EVM's Potential for Enabling Effective Integrated Cost-Risk Management

ICEAA 2016 Professional Development & Training Workshop

Grand Hyatt Buckhead

Atlanta, GA

7-10 June

David R. Graham (Galorath Federal Systems dgmogul1@Verizon.net; 703-489-6048)

Bryn Turner (Galorath Federal Systems)

Andrew Austin & Darren Elliott (Tecolote Research, Inc.)

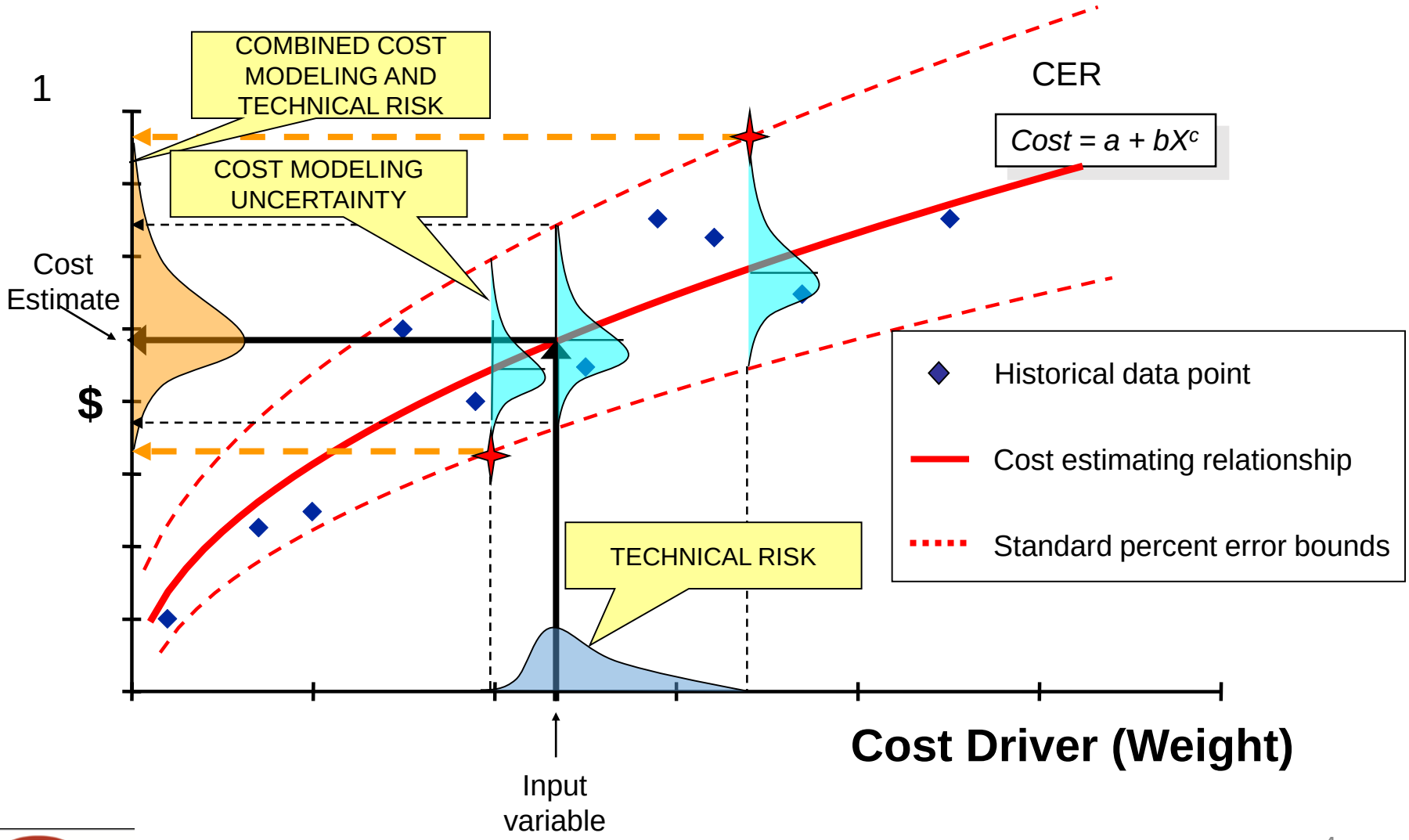
Outline

- Describe the present stove-piped nature of risk and cost-risk assessment and analysis
- Describe the benefits each of the presently stove-piped participants bring to cost-risk assessment and analysis if they work together
- Describe the 'Organizing Vehicles' of two new EVM cost-risk tools enabling such collaboration
- Illustrate these two new EVM cost-risk tools
- Summary and Conclusion
- References

Stove-Pipe Cost-Risk Chaos

- Stovepipe 1: Programs have early estimates of cost-risk from cost estimators at major milestones and annually in their cost estimates
- Stovepipe 2: Programs have Risk Management Team qualitative assessments on a monthly schedule, and usually no (or weak) quantification of cost-risk
- Stovepipe 3: Programs have EVM analysis and IEACs developed on a monthly basis without quantifying cost-risk
- Tomorrow, all three stovepipes can work together on cost risk assessment and analysis with two 'Organizing Vehicles'
- (Note: Acknowledging that schedule risk analysis is important and relevant, the focus of this briefing will be on cost-risk only)

Stovepipe 1: Cost Model and Input Parameter Cost-Risk Quantification at Major Milestones and Annually



Stovepipe 2: Risk Management Team Qualitative Assessments (DAU EVM 201 LAR Risk Register Assessment)

HIGH:

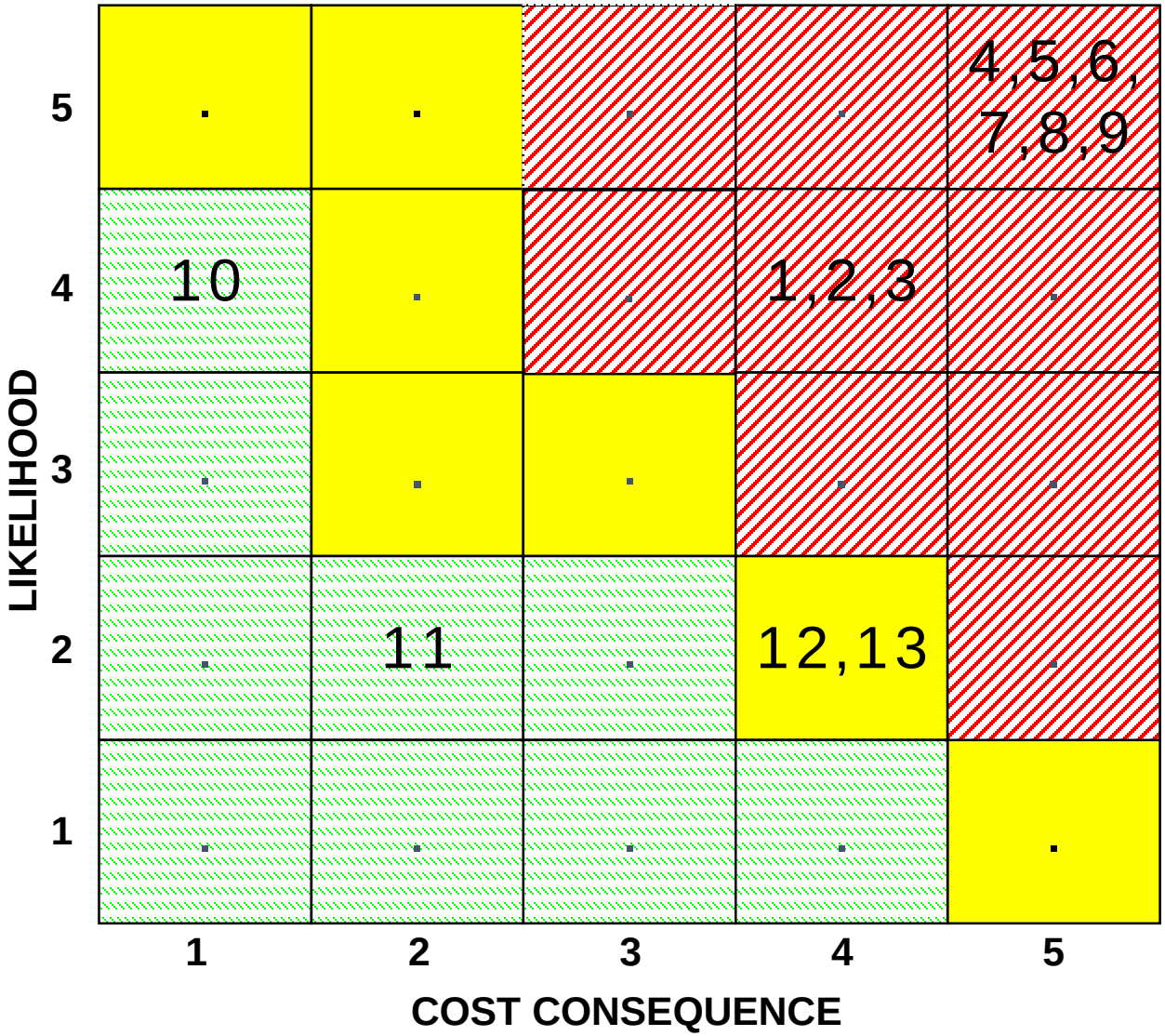
1. Reduce Wheelbase
2. Increase Maneuverability
3. Ruggedize LAR
4. Lower Infrared Profile
5. Reduce LAR Noise
6. Shrink LAR Visible Profile
7. Torque Increase
8. Increase LAR Speed
9. Decrease Pwr Pkg Complexity

