



CRITICAL THINKING.
SOLUTIONS DELIVERED.

Improving Cost Estimating during Program Execution through Integrated Program Management

presented by:

Wendy Freeman

MCR, LLC

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wfreeman@mcr.com

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Abstract

During program execution, Earned Value Management (EVM), the Integrated Master Schedule (IMS) and Technical Performance Measures are integrated with risk management in day-to-day program management. The program's cost estimate needs to take into account program performance, including contract performance, in order to estimate the cost and schedule resources necessary to complete the program and ensure sufficient budget is available. This presentation will explore an analysis tool which links the program management disciplines together (a best practice as described in the GAO Cost Assessment Guide) in order to produce a probability distribution around the cost estimate while providing actionable information to the Program Manager. The results will be demonstrated on a Major Defense Acquisition Program.

- Program Snapshot
- Cost Estimating Approach
- LCAA™
- Adjusting for Discrete Risks
- Software Cost Estimate
- Schedule Risk Analysis
- Program Office Estimate Results
- Conclusions



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Program Snapshot

- Mission Equipment Contract Awarded in Dec 03
 - Navy C4I program (MDAP)
- Software Critical Design Review (CDR) was recently postponed a couple of months – conducted separately from Hardware CDR

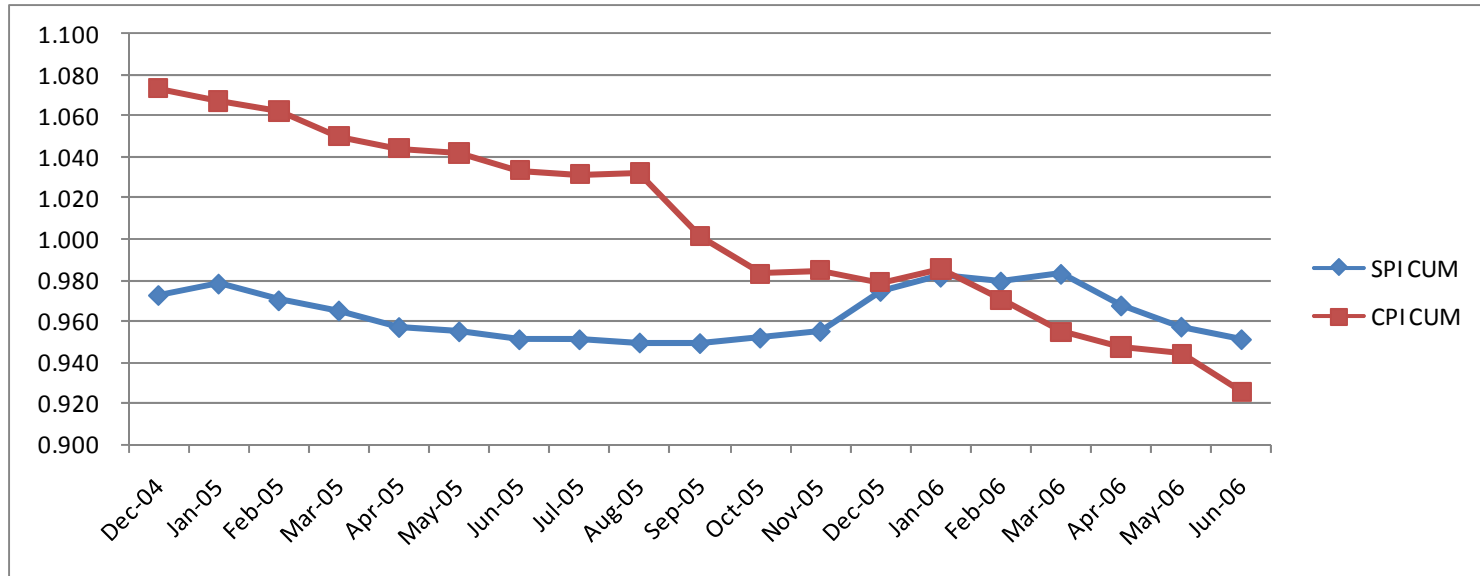
ID	Task Name	2003		2004		2005		2006		2007		2008		2009		2010		2011		2012	
		H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2
1	Mission Equipment Contract	[Timeline bar from H2 2003 to H2 2011]																			
2	Contract Award			◆	12/1																
3	PDR					◆	1/3														
4	CDR							◆	2/1												
5	S/W CDR							◆	4/3												
6	Build 5 Integration												◆	12/1							
7	TECHEVAL																		◆	12/1	
8	OPEVAL																			◆	7/1



