5	110.2	88.1	65.9	58.9		49.700
MAT/PE FY06$M	181.654	120.840	95.469	70.519	61.801		49.411
MAT/PE PER LBSFY06$M	0.00627	0.00417	0.00329	0.00243	0.00213		0.00170

ESC TY-FY07	0.8781	0.8897	0.9003	0.9117	0.9298	0.9544	0.9813
FY07-06	0.9756						

ENGIN HRS PER LB = e^ -5.089 x RATE^ -.5632	R SQ =	0.92	SEE =	+14.1%, - 12.4%
TOOL HRS PER LB = e^ -4.892 x MP^ -.1162 x RATE^ -.5289	R SQ =	0.99	SEE =	+24.6%, -19.7%
QC HRS PER LB = e^ -.211 x MFG HRS PER LB^ 1.32	R SQ =	0.98	SEE =	+7.5%, - 7.0%
MFG HRS PER LB = e^ -4.169 x MP^ -.1777	R SQ =	0.99	SEE =	+4.5%, - 4.3%
MATL/PE PER LB = e^ -6.17 x MP^ -.1227	R SQ =	0.85	SEE =	+19.7%, - 16.5%

Production Methodology Airframe – Example
New A/C Airframe Calculation

SYSTEM X CFE AIRFRAME COST MODEL

ANALOGOUS SYSTEM CERS:

ENGIN HRS PER LB = e^ -5.089 x RATE^ -.5632	**R SQ =**	**0.92**	**SEE =**	**+14.1%, - 12.4%**
TOOL HRS PER LB = e^ -4.892 x MP^ -.1162 x RATE^ -.5289	**R SQ =**	**0.99**	**SEE =**	**+24.6%, -19.7%**
QC HRS PER LB = e^ -.211 x MFG HRS PER LB^ 1.32	**R SQ =**	**0.98**	**SEE =**	**+7.5%, - 7.0%**
MFG HRS PER LB = e^ -4.169 x MP^ -.1777	**R SQ =**	**0.99**	**SEE =**	**+4.5%, - 4.3%**
MATL/PE PER LB = e^ -6.17 x MP^ -.1227	**R SQ =**	**0.85**	**SEE =**	**+19.7%, - 16.5%**

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
MIDPT	2.25	7.29	15.17	27.11	41.24	55.31	69.35	82.89	89.50	89.50	89.50	89.50	89.50	89.50	

SYSTEM X AUW =	22500	
ANALOGY AUW AUW =	28993	
ARCO FACTOR =	-0.2345	(Log.85/Log2)
RAW WT FACTOR =	0.7760	(22500/28993)
ARCO ADJ =	1.061	(22500/28993)^-.2345
NEW WT FACTOR =	0.824	(.7760 x 1.061)
T1 ADJUSTMENT FACTOR =	1.061	

ENGINEERING (INCLUDES SEPM & DATA)

ANALOGY T-1 PER LB =	0.006164	
SYSTEM X ADJ T-1 PER LB =	0.006542	
ENGINEERING RATE EXP =	-0.5632	**67.7%**
ENGIN LABOR RATE FY06$ =	123.17	(DIRECT + OVRHD, LESS G&A, FEE)

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
LOT HRS PER LB K	0.002996	0.002385	0.001788	0.00148	0.00148	0.00148	0.00148	0.001543	0	0	0	0	0	0	
TOT LOT HRS K	269.68	321.93	402.41	466.11	466.11	466.11	466.11	451.27	0.00	0.00	0.00	0.00	0.00	0.00	
ENG $'s FY06$K	33216.1	39652.0	49564.3	57411.3	57411.3	57411.3	57411.3	55582.7	0.0	0.0	0.0	0.0	0.0	0.0	
ENG $'s FY06$M	33.22	39.65	49.56	57.41	57.41	57.41	57.41	55.58	0.00	0.00	0.00	0.00	0.00	0.00	407.66