MEDIUM:

12. First/Unit LAR Full Integration Test Failure
13. OTS Parts Failure

LOW:

10. F/U Integration Test
11. Aux/Auto Sub-System Function Failures



GALORATH

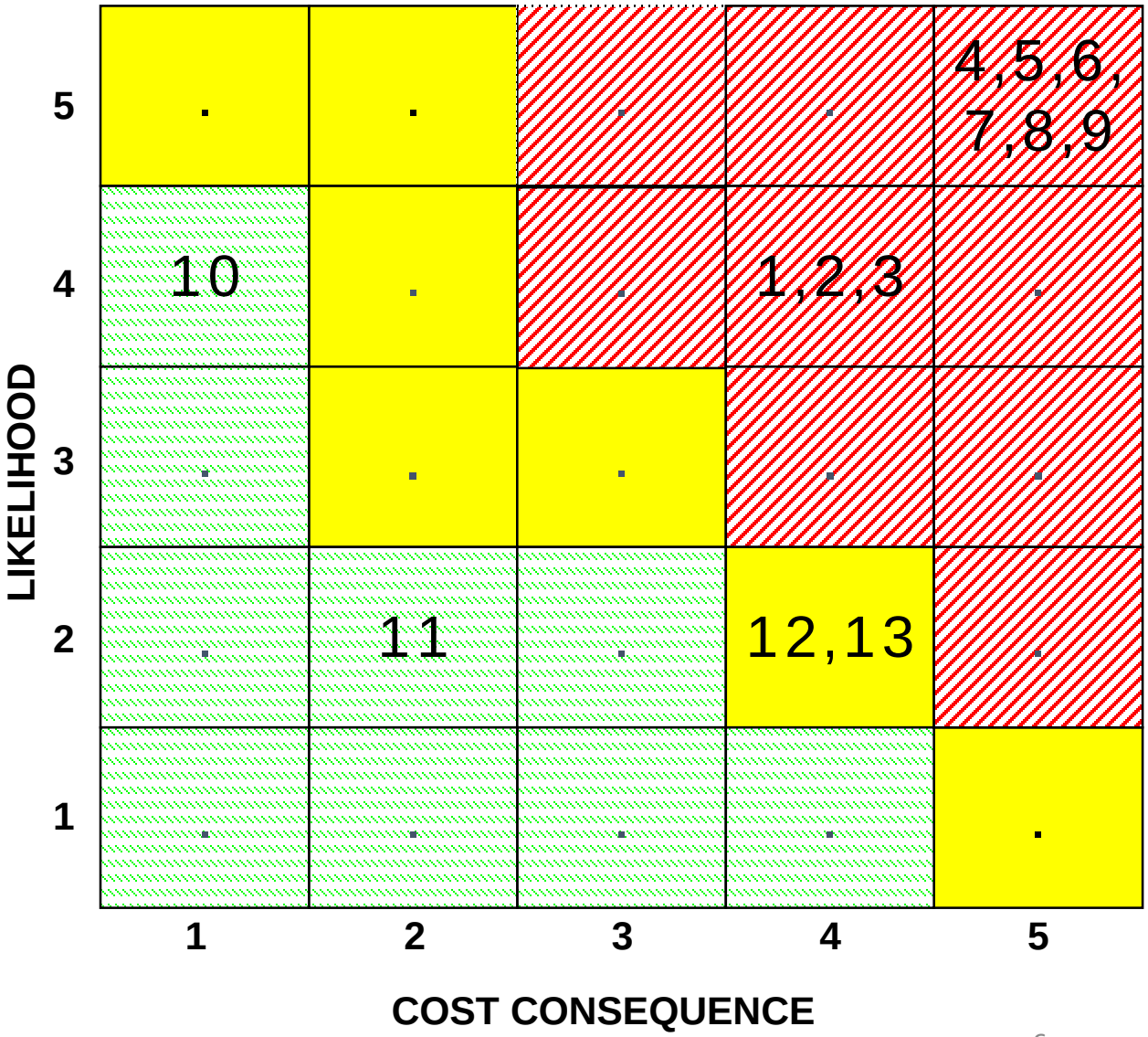
Stovepipe 2 (cont): 5x5 Risk Matrix Rating Scales

Definitions From Program's Risk Management IPT

- **Likelihood of Occurrence Levels**
  - 1 Not Likely (5% - 20%)
  - 2 Low Likelihood (21% - 40%)
  - 3 Likely (41% - 60%)
  - 4 Highly likely (61% - 80%)
  - 5 Near certainty (81% - 99%)

(Note: Percentages from DoD range guidance)

- **Cost Consequence Rating**
  - 1 Negligible (1% - 5%)
  - 2 Minor (5% - 10%)
  - 3 Moderate (10% - 15%)
  - 4 Serious (15%- 20%)
  - 5 Critical (23% - 28%)



Stovepipe 3: Monthly EVM Analysis & Independent IEAC (no explicit cost-risk)