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Program Snapshot (cont'd)

- Contractor Performance until recently has been good



- Recent Cost Variances (\$K) have Program concerned

	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06
Current CV	1,312.0	(4,059.4)	(4,966.8)	(2,769.0)	(1,842.5)	(6,781.0)



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Program Snapshot (cont'd)

- Contractor still projecting Estimate at Completion (EAC) less than Contract Budget Base (CBB)
 - CBB is \$875.8M
 - Contractor's Latest Revised Estimate (LRE) \$862.6M
 - Program Threshold is \$961M (normalized from Base-Year)
- Mission Equipment (ME) is only one piece of the program
 - ME delay will cause significant cost overruns in platform development costs
 - Schedule analysis must be *linked* to cost estimate

Cost Estimating Approach

- Given program is post-CDR, actual costs used to project future costs preferred primary estimating method
- MCR's LCAA™
 - Linked CREST Assessment and Analysis
 - Cost Estimate
 - Risk Management
 - Earned Value
 - Schedule
 - Technical Performance
 - Gated Process for linking all disciplines of Program Management
 - Tenants of “linking” concept captured in GAO Cost Estimating and Assessment Guide, GAO 09-3SP as best practice
- Compare EAC range to program budget
- Answer question: Is program likely to breach Acquisition Program Baseline (APB) (cost or schedule)?