TOOLING

SYSTEM X AUW =	0.007506	
ANALOGY AUW AUW =	0.007966	
TOOL LC EXP =	-0.1203	**92.0%**
TOOL RATE EXP =	-0.5289	**69.3%**
TOOL LABOR RATE FY06$ =	108.25	(DIRECT + OVRHD, LESS G&A, FEE)

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
LOT HRS PER LB K	0.003471	0.002432	0.001699	0.001326	0.001261	0.001217	0.001185	0.001206	0	0	0	0	0	0	
TOT LOT HRS K	312.38	328.29	382.35	417.79	397.22	383.45	373.15	352.70	0.00	0.00	0.00	0.00	0.00	0.00	
TOOL $'s FY06$K	33815.2	35537.1	41389.4	45225.5	42999.3	41507.9	40393.7	38179.5	0.0	0.0	0.0	0.0	0.0	0.0	
TOOL $'s FY06$M	**33.82**	**35.54**	**41.39**	**45.23**	**43.00**	**41.51**	**40.39**	**38.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**319.05**

Production Methodology Airframe – Example
New A/C Airframe Calculation (Continued)

QUALITY CONTROL

QC HRS PER LB INTERCEPT =	0.810	
MFG HR EXP =	1.32	
QC RATE FY06$ =	112.5	(DIRECT + OVRHD, LESS G&A, FEE)

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
LOT HRS PER LB K	0.00295	0.00224	0.001886	0.001646	0.001491	0.001392	0.00132	0.001266	0	0	0	0	0	0	
TOT LOT HRS K	265.53	302.35	424.29	518.35	469.76	438.52	415.86	370.33	0.00	0.00	0.00	0.00	0.00	0.00	
QC $'s FY06$K	29871.66	34013.99	47732.87	58314.25	52848.36	49333.23	46783.95	41661.87	0	0	0	0	0	0	
QC $'s FY06$M	**29.87**	**34.01**	**47.73**	**58.31**	**52.85**	**49.33**	**46.78**	**41.66**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**360.56**

MANUFACTURING

ANALOGY ENG T-1 PER LB =	0.0155	
SYS X ADJ T-1 PER LB =	0.016415	(.0155 x 1.061)
MFG LC EXP =	-0.1777	**88.4%**
MFG RATE FY06$ =	97.04	(LESS G&A, FEE)

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
LOT HRS PER LB K	0.014212	0.011534	0.010125	0.009132	0.008476	0.008045	0.007728	0.007487	0	0	0	0	0	0	
TOT LOT HRS K	1279.07	1557.07	2278.12	2876.59	2669.91	2534.26	2434.41	2189.99	0.00	0.00	0.00	0.00	0.00	0.00	
MFG $'s FY06$K	124121.1	151098.6	221068.4	279144	259087.9	245924.4	236235.5	212516.5	0	0	0	0	0	0	
MFG $'s FY06$M	**124.12**	**151.10**	**221.07**	**279.14**	**259.09**	**245.92**	**236.24**	**212.52**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1729.20**

MATERIAL/PP/PE

ANALOGY ENG T-1 PER LB =	0.00209	
SYS X ADJ T-1 PER LB =	0.00209	NO ARCO ADJUST
MFG LC EXP =	-0.1227	**91.8%**

FY	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
QTY	4	6	10	14	14	14	14	13	0	0	0	0	0	0	89
RM/PP/PE $M PER LB	0.001893	0.001639	0.001498	0.001395	0.001325	0.001278	0.001243	0.001216	0	0	0	0	0	0	
LOT RM/PP/PE $'S M	170.38	221.26	337.03	439.39	417.34	402.58	391.56	355.72	0.00	0.00	0.00	0.00	0.00	0.00	
RM/PP/PE OVHD RATE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
RM/PP/PE OVHD$ M	1.70	2.21	3.37	4.39	4.17	4.03	3.92	3.56	0.00	0.00	0.00	0.00	0.00	0.00	
TOT PM/PP/PE $'s M	**172.08**	**223.47**	**340.40**	**443.78**	**421.51**	**406.61**	**395.48**	**359.28**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2762.62**