	Inputs						Standard EV Measures											
Month Number	Month	$BCWS_{CUM}$	$BCWP_{CUM}$	$ACWP_{CUM}$	BAC	LRE EAC	CPI	SPI	SCI (= CPI * SPI)	$IEAC_{SCI}$ Using CPR BAC	Earned Schedule End Mo Using CPR BAC	Raw % Complete	Adjusted % Complete	% Spent	Cost Var	SV	VAC
25	Sep-95	$2,034	$1,988	$2,017	$5,750	$5,750	98.6%	97.7%	96.33%	$5,922	72	35%	35%	35%	-$29	-$46	$0
26	Oct-95	$2,150	$2,095	$2,142	$5,776	$5,776	97.8%	97.4%	95.30%	$6,004	72	36%	28%	37%	-$47	-$55	$0
27	Nov-95	$2,247	$2,191	$2,243	$5,785	$5,785	97.7%	97.5%	95.25%	$6,016	71	38%	32%	39%	-$52	-$56	$0
28	Dec-95	$2,358	$2,294	$2,353	$5,823	$5,823	97.5%	97.3%	94.91%	$6,071	71	39%	32%	40%	-$58	-$63	$0
29	Jan-96	$2,477	$2,400	$2,462	$5,871	$5,871	97.5%	96.9%	94.44%	$6,138	71	41%	31%	42%	-$62	-$77	$0
30	Feb-96	$2,586	$2,501	$2,565	$5,907	$5,917	97.5%	96.7%	94.32%	$6,176	71	42%	31%	43%	-$64	-$85	-$10
31	Mar-96	$2,705	$2,617	$2,694	$5,961	$5,972	97.1%	96.7%	93.97%	$6,253	71	44%	31%	45%	-$77	-$88	-$11
32	Apr-96	$2,817	$2,729	$2,817	$6,000	$6,017	96.9%	96.9%	93.84%	$6,304	70	45%	31%	47%	-$89	-$88	-$17
33	May-96	$2,921	$2,828	$2,932	$6,088	$6,146	96.5%	96.8%	93.38%	$6,423	71	46%	30%	48%	-$104	-$93	-$58
34	Jun-96	$3,038	$2,939	$3,051	$6,161	$6,350	96.3%	96.7%	93.15%	$6,510	71	48%	30%	50%	-$112	-$100	-$189
35	Jul-96	$3,152	$3,047	$3,169	$6,157	$6,344	96.1%	96.7%	92.92%	$6,516	71	49%	31%	51%	-$123	-$105	-$187
36	Aug-96	$3,245	$3,138	$3,274	$6,132	$6,352	95.8%	96.7%	92.66%	$6,506	70	51%	34%	53%	-$136	-$107	-$220
37	Sep-96	$3,370	$3,258	$3,407	$6,212	$6,401	95.6%	96.7%	92.45%	$6,602	71	52%	35%	55%	-$149	-$112	-$189
38	Oct-96	$3,479	$3,373	$3,535	$6,174	$6,363	95.4%	96.9%	92.46%	$6,565	70	55%	38%	57%	-$163	-$107	-$189
39	Nov-96	$3,579	$3,470	$3,656	$6,118	$6,396	94.9%	96.9%	92.01%	$6,535	69	57%	42%	60%	-$186	-$109	-$278
40	Dec-96	$3,667	$3,554	$3,571	$6,146	$6,424	99.5%	96.9%	96.47%	$6,258	69	58%	45%	58%	-$17	-$113	-$278
41	Jan-97	$3,765	$3,647	$3,869	$6,292	$6,570	94.2%	96.9%	91.29%	$6,767	71	58%	46%	61%	-$223	-$118	-$278

Synchronized Work Cycles

- EVM analysis occurs on a monthly basis
- Risk Management Team assessment occurs on a monthly basis
- Cost estimation occurs on a major milestone and annual basis
- Two of the three cost-risk participants work in cycles that are in synch with each other on a monthly cycle
- Cost estimators can participate on a monthly cycle as facilitators and to improve their estimated cost-risk through feedback of cost-risk actuals

Benefits From Stovepipes Collaborating

- EVM analysts bring a credible cost projection discipline based on performance to date
- Risk management team engineers bring insight into potential risks, their likelihoods of occurring and qualitative assessment of cost consequences
- Cost estimators bring techniques for projecting estimates of new systems based on actual cost data and expertise in the use of estimating models (e.g., ACEIT)
- How can we get these stove-pipes to bring their beneficial skills to bear to improve cost-risk assessment and analysis?

'Organizing Vehicles' for Cost-Risk

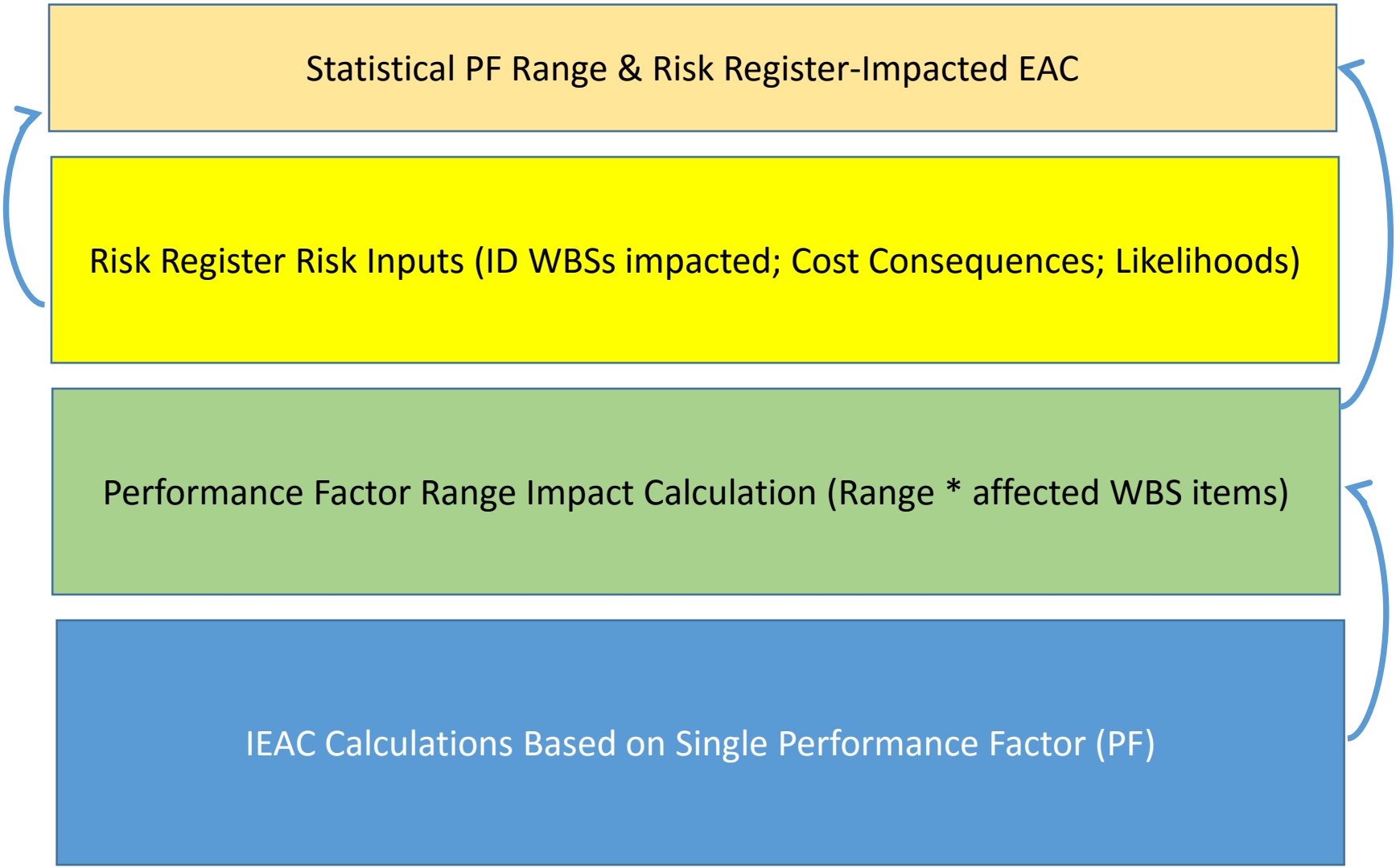
- EVM analysts do not participate enough in the quantification and management of cost-risk when, in fact, they are strategically positioned to do so
- Risk and cost-risk management requires 'Organizing Vehicles' that focus risk management teams, EVM analysts, schedule analysts and cost estimators into coordinating risk and cost-risk participation perspectives
- 'Organizing Vehicles' are tools enabling contributions from different perspectives to produce useable results so that:

"After all was said and done, there actually was more done than said"

Using EVM Cost-Risk Organizing Vehicles

- Organizing Vehicle #1:Integrated Cost-Risk Model (ICRM)
  - EVM analysts, technical risk teams & cost estimators utilize performance factors to build past performance IEACs then add EVM-quantified Risk Register results, all at WBS element levels
- Organizing Vehicle #2: EVM Trend Tool (EVMTT)
  - EVM analysts exploit relative $BCWP_{CUM}$ and BAC growth rate differences at the contract level monthly in projecting completion months, final BAC and EAC
  - These results motivate cost estimators, risk management teams and schedule analysts to discover, eliminate and mitigate risks driving such estimates
- EVMTT & ICRM complement each other
  - Contract level (EVMTT)
  - WBS element-level (ICRM)