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LCAA™ Gates

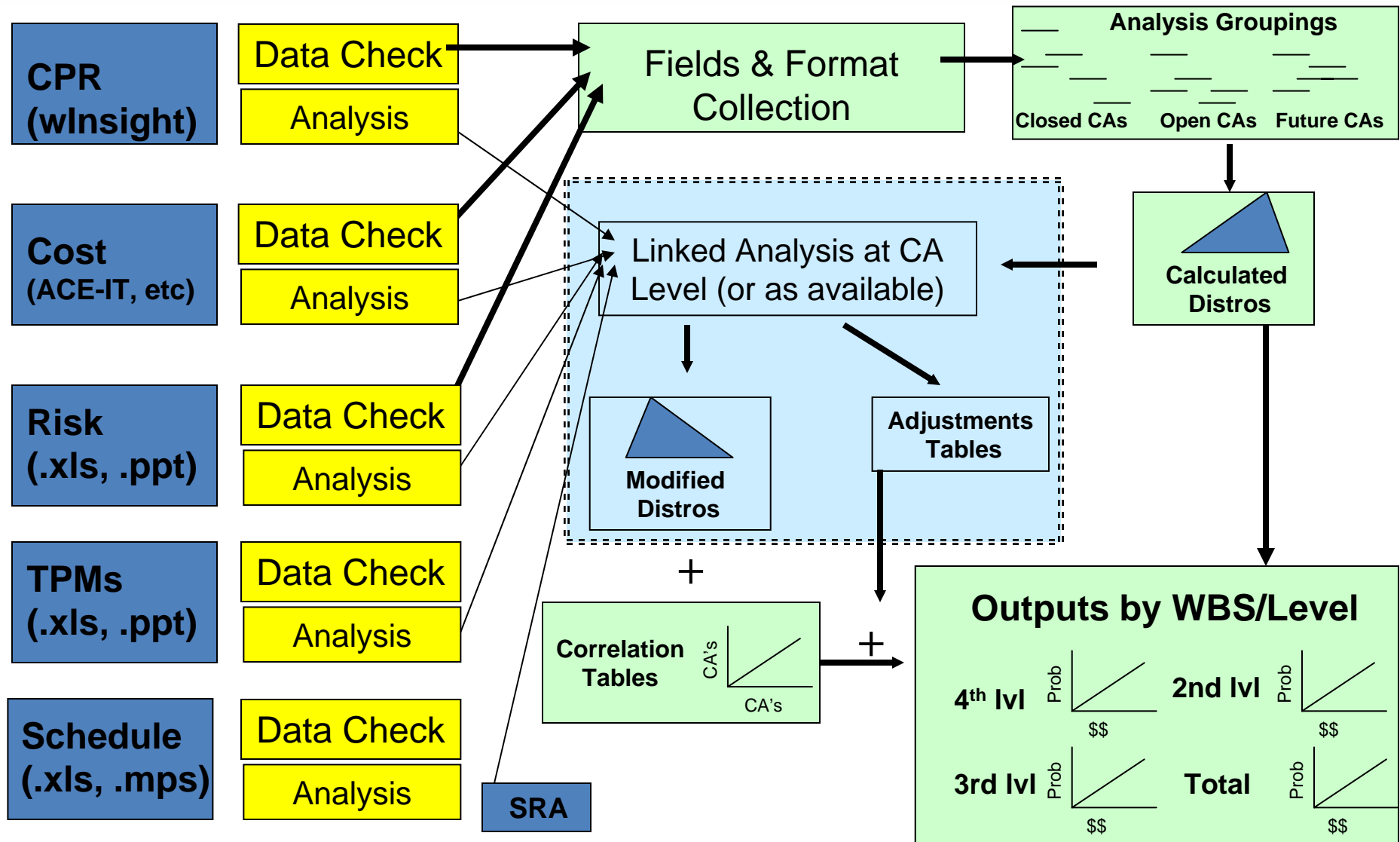
Gates 1 & 2 LCAA™

- Provides Transparency Assessment
 - Helps identify potential ROOT CAUSES for future variances
- Overall Gates 1 & 2 frame of reference built from published guidelines (such as ANSI) and known Best Practices (e.g., sources from GAO, DAU, PMI)
- Allows insight into:
 - Intensity of *Linkage* across quantitative PM knowledge areas
 - Degrees of discipline in implementing knowledge areas
 - Level of detail in information

Gates 3 & 4 LCAA™

- Provides ETC analysis via integration of Schedule Risk Analysis (SRA) and cost risk analysis
 - Relies on Gate 1 and Gate 2 results to assess quality of LCAA inputs and confidence level associated with LCAA outputs.
- Detailed ETC analysis translated into indices for program execution via generation of MCR Risk Indexes™

LCAA™ Gate 3 and 4 Information Flow





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LCAA™ Gates 1 and 2

- Contractor LRE is badly in need of updating
 - LRE failed many observations
 - LRE less than ACWP for many lower level WBS elements at or near completion
- CFSR is giving poor projection of funds required
 - Each month's overrun is only adjustment in projections
- Risk and Opportunity Register has only 52 risks and 10 opportunities
 - Almost all with less than 40% probability of occurrence
 - Little discussion of software development problems despite delay in software portion of CDR and overruns
- Need to reconcile Program Office Estimate and Contractor WBS
- Positive Performance on LOE tasks masking poor performance on discrete tasks
 - 42% of PMB is LOE