CFE A/F LESS SEPM, W/G&A, FEE

TOT REC CFE A/F L/G&A, FEE	393.11	483.77	700.16	883.88	833.86	800.78	776.30	707.22	0.00	0.00	0.00	0.00	0.00	0.00	5579.08
G&A	70.76	87.08	126.03	159.10	150.10	144.14	139.73	127.30	0.00	0.00	0.00	0.00	0.00	0.00	
TOT REC A/F W G&A	463.87	570.85	826.19	1042.98	983.96	944.93	916.04	834.52	0.00	0.00	0.00	0.00	0.00	0.00	
FEE	69.58	85.63	123.93	156.45	147.59	141.74	137.41	125.18	0.00	0.00	0.00	0.00	0.00	0.00	
TOT REC CFE A/FW/G&A, FEE	**533.45**	**656.48**	**950.12**	**1199.42**	**1131.55**	**1086.67**	**1053.44**	**959.70**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7570.82**
UNIT REC A/F FY06$M	133.36	109.41	95.01	85.67	80.82	77.62	75.25	73.82	0.00	0.00	0.00	0.00	0.00	0.00	85.07

Production Methodology – Recurring Propulsion

- **If new A/C uses legacy engine use most current pricing**
- **New engine - numerous CERs available or in-house developed CER**

JET ENGINE:

AVG UNIT REC (FY91$K) = .225 x MAX THR^.7941 x (MAX THR / DRY WT)^.7415 x 1.003^1st Proc FY x (1.5)(If Turbofan) x MP^-.0944

Source: SPA Derived (FY2001)

R Sq = .97
SEE = +18.4%, -15.5%
Database - J79-GE-2A/B(F-4A/B), TF-30-P-412A(F-14A), F-414-GE-400(FA-18E/F), J65-W-16A(A-4A/B), J52-P-8A(A-6A), TF-34-GE-2(S-3A), F-402-RR-406(AV-8B), J57-P-4A/12 (F-8A/B), F-110-GE-400(F-14B/D), TF-41(A-7E)

AVG UNIT REC = Lot Average Unit Recurring cost including accessories in FY91$ K
MAX THR = Total maximum thrust (military power) including afterburner in pounds of thrust
MAX THR/DRY WT = Total max thrust above divided bt engine dry weight in pounds
1st Proc FY = FY of first production engines (last 2 or 3 digits of FY, ex. FY1997 = 97, FY2012 = 112)
Turbofan Dummy = Multiply equation results by 1.5 if Turbofan engine
LC = -0.0944 Learning Curve Slope

lnT1 = -10.4 - 8.55(lnSlope) + .482ab + 1.162(lnritf) + .261(lndrywt)

Source: RAND (FY 2001)

R Sq = .96 RMSE = .137
Database: TF-30, TF-33, TF-34, TF-39, SPEY-202, TF-41, F-100, F101, F110, F117, F119, F404, F414, JT8D-9, JT9D-3,

lnT1 = Natural log of Production T1 unit in FY2001$ Millions
lnSlope = Natural log of learning curve slope (ex., .95, .90, .88, etc.) Analyst has to select approp slope
ab = 1 if afterburning engine, 0 if not
lnrift = Natural log of Rotor Inlet Temp in degrees F
lndrywt = Natural log of Engine Dry Weight in lbs

TURBOSHAFT ENGINE:

ALT 1 CER:

ENG PROD 1000(FY91$K) =1.697 x DRY WT^.3110 x SHP^.2990 x 1.017^1st Proc FY

Source: SPA Derived (FY1995)

R Sq = .97
SEE = +7.0%, -6.6%
DATABASE - T-59, T-64, T-700, T-56, T-400, T-53

ENG PROD 1000 = Recurring Engine Production Cost of the 1000th unit in FY91$K, using a 92% Learning Curve
DRY WT = Engine Dry Weight in pounds
SHP = Engine Shaft Horsepower at Max Power
1st Proc FY = last 2 or 3 digits of first production lot (FY1987 = 87, FY2005 = 105, FY2012 = 112, etc.)