ICRM Model Structure Illustration



Integrated Cost-Risk Model (ICRM)

- In the latest ACEIT versions, ICRM capability is enabled with the new 'Probability of Occurrence' column
- The ICRM integrates both probabilistic WBS-level EVM performance factor (PF)-based EACs and WBS-level Risk Register likelihood-based distributions
- If EVM analysts are not proficient ACEIT users, they can work with cost estimators familiar with ACEIT in:
  - Calculating probabilistic PF-driven WBS-level IEACs
  - Producing WBS-level Risk Register-driven cost-risk distributions
- EVM analysts and cost estimators also work with technical experts in translating Risk Register results into WBS element level cost-risk impacts

ICRM (cont)

- Statistically sums probabilistic WBS-level EVM PF-based IEACs and WBS-level Risk Register likelihood-based distributions through Monte Carlo simulations in ACEIT producing an overall IEAC cost-risk distribution
- Enables prioritization
  - By WBS elements most cost-impacted by risks, and
  - By risks causing the most significant cost impacts
- ***These results provide the basis for an ongoing meaningful dialogue that I think is not happening enough today between the EVM analysts, technical risk management teams, cost estimators, schedule analysts, project officers and, ultimately, the program managers based on cost impacts caused by risks***

DAU LAR EVM DATA INPUTS IN "EVM Input" WORKSHEET

Basic EVM Metrics

	WBS/CES Description	Equation / Throughput	BCWS_Cum (+) Budgeted Cost of Work Scheduled - Cumulative	BCWP_Cum (+) Budget Cost of Work Performed - Cum	ACWP_Cum (+) Actual Cost of Work Performed - Cumulative	BAC (+) Budget At Complete
165	EVM Data - Inputs					
166	LAR Vehicle - Adjusted BCWR					
167	1.1 - Prime Vehicle		24626.1	[illegible]	25234.5	36301.4
168	1.1.1 - Frame	BCWR * Case(Select_EAC_Adjust,1, CPI_Cum_PerfFactor,CPI_x_SPI_PerfFactor)	2039.8	1783.3	1853.5	2709.7
169	1.1.2 - Suspension/Steering	BCWR * Case(Select_EAC_Adjust,1,	5592.5	5674.9	6338.3	7803.3
170	1.1.3 - Power Package		8704.9	8373.9	9084.8	11455.1
171	1.1.3.1 - Engine	BCWR * Case(Select_EAC_Adjust,1,	2825.6	2718.2	2948.9	3718.3
172	1.1.3.10 - Cooling System	BCWR * Case(Select_EAC_Adjust,1,	1809.7	1740.9	1888.7	2381.5
173	1.1.3.9 - Exhaust System	BCWR * Case(Select_EAC_Adjust,1,	1358.0	1306.3	1417.2	1787.0
174	1.1.3.A - Other	BCWR * Case(Select_EAC_Adjust,1,	2711.6	2608.5	2829.9	3568.3
175	1.1.4 - Auxiliary Auto	BCWR * Case(Select_EAC_Adjust,1,	223	215.2	192.9	283.7
176	1.1.5 - Armament	BCWR * Case(Select_EAC_Adjust,1,	3382.9	3243.4	3349.8	4323
177	1.1.6 - Body/Cab	BCWR * Case(Select_EAC_Adjust,1,	3048.9	2807.4	3261.7	3818.4
178	1.1.7 - Communications	BCWR * Case(Select_EAC_Adjust,1,	1413.4	920.4	1013.8	2318.5
179	1.1.8 - Integ & Assembly	BCWR * Case(Select_EAC_Adjust,1,	220.7	169.1	139.7	3589.7
180	1.2 - System Program Mgt		7662	7189.6	7707.1	15597
181	1.2.1 - Project Management	BCWR * Case(Select_EAC_Adjust,1,	1518.9	1518.9	1558.9	4200.8
182	1.2.2 - Systems Engineering	BCWR * Case(Select_EAC_Adjust,1,	6143.1	5670.7	6148.2	11396.2
183	1.3 - System Test & Eval		1089.6	920	906.5	2491.5
184	1.3.1 - Acceptance Test Plan	BCWR * Case(Select_EAC_Adjust,1,	556.6	536.8	498.1	1399.5
185	1.3.2 - DT & OT Testing	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	333
186	1.3.3 - Mock-Ups	BCWR * Case(Select_EAC_Adjust,1,	385.9	261.3	311.3	410.1
187	1.3.4 - Test & Eval Support	BCWR * Case(Select_EAC_Adjust,1,	147.1	121.9	97.1	348.9
188	1.4 - Training	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	0
189	1.5 - Systems Data		176.3	164.1	216.7	846.3
190	1.5.1 - Engineering Data	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	577
191	1.5.2 - Management Data	BCWR * Case(Select_EAC_Adjust,1,	176.3	164.1	216.7	269.3
192	1.6 - Peculiar Support Equip		609.6	584.1	650.7	1410.7
193	1.6.1 - Test & Measurement	BCWR * Case(Select_EAC_Adjust,1,	609.6	584.1	650.7	785.2
194	1.6.2 - Support & Handling	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	625.5
195	1.9 - Spares & Reparables		0	0	0	5707.3
196	1.9.1 - Brakes S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	1293.2
197	1.9.2 - Wheels S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	2439.7
198	1.9.3 - Skid Plates S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	104.3
199	1.9.4 - Engine S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	117.3
200	1.9.5 - Drive Train S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	522
201	1.9.6 - Misc S&R	BCWR * Case(Select_EAC_Adjust,1,	0	0	0	1230.8
202						

EVM Input | Risk Input | Risk Factor Calc | Risk Adjusted EAC Output | RI$K All Columns

ICRM EVM Input Worksheet

Basic EVM information entered into ICRM

RISK REGISTER/WBS ELEMENT MATRIX

Likelihood	61-80%	61-80%	61-80%	81-99%	81-99%	81-99%	81-99%	81-99%	81-99%	61-80%	21-40%	21-40%	21-40%
Impact	15-20%	15-20%`	15-20%`	23-28%	23-28%	23-28%	23-28%	23-28%	23-28%	5-10%	5-10%	15-20%	15-20%
	1	2	3	4	5	6	7	8	9	10	11	12	13
RISKS:	LAR vehicle won't fit into helicopter because wheelbase is too wide (Reduce Wheelbase)	LAR vehicle lacks necessary maneuverability (Increase Maneuverability)	LAR vehicle cannot withstand expected rough enemy terrain (Ruggedize LAR)	LAR vehicle still too visible in infrared spectrum (Shrink LAR Infrared Profile)	LAR vehicle too loud to disguise presence (Reduce LAR Noise)	LAR vehicle's visible profile too high (Shrink LAR Visible Profile)	LAR vehicle cannot generate enough torque for expected performance on hills (Torque Increase)	LAR vehicle's top speed too low (Increase LAR Speed)	LAR engine's, exhaust's and cooling's complexity too high for reliability (Decrease Pwr Pkg Complexity)	LAR vehicle first unit integration test of armament system components (First Unit Integ Test)	(Aux/Auto Sub Sys Function Failures) Changes to surrounding subsystems can cause internal LAR AUX/AUTO electrical and electronic subsystems; on-board diagnostics/prognostics system; fire extinguisher system and controls; chassis mounted accessories such as the winch and power take-off, tools and on-vehicle equipment to function sub-optimally	No prototype history of LAR vehicle overall integration testing (F/U LAR Full Integ Test Failure)	Off-the-shelf components not meeting stricter military standards (OTS Parts Failure)
WBS ELEMENTS													
1.1 - Prime Vehicle													
1.1.1 - Frame	X	X	X	X		X							
1.1.2 - Suspension/Steering	x	x											
1.1.3 - Power Package													
1.1.3.1 - Engine				X	X	X	X	X	X				
1.1.3.10 - Cooling System				X					X				
1.1.3.9 - Exhaust System				X	X				X				
1.1.3.A - Other													
1.1.4 - Auxiliary Auto											X		
1.1.5 - Armament										X			
1.1.6 - Body/Cab	X		X			X							
1.1.7 - Communications											X		
1.1.8 - Integ & Assembly	X	X	X							X	X	X	X
1.2 - System Program Mgt													
1.2.1 - Project Management													
1.2.2 - Systems Engineering	X	X	X	X	X	X					X	X	X
1.3 - System Test & Eval													
1.3.1 - Acceptance Test Plan													
1.3.2 - DT & OT Testing													
1.3.3 - Mock-Ups													
1.3.4 - Test & Eval Support	x	X		X	X					X	X	X	X
1.4 - Training											X		
1.5 - Systems Data													
1.5.1 - Engineering Data											X		X
1.5.2 - Management Data													
1.6 - Peculiar Support Equip													
1.6.1 - Test & Measurement											X	X	X
1.6.2 - Support & Handling													