Assessment shows Poor Data Transparency



LCAA™ Gates 3 and 4: Adjusting for Discrete Risks

Risk/Opportunities Summary by Level 3 WBS

WBS	Description	Risk	Opportunity	Risk Register Risks						Opportunities				
				WBS ID	Item ID	Level	Prob	K\$ Impact	Factored K\$Impact	WBS ID	Item ID	K\$ Impact	Factored K\$Impact	Prob
1.1.1	Requirements			1.3.6.2	R1	High	1	1200	1200	1.4.1	O1	1500	375	0.25
1.1.1.11	Intra-Payload Interface Requirements			1.3.10	R2	Low	0.35	112		1.2.2	O2	13	3.9	0.3
1.1.1.12	XYZ Company UAV #2 Suite	75.0		1.3.12	R3	Low	0.3	74	22.2	1.2.2	O3	500	150	0.3
1.1.2	Airframe			1.3.6	R4	Low	0.42	631	265.02	1.2.2	O4	3800	1520	0.4
1.1.3	Propulsion			1.3.2	R5	Low	0.1	328	32.8	1.2.2	O5	2100	420	0.2
1.1.4	On-board Communications/Navigation	187.1		1.3.2	R6	Low	0.1	99.3	9.93	1.2.3	O6	131.3	32.825	0.25
1.1.5	Auxiliary Equipment			1.3.11	R7	Low	0.4	317	126.8	1.2.6	O7	129	12.9	0.1
1.1.6	Survivability Modules			1.3.17	R8	Low	0.4	188	75.2	1.2.6	O8	218	43.6	0.2
1.1.7	Electronic Warfare Module			1.3.7	R9	Low	0.4	181	72.4	1.2.4	O9	40	8	0.2
1.1.8	On Board Application & System SW			1.3.13	R10	Low	0.4	3837	1534.8	1.9	O10	400	80	0.2
1.1.9	Payload Configuration Mgt			1.3.17	R11	Low	0.4	565	226					
1.2.1	Requirements			1.4.1.3	R12	Low	0.09	500	45	Total			2646.225	
1.2.10	UAV #1 IPT FE EMC			1.4.1.3	R13	Mod	0.4	1000	400					
1.2.11	UAV #1 IPT Lead	12.4		1.7.5.2	R14	Low	0.35	200	70					
1.2.12	UAV #2 Parts Engineering			1.7.6.7	R15	Low	0.4	586	234.4					
1.2.2	Airframe	1548.0	2093.9	1.7.6.7	R16	Low	0.4	388	155.2					
1.2.3	Propulsion	387.6	32.8	1.7.5	R17	Low	0.4	310	124					
1.2.4	On-board Communications/Navigation	625.3	8.0	1.7.7.2.2	R18	Low	0.3	247	74.1					
1.2.5	UAV#1 Auxiliary Equipment	302.6		1.8.2.7.1	R19	Mod	0.21	1200	252					
1.2.6	Survivability Modules	249.5	56.5	1.8.2	R20	Low	0.4	43	17.2					
1.2.7	Electronic Warfare Module			1.8.1.1	R21	Low	0.4	600	240					
1.2.8	Integrated EW Package			1.1.12	R22	Low	0.2	250	50					
1.2.9	Onboard Application & System SW			1.1.12	R23	Low	0.1	250	25					
1.3.1	Control Station Specifications			1.2.2	R24	Low	0.3	2990	897					
1.3.10	Suite Software Integration	39.2		1.2.2	R25	Low	0.4	450	180					
1.3.11	IPT Lead	126.8		1.2.2.7	R26	Low	0.4	167	66.8					
1.3.12	Task A Support Activities	22.2		1.2.2	R27	Low	0.4	950	380					
1.3.13	Task B Support Activities	1534.8		1.2.2.B	R28	Low	0.2	60	12					
1.3.15	Build Configuration Management			1.2.2.E	R29	Low	0.1	122	12.2					
1.3.16	EMI Mitigation SW			1.2.3	R30	Low	0.3	629	188.7					
1.3.17	Software Management	301.2		1.2.3	R31	Low	0.4	95	38					
1.3.2	Signal Processing SW (SPSW)	42.7		1.2.3.7	R32	Low	0.4	261	104.4					
1.3.3	Station Display and Configuration SW (DCSW)			1.2.3	R33	Low	0.4	77	30.8					
1.3.4	Operating System SW (OSSW)			1.2.3	R34	Low	0.25	54	13.5					
1.3.5	ROE Simulations SW (RSSW)			1.2.3.8	R35	Low	0.1	122	12.2					
1.3.6	Mission Attack Commands SW (MACSW)	1465.0		1.2.6	R36	Low	0.3	443	132.9					
1.3.7	Qual Tests	72.4		1.2.6	R37	Low	0.4	67	26.8					
1.3.8	Performance Planning SW (PPSW)			1.2.6	R38	Low	0.4	101	40.4					
1.3.9	External Coordination SW (ECSW)			1.2.6.7.1	R39	Low	0.3	80	24					
1.4.1	Integration	445.0	375.0	1.2.6.6	R40	Low	0.2	127	25.4					
1.4.2	Test			1.2.11	R41	Low	0.1	124	12.4					
1.5.4	Test and Measurement Equipment			1.2.4	R42	Low	0.3	1411	423.3					
1.5.5	Support and Handling Equipment			1.2.4	R43	Low	0.4	213	85.2					
1.7	ILS	657.7		1.2.4	R44	Low	0.4	62	24.8					
1.8.1	Program Management	240.0		1.2.4	R45	Low	0.4	210	84					
1.8.2	System Engineering	269.2		1.1.4	R46	Low	0.2	900	180					
1.9	Multi- Airframe Multi-Payload Integration		80.0	1.1.4	R47	Low	0.1	71	7.1					
1.10	Proposal Effort			1.2.4	R48	Low	0.1	80	8					
1.11	Subcontract COM			1.2.5	R49	Low	0.3	528	158.4					
				1.2.5	R50	Mod	1	80	80					
				1.2.5	R51	Low	0.4	130	52					
				1.2.5.6	R52	Low	0.1	122	12.2					
Total		8603.8	2646.2											
				Total					8603.75					