Production Methodology – Recurring Avionics and ECO

- **Recurring Avionics discussed in SDD methodology**
- **ECO estimated by historical factor (percent of Recurring Flyaway Cost each lot)**
- **NAVAIR average of historical programs percents**

FY	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
ECO % REC FLY	0.06	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Production Methodology – SE/PM

- **Methodologies**
  - Percent of Recurring Airframe Costs – Example 10%
  - CERs – RAND Study addresses and contains several CERs for estimating at cost level
  - Headcount based on analogous programs by same manufacturer

SEPM ENGINEER HEADCOUNTS FOR ACTUAL PROGRAMS

SYSTEM A Qty	x	x	x	x	x	x	x	x	x
SYSTEM A	60	99	93	90	88	86	85	84	69
SYSTEM B Qty	x	x	x	x	x	x	x	x	x
SYSTEM B	26	48	48	47	47	47	47	47	39
SYSTEM C Qty	x	x	x	x	x	x	x	x	x
SYSTEM C	19	33	32	32	31	31	31	30	26
SYSTEM D Qty	x	x	x	x	x	x	x	x	x
SYSTEM D	29	52	51	50	49	48	48	48	40
SYSTEM E Qty	x	x	x	x	x	x	x	x	x
SYSTEM E	17	32	31	30	30	30	29	29	24

SEPM HEADCOUNT = 7.89 x QTY^.735 **R SQ = .93** **SEE = +4.9,-4.6%**

Production Methodology – Non Recurring Flyaway

- **Typically estimates as percent of Recurring Flyaway**
- **Normally front loaded (i.e., highest Non Rec percent in first 2 to 3 lots)**
  - Major portion on Non Rec is for Rate Tooling
  - NAVAIR program history average

FY	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7	YR 8	YR 9	YR 10
Non Rec Percent of Flyaway	0.16	0.08	0.06	0.04	0.02	0.02	0.02	0.02	0.02	0.02

- **Example selected program average**

PRODUCTION NON REC PERCENT OF REC FLYAWAY

PROGRAM	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7	YR 8
MH-60S	0.115	0.002	0.03	0.013	0.048	0.216	0.201	0.036
MH-60R	0.242	0.158	0.011	0.01	0.028	0.017	0.001	0.001
AH-1Z/UH-1Y	0.12	0.131	0.28	0.224	0.018	0.021	0.001	0.001
AVG	0.159	0.097	0.107	0.082	0.031	0.085	0.068	0.013

Production Methodology – Aircraft Support Costs

- **Typically referred as "Below the Line Costs"**
- **Estimating level of detail/methodology driven by program information**
- **MS B and prior normally estimated by factor (i.e., percent of recurring flyaway)**
  - Estimated at Total Support level or by each Support Cost element
- **MS C (LRIP and FRP)**
  - Details such as qty of operational Flight and Maintenance Trainer requirements, number of support sites/test facilities, equipment requirements and locations, common support, technical data requirements, etc. are established by Program Office
  - Program Office typically either provides estimates or major inputs above to cost analysts for estimating purpose

Production Methodology – Aircraft Support Sample Support Factors

PERCENT OF REC FLYAWAY BY SUPPORT ELEMENT

AIRFRAME PGSE	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	LOT 9	LOT 10
AV-8B	10.2%	18.5%	21.2%	5.4%	2.4%	2.4%	3.1%	6.3%		
EA-6B	16.7%	38.2%	8.8%	42.6%	12.8%	11.1%	17.1%	32.8%	37.8%	19.1%
F-14A	8.7%	6.1%	5.0%	7.1%	5.2%	7.0%	5.1%	3.4%	3.9%	3.2%
F/A-18A-D	8.9%	12.3%	13.6%	22.1%	11.5%	17.0%	10.9%	9.3%	10.5%	7.8%
F/A-18E/F	2.4%	0.8%	2.2%	3.1%	1.4%	0.7%	0.4%	0.7%	0.2%	0.7%
AVERAGE	9.4%	15.2%	10.2%	16.1%	6.7%	7.6%	7.3%	10.5%	13.1%	7.7%