- Affected WBS elements inherit each risk likelihood and cost impact percentage that affects it

GALORATH

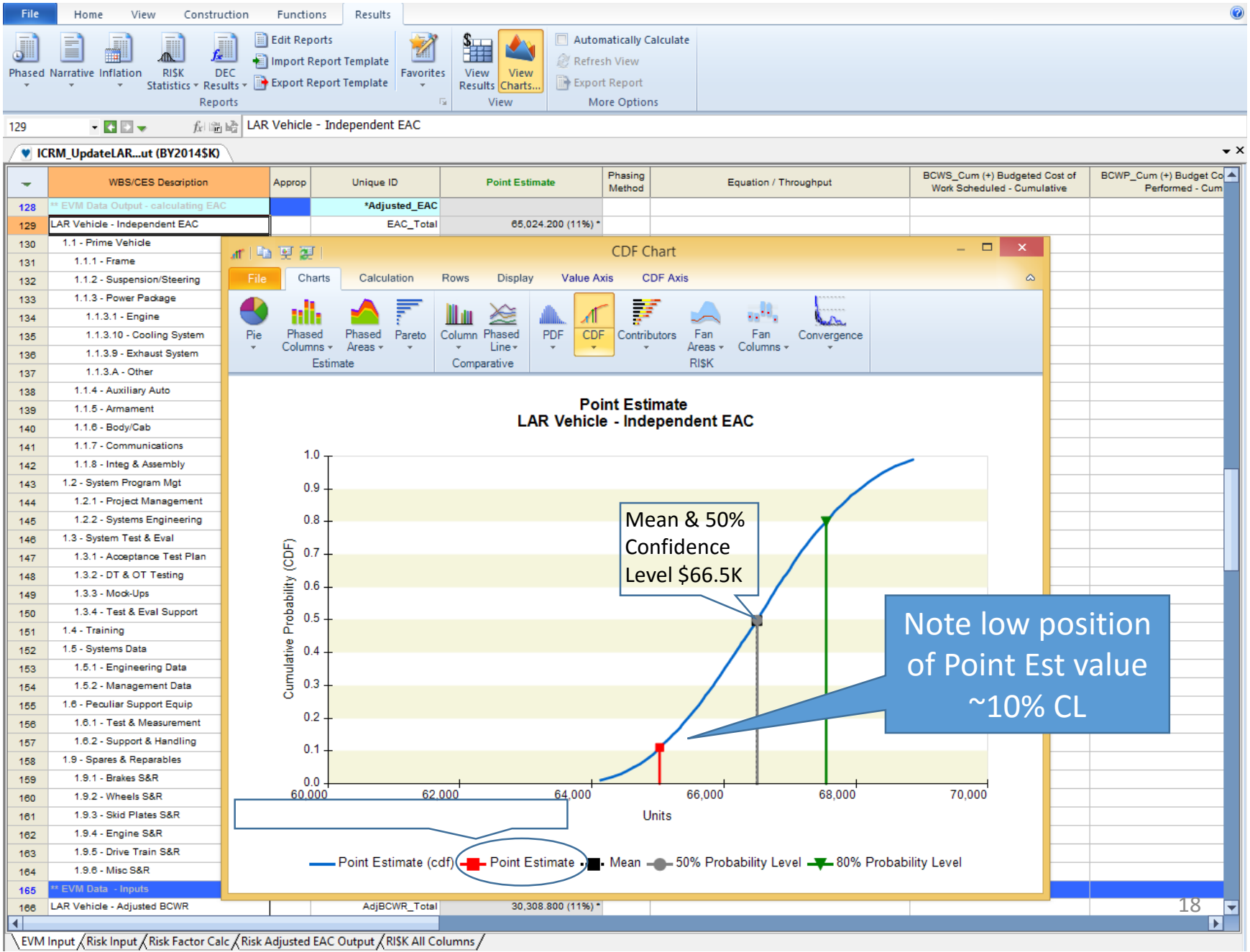
RISK LIKELIHOODS & COST CONSEQUENCE IMPACTS INPUT INTO ICRM 'RISK Input' WORKSHEET

	WBS/CES Description	Phasing Method	Equation / Throughput	Probability % of Occurrence	Impacted_WBS_Items (*) What WBS items adj BCWR are impacted	Low_Cost_Impact% (!) Low Cost	ML_Cost_Impact % (!) Most Liikely	High_Cost_Impact % (!) High Cost
108								
109	*INPUT VARIABLES							
110								
111	** Risk Inputs							
112	* Risk Impacts - Inputs							
113	Risk 1	C	ML_Cost_Impact% / 100	70.5	Frame, Suspension, Body, I&A, SysEng, T&E	15	17.5	20
114	Risk 2	C	ML_Cost_Impact% / 100	70.5	Frame, Suspension, I&A, SysEng, T&E	15	17.5	20
115	Risk 3	C	ML_Cost_Impact% / 100	70.5	Frame, Suspension, Body, I&A, SysEng	15	17.5	20
116	Risk 4	C	ML_Cost_Impact% / 100	90	Frame, Eng, Cooling, Exhaust, Aux, SysEng, T&E	23	25	28
117	Risk 5	C	ML_Cost_Impact% / 100	90	Eng, Exhaust, SysEng, T&E	23	25	28
118	Risk 6	C	ML_Cost_Impact% / 100	90	Frame, Body, SysEng	23	25	28
119	Risk 7	C	ML_Cost_Impact% / 100	90	Engine	23	25	28
120	Risk 8	C	ML_Cost_Impact% / 100	90	Engine	23	25	28
121	Risk 9	C	ML_Cost_Impact% / 100	90	Engine, Cooling, Exhaust	23	25	28
122	Risk 10	C	ML_Cost_Impact% / 100	70.5	Armament, I&A, T&E	5	7.5	10
123	Risk 11	C	ML_Cost_Impact% / 100	30.5	Aux, Comm, I&A, SysEng, T&E, Train, EngData, T&M	5	7.5	10
124	Risk 12	C	ML_Cost_Impact% / 100	30.5	I&A, SysEng, T&E, T&M	15	17.5	20
125	Risk 13	C	ML_Cost_Impact% / 100	30.5	I&A, SysEng, T&E, EngDataT&M	15	17.5	20