Risk/Opportunity list

Adjustment to ETC



LCAA™ Gates 3 and 4: Software Cost Estimate

- Primary Estimating Methodology: SEER-SEM
 - Predicts Total Effort, Staffing Profile, and Schedule Months
- SLOC Data from Design Disclosures, Post CDR IPR Charts and Government Engineering Assessment
- Reuse captured
 - Five-Build Approach
 - Contractor brought code from previous development program
- Significant Findings
 - Effort underestimated
 - Near-term schedule unrealistic
 - Delay in Builds 1-4 could have serious consequences for more than software



LCAA™ Gates 3 and 4: Software Cost Estimate (cont'd)

			Schedule	C&UT	CSC I&T	SI I&T	Contractor
		ESLOC	Months	Start	Start	Complete	Schedule
Build 1							
	CSCI 1	16441	12.6	1/31/2006	6/16/2006	2/18/2007	8/30/2006
	CSCI 2	2659	5.9	3/15/2006	5/23/2006	9/7/2006	
	CSCI 3	3775	6.7	4/5/2006	6/26/2006	10/28/2006	
	CSCI 4	13415	10.7	2/23/2006	7/10/2006	1/13/2007	
	CSCI 5	1318	4.3	2/21/2006	4/14/2006	7/1/2006	
	CSCI 6	2026	5.0	2/21/2006	4/24/2006	7/22/2006	
	CSCI 7	9605	8.9	2/28/2006	6/24/2006	11/26/2006	
Build 2							
	CSCI 1	21346	24.6	7/1/2006	11/30/2006	8/30/2007	
	CSCI 3	21487	24.3	9/18/2006	3/3/2007	11/3/2007	5/1/2007
	CSCI 4	17454	22.1	6/18/2006	11/20/2006	6/15/2007	
	CSCI 6	2226	9.6	5/5/2006	7/10/2006	10/12/2006	
	CSCI 7	11208	17.8	6/17/2006	10/20/2006	4/1/2007	



LCAA™ Gates 3 and 4: Software Cost Estimate (cont'd)

			Schedule	C&UT	CSC I&T	SI I&T	Contractor
		ESLOC	Months	Start	Start	Complete	Schedule
Build 3							
	CSCI 1	24241	25.9	4/30/2007	10/7/2007	7/21/2008	
	CSCI 2	42974	32.1	7/15/2006	2/19/2007	1/10/2008	
	CSCI 3	45058	32.7	6/30/2007	2/8/2008	1/4/2009	4/1/2008
	CSCI 4	9092	17.0	3/14/2007	7/10/2007	12/18/2007	
	CSCI 6	3269	11.2	8/28/2006	11/13/2006	3/2/2007	
	CSCI 7	26980	25.2	1/21/2007	7/18/2007	3/8/2008	
	CSCI 8	11182	21.5	6/9/2005	11/5/2005	5/30/2006	
Build 4							
	CSCI 2	52791	34.9	7/27/2007	3/19/2008	3/10/2009	
	CSCI 3	19906	23.6	7/19/2008	12/26/2008	8/22/2009	8/1/2008
	CSCI 4	15811	21.2	10/5/2007	3/2/2008	9/17/2008	
	CSCI 6	30127	27.1	1/9/2007	7/15/2007	4/2/2008	
	CSCI 7	64136	35.7	11/26/2007	8/4/2008	6/28/2009	