ENGINE PGSE	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	LOT 9	LOT 10
AV-8B	0.61%	0.84%	0.63%	0.47%	0.68%	0.05%	0.80%	0.10%		
EA-6B	0.13%	0.16%	0.09%	0.15%	0.12%	0.19%	0.00%	0.07%	0.00%	0.18%
F-14A	0.39%	0.27%	0.35%	0.20%	0.18%	0.46%	0.46%	0.17%	1.12%	0.83%
F/A-18A-D	1.02%	2.06%	0.80%	1.15%	0.42%	0.48%	0.20%	0.09%	0.85%	0.39%
F/A-18E/F	0.92%	0.89%	0.97%	0.69%	0.69%	0.53%	0.20%	0.27%	0.08%	0.15%
AVERAGE	0.6%	0.8%	0.6%	0.5%	0.4%	0.3%	0.3%	0.1%	0.5%	0.4%

AVIONICS PGSE	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	LOT 9	LOT 10
AV-8B	1.3%	3.3%	0.6%	3.2%	1.2%	0.3%	0.5%	0.9%		
EA-6B	0.3%	0.7%	1.6%	1.4%	0.0%	0.3%	0.1%	0.7%	3.2%	1.8%
F-14A	10.3%	12.5%	4.3%	5.0%	4.6%	6.4%	4.0%	2.9%	3.2%	2.6%
F/A-18A-D	0.3%	1.2%	0.7%	0.6%	0.6%	2.5%	1.2%	0.9%	0.7%	2.7%
F/A-18E/F	2.0%	0.2%	0.8%	1.6%	2.5%	1.3%	1.6%	1.9%	0.6%	0.8%
AVERAGE	2.8%	3.6%	1.6%	2.4%	1.8%	2.2%	1.5%	1.5%	1.9%	2.0%

PEC TRAIN	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	LOT 9	LOT 10
AV-8B	1.3%	5.6%	6.8%	1.9%	1.9%	1.6%	0.5%	1.2%		
EA-6B	2.8%	5.5%	1.4%	4.6%	2.8%	19.4%	2.2%	6.2%	5.5%	0.8%
F-14A	8.5%	5.3%	2.3%	5.0%	4.9%	1.8%	2.2%	2.9%	0.4%	1.7%
F/A-18A-D	12.1%	4.0%	7.4%	2.7%	1.7%	1.5%	2.8%	4.7%	3.9%	0.8%
F/A-18E/F	6.4%	2.1%	3.3%	4.8%	0.6%	1.1%	2.9%	1.4%	1.2%	2.9%
AVERAGE	6.2%	4.5%	4.2%	3.8%	2.4%	5.1%	2.1%	3.3%	2.7%	1.6%

PUBS/TECH DATA	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6	LOT 7	LOT 8	LOT 9	LOT 10
AV-8B	5.9%	2.5%	3.6%	3.2%	1.4%	1.7%	2.2%	1.5%		
EA-6B	3.0%	9.4%	3.7%	5.7%	7.1%	4.5%	6.1%	7.3%	7.2%	5.5%
F-14A	2.5%	2.9%	1.5%	0.9%	2.1%	4.4%	3.5%	0.8%	2.2%	1.5%
F/A-18A-D	3.7%	1.0%	2.2%	6.1%	1.7%	2.0%	1.2%	1.9%	0.9%	0.9%
F/A-18E/F	3.4%	0.6%	2.5%	1.3%	1.6%	1.2%	1.2%	1.0%	0.9%	1.2%
AVERAGE	3.7%	3.3%	2.7%	3.4%	2.8%	2.7%	2.9%	2.5%	2.8%	2.3%

Production Methodology – Sample Production Cost Comparison Results

AoA ALT	COMPARISON QTY	CONTRACTOR AVG UNIT PROC FY06$M	COST TEAM AVG UNIT PROC FY06 $M	DELTA
SYS A	50	4.85	7.39	152%
SYS B	44	4.73	8.16	173%
SYS C	40	5.70	7.91	139%
SYS D	100	7.19	11.15	155%
SYS E	100	6.50	12.14	187%
SYS F	50	17.00	24.43	144%