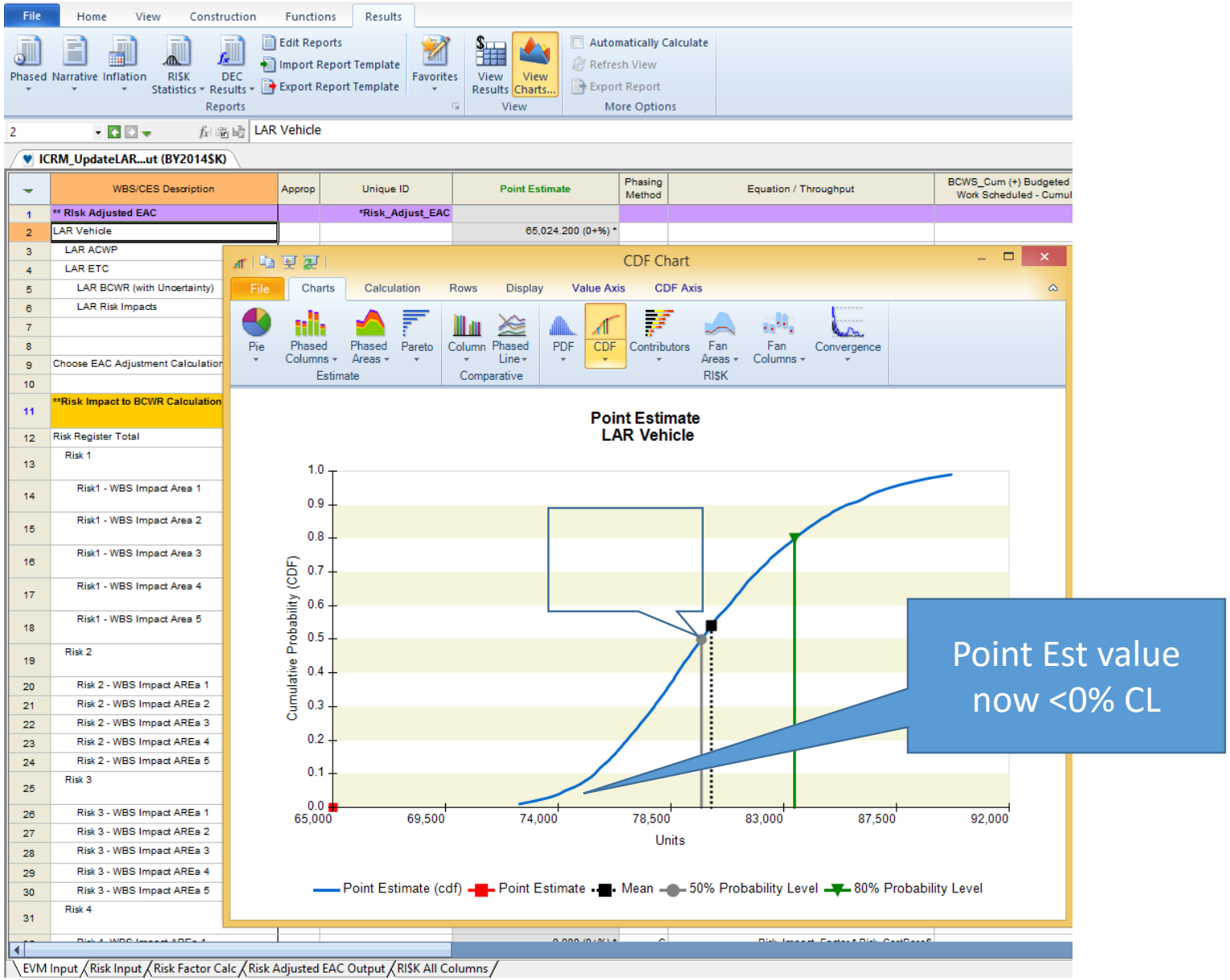
EVM Input | Risk Input | Risk Factor Calc | Risk Adjusted EAC Output | RISK All Columns

Fig. 8

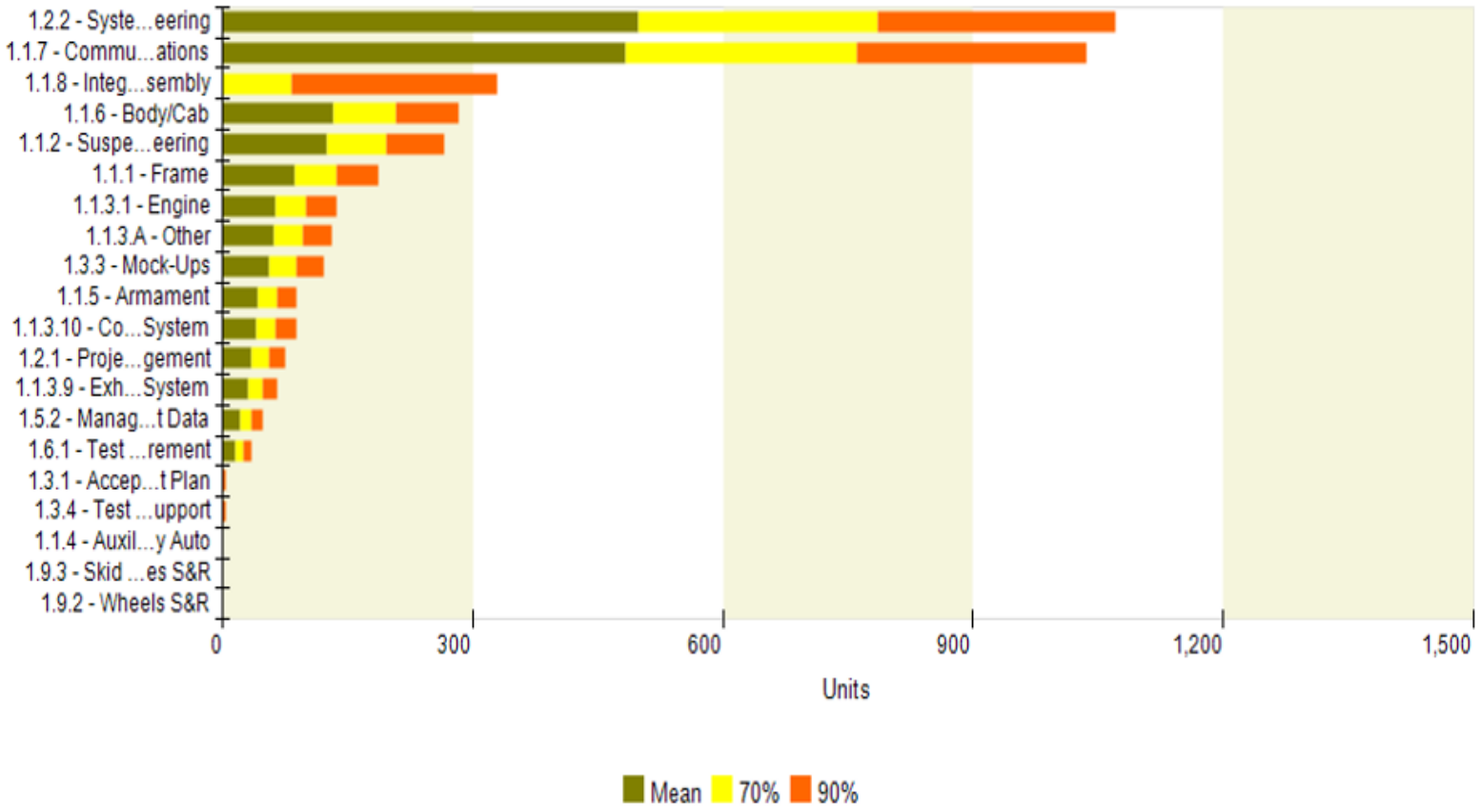
"LAR Vehicle – Independent EAC" LEVEL CDF (no Risk Register Results)



LAR VEHICLE CDF WITH POINT ESTIMATE, MEAN, 50% & 80% CONFIDENCE LEVELS (includes Risk Register Results)