LCAA™ Gates 3 and 4: Software Cost Estimate (cont'd)

			Schedule	C&UT	CSC I&T	SI I&T	Contractor
		ESLOC	Months	Start	Start	Complete	Schedule
Build 5							
	CSCI 1	5533	14.4	3/15/2008	6/12/2008	11/19/2008	
	CSCI 2	11422	18.9	9/9/2008	1/15/2009	7/25/2009	
	CSCI 3	13329	20.1	4/22/2009	9/6/2009	3/28/2010	3/1/2010
	CSCI 4	17881	22.3	6/17/2008	11/21/2008	6/18/2009	
	CSCI 5	11144	18.5	5/23/2006	9/27/2006	3/27/2007	
	CSCI 6	6324	14.5	11/30/2007	3/10/2008	7/27/2008	
	CSCI 7	20730	22.7	2/6/2009	7/15/2009	2/10/2010	

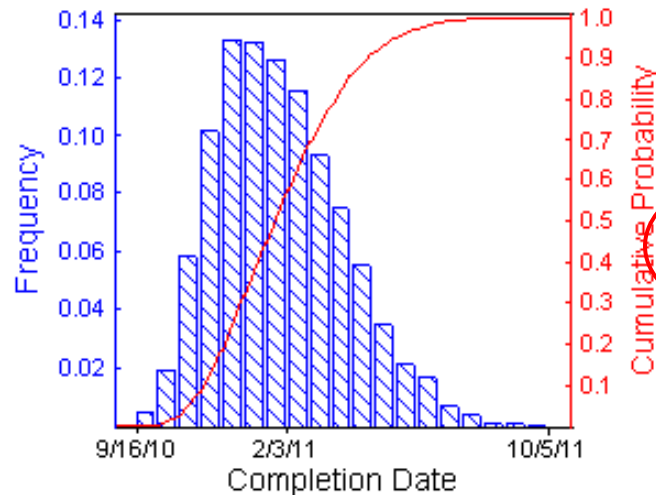


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Schedule Risk Analysis

Date: 6/12/2006 7:28:09 AM
Samples: 5000
Unique ID: 98
Name: TECHEVAL

Completion Std Deviation: 44.07 d
95% Confidence Interval: 1.22 d
Each bar represents 15 d



Completion Probability Table

Prob	Date	Prob	Date
0.05	11/8/10	0.55	2/4/11
0.10	11/23/10	0.60	2/15/11
0.15	12/2/10	0.65	2/23/11
0.20	12/13/10	0.70	3/4/11
0.25	12/21/10	0.75	3/15/11
0.30	12/28/10	0.80	3/29/11
0.35	1/4/11	0.85	4/12/11
0.40	1/12/11	0.90	4/29/11
0.45	1/20/11	0.95	5/27/11
0.50	1/27/11	1.00	10/5/11

TECHEVAL in Dec 2010 has LOW probability of occurring

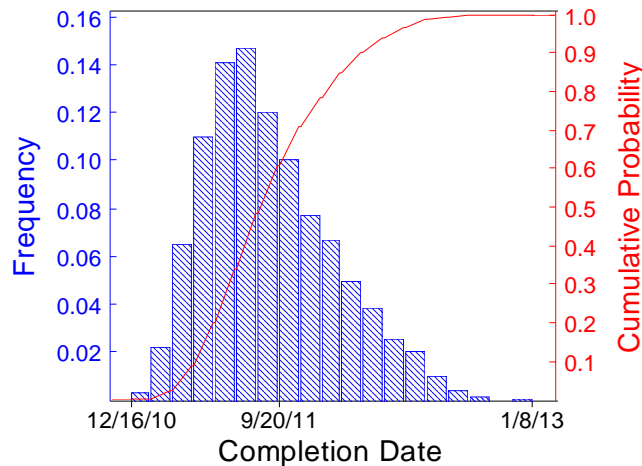


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Schedule Risk Analysis

Date: 7/9/2006 1:47:55 PM
Samples: 5000
Unique ID: 98
Name: TECHEVAL

Completion Std Deviation: 90.78 d
95% Confidence Interval: 2.51 d
Each bar represents 30 d