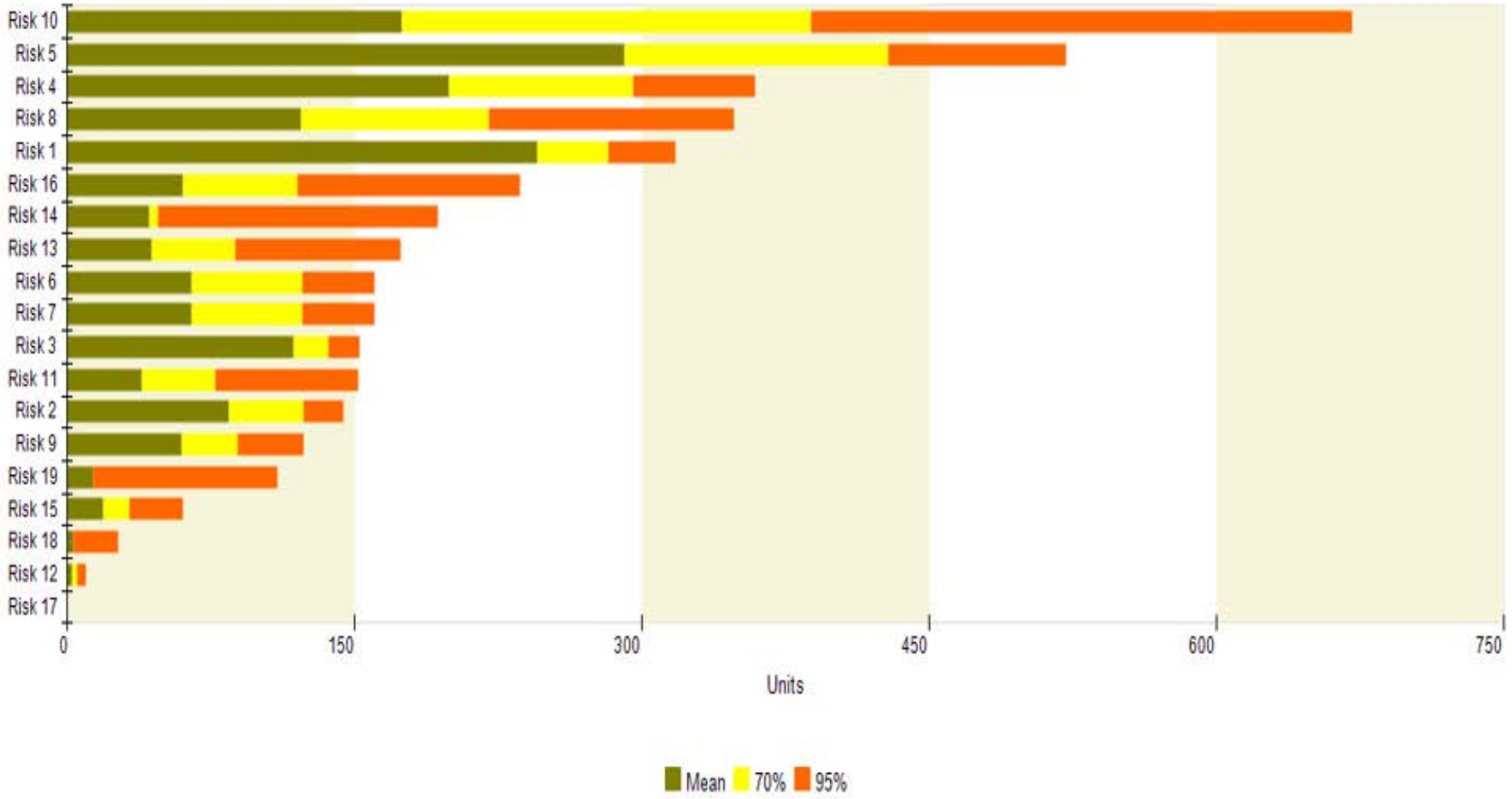


Main ICRM EAC Contributors *by WBS*



- Prioritization of main WBS element contributors to the ICRM's EAC at the 90% CL

Main ICRM EAC Contributors *by Risks* (@ 95% CL)



- Prioritization of risk contributors to the ICRM EAC at the 95% CL
- Risk #10 is largest contributor
- Risk #5 is second largest

Key Points of EVMTT Analysis

- Provides a 25,000 foot view of contract performance
  - EVMTT analysis is at total contract level monthly
- No traditional EVM performance efficiency used (e.g., CPI, SPI, SCI, etc.) in Dr. Smoker's paper[2], however, the EVMTT v2 produces them
- Utilizes a database of monthly CPR (or IPMR) EVM information to derive linear regression equations for $BCWS_{CUM}$, $BCWP_{CUM}$, BAC & LRE projections from linear sections of PMB & BAC data
  - Coefficients in equations are rate-of-growth (aka 'slopes') in $BCWS_{CUM}$, $BCWP_{CUM}$, BAC & LRE

KEY RELATIONSHIP:

- Since $BCWP_{CUM}$ must equal BAC at end of effort, equate $BCWP_{CUM}$ and BAC regression equations and solve for effort end month
  - $BCWP_{42} = BAC_{42}$ ➔ \$86.35M*Months = \$4,970.56 + \$31.76M * Months

    Months = \$4,970.56/(\$86.35 - \$31.76) = 91.06 mos
  - Plug end month into BAC & LRE equations to get end month BAC & LRE estimates
  - Repeat this process each month with one more month of EVM information

A Very Important Note about $BCWP_{CUM}$ & BAC Coefficients

- Recall, **Completion Months = $4,970.56/($86.35 - $31.76)**
  - $86.35 and $31.76 are BCWP & BAC coefficients (aka slopes)

1. If these two slopes (aka rates of growth) get close to one another, what happens to the value of the completion months?
2. If these two slopes (aka rates of growth) equal one another, what happens to the value of the completion months?
3. If the BAC slope is larger than the BCWP slope, what happens to the value of the completion months?

- If either conditions #2 or #3 are the EVMTT result, the numerical results from the EVMTT are just indications that something fundamental is going wrong with the project and it is time to take a very hard look at the project

Key Points of EVMTT Analysis (cont)

- EVMTT also calculates the Earned Schedule end-of-contract month for comparison
  - $\text{Earned Schedule}_{42} = 42 + (\text{BAC}_{\text{CPR 42}} - \text{BCWP}_{\text{CUM 42}})/\text{WorkRate}_{42}$
    ($\text{WorkRate} = \text{BCWP}_{\text{CUM}}/\text{Months-to-Date (42)}$); so,
  - $\text{Earned Schedule}_{42} = 42 + (6269.68 - 3737.55)/88.99 =$ **70.45 mos (< 91.06 mos)**
- Using EVMTT estimate of end month BAC we derive Percent Complete based on $\text{PC} = \text{BCWP}_{\text{CUM}}/\text{BAC}_{\text{EndMo}} * 100\%$
  - More conservative as long as BAC is increasing
- In Dr. Smoker's paper, risk is measured in EVM terms as any deviation from the original baseline
  - That is, *risk is anything that results in a variance*
- Therefore, VAC is the basic measure of cost-risk projected at the end of the contract effort
  - Whether the risk is rooted in opportunity with a positive variance
  - Or, is rooted in issues related to planning of scope, estimating, scheduling, or technical criteria that are identified during performance and/or testing and generally associated with a negative variance

Summary & Conclusion

- Described the present stove-piped nature of risk and cost-risk assessment and analysis
- Described the benefits each of the presently stove-piped participants bring to cost-risk assessment and analysis if they work together
- Described the 'Organizing Vehicles' of two new EVM cost-risk tools enabling such collaboration
- Illustrated these two new EVM cost-risk tools
  - The ICRM is implemented in ACEIT, a Government owned cost estimating model maintained and nominal cost site-licensed to users by Tecolote
  - The EVMTT is implemented in Excel and is free to all users
- All that remains is for these presently stove-piped participants in the risk and cost-risk assessment and analysis process to:
  1. Use these tools
  2. Work together with them and, by so doing
  3. Improve the cost-risk process

References

BACKUPS

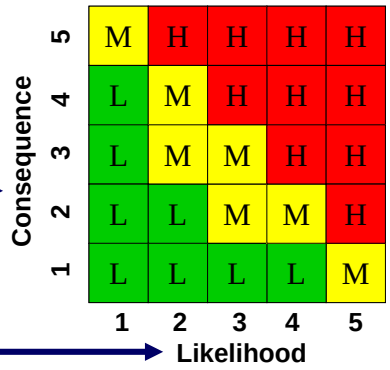
Dominant Likelihood Algorithm

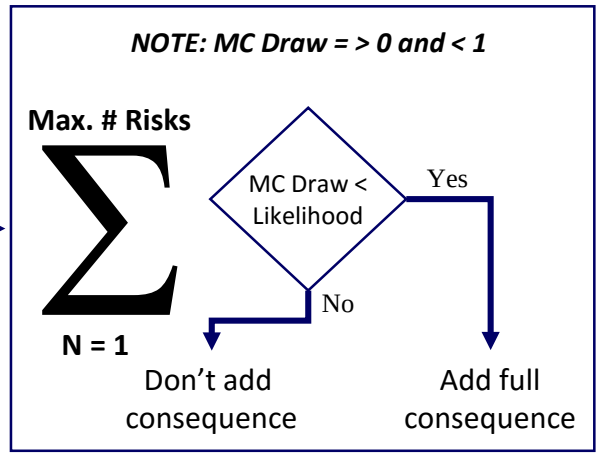
General Process Overview

1). Identify Discrete Risks
Risk #1
Risk #2
Risk #3
…

2). Estimate Consequence
WBS, Months delay, Phase of Delay
WBS % Increase in NRE, REC or both
Convert both to $

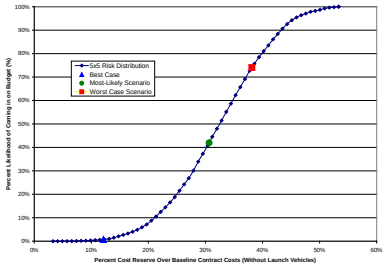
3). Estimate Likelihood
Remote, Unlikely, Likely, Very Likely, Near Certainty





Run appropriate # of iterations

Develop Cumulative Distribution



Analogy with Decision Support

- Past uses of various decision support tools, e.g., Analytic Hierarchy Process (AHP), group participation is enhanced by focusing on pairwise comparison discussions (AHP) versus just talking to one another
- This subtle difference psychologically dispenses with the 'loudest' voice holding sway since the focus is away from personal interaction towards working together in building an actual 'product'
- By analogy, producing an ICRM result focuses group participation in building an actual 'product'

Pairwise EVMTT/ICRM Summary EAC Comparison Table

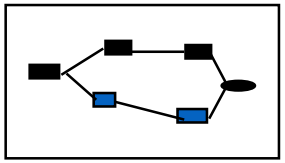
EVM DATA: OCT 04 (Month #14)	CPR LRE ($64.7)	EVMTT LRE (End Mo) ($67.1)	SCI (CPI*SPI) EAC ($70.6)	ICRM EAC With R/R Risk ($80.1) (MEAN)
	DIFF/%-DIFF	DIFF/%-DIFF	DIFF/%-DIFF	DIFF/%-DIFF
CPR LRE ($64.7)		*$2.4/3.7%*	*$5.9/9.1%*	*$15.4/23.8%*
EVMTT LRE (End Mo) ($67.1)			*$3.5/5.2%*	*$13.0/19.4%*
SCI (CPI*SPI) EAC ($70.6)				*$9.5/13.5%*

- Table pairwise compares CPR, EVMTT & ICRM EACs
- ICRM EAC at 80% CL is $83.4M ($12.8/18.1% SCI vs R/R)

Adding Risk Register Risk to PF-Only EAC Improves Insight for Program Management

EVMTT Results Characteristics

- We expect BAC to rise early in contract
  - That's when PMs realize the original plan assumed less risk or
  - Was too narrow in scope so more requirements are added or
  - Schedule or cost were underestimated
- We also hope that BAC ceases to increase over time
  - Indicates any BAC-driven cost-risk has been eliminated
- VAC is a quantification of cost-risk needing to be eliminated (no identification of what the risk driving the cost-risk is however)
  - Risk identification, quantification and assessment requires a tool with more fidelity, e.g., Integrated Cost-Risk Model (ICRM)
  - ICRM integrates Risk Register results with EVM analysis statistically at the WBS element level

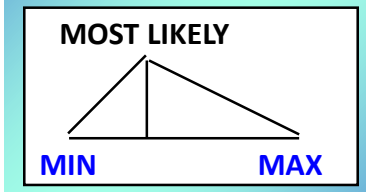


1. Develop a complete critical path network

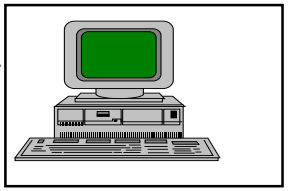
TECHNICAL RISKS:
- EMC TESTING
- S/W CODING
- FLIGHT TEST

2. Identify reporting tasks and risk candidates

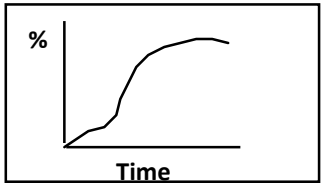
Contractor CAMs responsibility



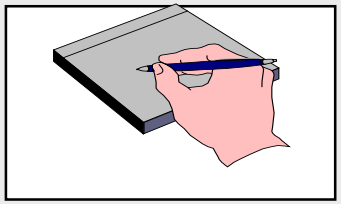
3. Enter risk parameters



4. Run Schedule Simulation & Quantify Impact of Risk on Schedule



5. Analyze Schedule Results & Integrate Into Cost Estimate



6. Document Results

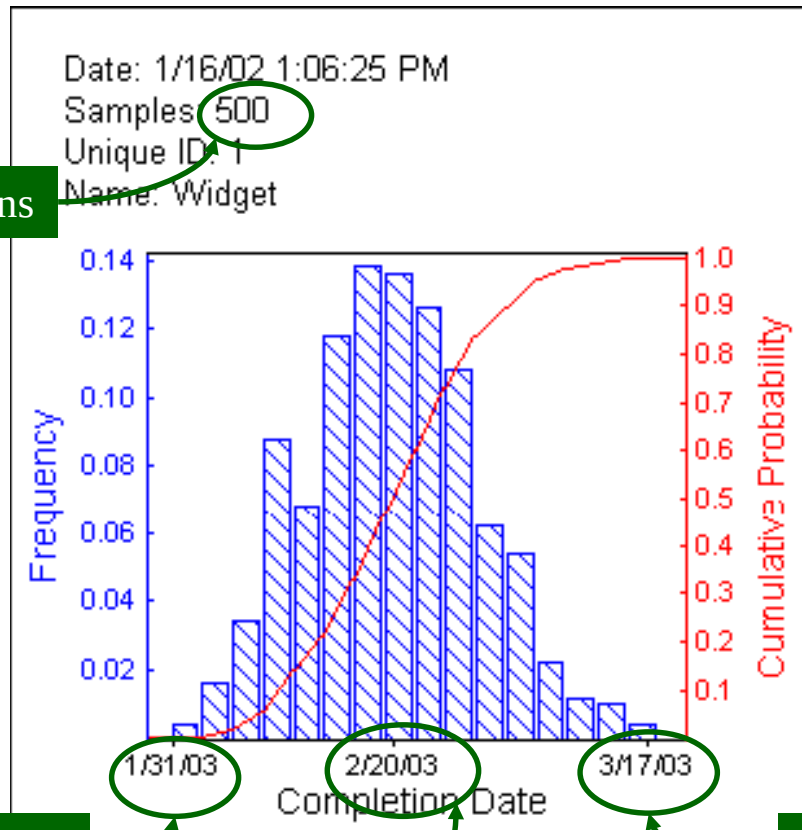
As part of final process steps, the analyst prepares the report and presents a SRA position.

SA RISK ACTION PLAN

ISSUE -- ACTION -- DATE

7. Present to Program office and IPTs Develop Risk Mitigating Actions

This example is from MS Project, Risk + add-in tool



Completion Std Deviation: 5.65d
95% Confidence Interval: 0.49d
Each bar represents: 2d

Completion Probability Table

Prob	Date	Prob	Date
0.05	2/7/03	0.55	2/21/03
0.10	2/10/03	0.60	2/21/03
0.15	2/12/03	0.65	2/24/03
0.20	2/13/03	0.70	2/25/03
0.25	2/14/03	0.75	2/26/03
0.30	2/17/03	0.80	2/27/03
0.35	2/18/03	0.85	2/28/03
0.40	2/19/03	0.90	3/4/03
0.45	2/19/03	0.95	3/5/03
0.50	2/20/03	1.00	3/17/03

Standard Deviation

95% Confidence Interval

Iterations

Bar Width

Earliest Completion

Expected Completion

Latest Completion

Cumulative Probability Table