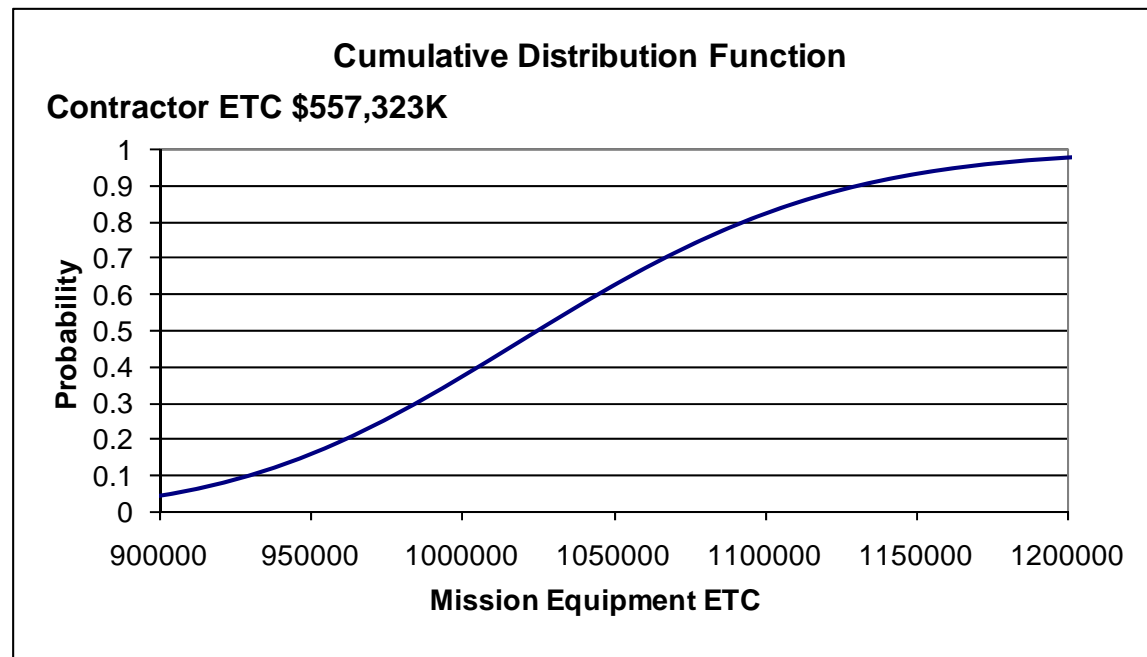
Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	3/29/11	0.55	9/13/11
0.10	4/26/11	0.60	10/3/11
0.15	5/16/11	0.65	10/21/11
0.20	6/2/11	0.70	11/10/11
0.25	6/17/11	0.75	12/7/11
0.30	7/1/11	0.80	1/4/12
0.35	7/18/11	0.85	2/6/12
0.40	7/31/11	0.90	3/20/12
0.45	8/12/11	0.95	5/17/12
0.50	8/26/11	1.00	1/8/13

*Factor in Software Modeling results and
TECHEVAL in Dec 2010 has NO probability of occurring*

POE Results Estimate to Complete (ETC)

\$ 1,027,399	Mean (Expected Cost)
\$ 1,024,443	Median (50th percentile)
\$ 1,018,556	Mode (Most Likely)
\$ 78,109	Std. Deviation
Confidence Percentiles	
\$ 904,183	5%
\$ 929,469	10%
\$ 946,927	15%
\$ 961,035	20%
\$ 973,307	25%
\$ 984,460	30%
\$ 994,910	35%
\$ 1,004,928	40%
\$ 1,014,716	45%
\$ 1,024,443	50%
\$ 1,034,263	55%
\$ 1,044,337	60%
\$ 1,054,853	65%
\$ 1,066,049	70%
\$ 1,078,266	75%
\$ 1,092,034	80%
\$ 1,108,305	85%
\$ 1,129,122	90%
\$ 1,160,697	95%

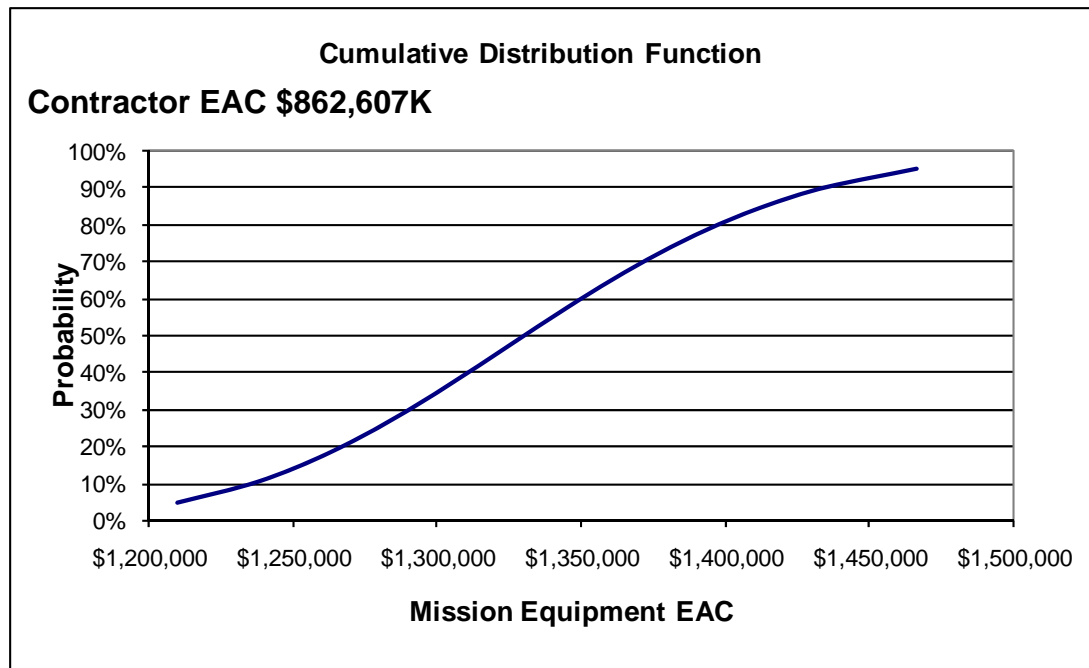


*ETCs for Lowest Level WBS elements show Poor Performance
And Significant Cost Overruns*

POE Results Estimate at Completion (EAC)

\$ 1,332,683	Mean (Expected Cost)
\$ 1,329,727	Median (50th percentile)
\$ 1,323,840	Mode (Most Likely)
\$ 78,109	Std. Deviation

Confidence Percentiles	
\$ 1,209,468	5%
\$ 1,234,753	10%
\$ 1,252,211	15%
\$ 1,266,319	20%
\$ 1,278,591	25%
\$ 1,289,744	30%
\$ 1,300,194	35%
\$ 1,310,212	40%
\$ 1,320,000	45%
\$ 1,329,727	50%
\$ 1,339,547	55%
\$ 1,349,621	60%
\$ 1,360,137	65%
\$ 1,371,333	70%
\$ 1,383,550	75%
\$ 1,397,318	80%
\$ 1,413,589	85%
\$ 1,434,406	90%
\$ 1,465,981	95%



Contractor Management Reserve \$15,254K

POE shows program will Breach unless Corrective Actions are taken



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Conclusions

- Need Realistic Contractor ETC Immediately
 - Possible Reprogram vise Re-plan
 - Need Integrated Baseline Review (IBR)
 - FY07 Funding Shortfall is Real
 - Current Schedule has NO Probability of Occurrence
- Current path shows Breach in cost and schedule inevitable without Corrective Actions
- Poor Data Transparency
- LCAA™ links PM Disciplines
 - CREST (C Cost Estimating, R Risk Management, E Earned Value, S Schedule, T Technical Performance)
 - Probability Distribution around POE
 - Actionable Information to the Program Manager.