

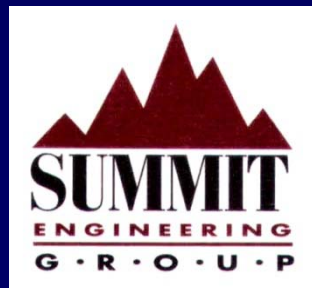
# Applying EV Techniques to R&D Efforts

by

Mr. Kirk L. Hoy & Mr. Kurt Willstatter  
Summit Engineering Group

for

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# Abstract



The Defense Advanced Research Projects Agency (DARPA) is a research and development (R&D) organization. Many of its projects involve state-of-the-art technologies for military end-user applications with many schedule and cost constraints. DARPA PMs utilize Earned Value (EV) as a cost and schedule risk mitigation and management tool. The challenge is correctly applying EV techniques to many ill-defined, research-oriented projects in order to gain the predictive insights desired.



# Authorship Caveats



The opinions represented are solely the position of the authors and do not represent an official DARPA position on such matters.

The observations, thoughts and views regarding tailored application of EV to R&D programs are those of the authors.

The intent of this presentation is not a tutorial on EV, but instead on what needs to be accomplished prior to and during execution of a R&D oriented contract.



# Outline



- Overview
- Proper Setup
- Contract Execution
- Final Remarks



# Why EV Reporting?



- Schedule performance and cost performance can be analyzed in the same terms since project progress is measured in dollars
- Desire for predictive analysis framework to ensure cost, schedule, and performance risks are identified as early as possible
- It's the Law (FAR/DFAR/....)
  - Mandated for program awards over \$20M
- Often requested for technically / programmatically complex R&D efforts regardless of project size



# R&D Program Attributes



- **Applied Research and Integration to explore feasibility**
  - Not a production contract with everything predetermined
- **Typically collaborative teams to mitigate technical risk**
  - Leverage specialized expertise across team members
- **Use basic research in specific application and representative operational environment via field experiment**
- **Create / Demonstrate prototype system to facilitate ...**
  - Understanding Requirements Trade-space
  - Ability to Satisfy Performance / Cost Objectives
  - Development of CONOPs
  - Transitioning technology to customers/users



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# EV Expectation Management



- EV planning starts BEFORE solicitation release
  - Must set the groundwork in the cost proposal instructions
- Success is largely determined by decisions made during Contract Negotiations and Contract Kick-off
  - Must be very clear on expectations / formats / timing / etc.
- First three to six months after contract award should focus on 'fine tuning' efforts
  - Level of Cost account structure
  - Schedule reporting rules
    - FFP vs. CPFF vs. T&M
    - LOE and Basic Material Purchases
    - Sub and IWO consistency in reporting



# WBS\* (Root of All Evils)



- **Solicitation Instructions**
  - WBS must track to SOW / IMS in Proposal
  - Subs and IWOs must use same WBS structure / definitions as Prime
  - WBS must be product-oriented (i.e., broken down by critical sub-systems and hardware / software components)
- **Negotiations / Kickoff**
  - Re-mapping of Subs and IWOs into Prime's WBS, as needed
  - Determine schedule progress reporting rules
  - Determine level of cost account assignment
    - Can't get any lower level resolution than the lowest level cost account
- **Program Execution**
  - Calculate EV metrics for each reported WBS element
  - Utilize Monthly Status Reports and Technical Meetings to verify consistency with EV metrics
  - Explain EV variances in a Technical / Schedule context vs. strictly Financial analysis

\* Work Breakdown Structure



# On-Orbit Servicing Satellite WBS Example



## ASTRO Servicing Vehicle

Spacecraft Bus

**Auto-GN&C System (Includes Software)**

Command, Data Handling and Processing System

**Servicing Mission Instruction Set**

Sensor System

Power and Power Distribution System

Propulsion System

Tracking, Telemetry and Communications System

Environmental Survivability

**Fluid Payload Storage and Handling**

**Hardware Payload Storage and Handling**

Integration and Test

**Satellite Servicing Interface (SSI)**

**Mechanical Interfaces**

**Electrical Interfaces**

**Enabling Software**

**Associated Protocols**

**Tools / End Effectors**

## NEXTSat Serviceable Satellite

Spacecraft Bus

Command, Data Handling and Processing System

**Cooperative Servicing Aids System**

**Fluid Consumables Receipt and Handling**

**Hardware (ORU) Receipt**

Power and Power Distribution System

Propulsion System

Tracking, Telemetry and Communications System

Environmental Survivability

Integration and Test

**█** = First Level Servicing Impacts

*Key: The design effort, representing the Non-Recurring Engineering (NRE), needs to be separated from the product procurement / fabrication / assembly efforts*



# On-Orbit Servicing Satellite WBS Example (Cont'd)



## Commodity Payload

Spacecraft Bus  
Command, Data Handling and Processing  
**Cooperative Servicing Aids System**  
**Fluid Consumables Payload Storage, Handling and Transfer**  
**Hardware Payload Storage, Handling and Transfer**  
Power and Power Distribution System  
Propulsion System  
Tracking, Telemetry and Communications  
Environmental Survivability  
Integration and Test

## Ground Facility Support

Mission Planning  
Command, Data Handling and Processing  
Tracking, Telemetry and Communications  
Manpower, Personnel & Training  
Security

## Micro-Satellite

Spacecraft Bus  
Command, Data Handling and Processing  
**Cooperative Servicing Aids System**  
**Fluid Consumables Payload Storage, Handling and Transfer**  
**Hardware Payload Storage, Handling and Transfer**  
Power and Power Distribution System  
Propulsion System  
Tracking, Telemetry and Communications System  
Environmental Survivability  
Integration and Test

## Other

Integrated Logistics Support (ILS)  
Systems Engineering/Program Management (SE/PM)  
System Test & Evaluation (ST&E)

**█** = First Level Servicing Impacts



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# EV Modeling



CONTRACT PERFORMANCE REPORT (CPR)													Form Approved									
FORMAT 1 - WORK BREAKDOWN STRUCTURE													OMB No. 0704-0188									
1 CONTRACTOR			2 CONTRACT			3 PROGRAM			4. REPORT PERIOD				5. HIGHLIGHTING KEY									
a NAME: Mnt Julip			a NAME: My Program			a NAME: Phase 1			a FROM: xx-JAN-xx				Column A (N) - color changes with each 2-level element. Color link elements were included in CPR 5.									
b LOCATION: La La Land			b NUMBER: XXXXXX-X-X-XXXX			b PHASE: 1			b TO: xx-JAN-xx				Column O (% Cost) - Dark green shows any element that is at cost.									
			c TYPE: CPFF			c EVMS ACCEPTANCE							Column P (% Complete) - Orange w/black - expenditures % exceeds elapsed program time % (14 mo schedule). Orange w/white - expenditures % exceeds elapsed program time % (12mo schedule).									
			d SHARE RATIO:			[ ] NO [X] YES							Column Q (TCPI) - red cells exceed 1.15									
8 PERFORMANCE DATA																						
CURRENT PERIOD																						
CUMULATIVE TO DATE																						
AT COMPLETION																						
ITEM	BUDGETED COST		ACTUAL COST		VARIANCE		BUDGETED COST		ACTUAL COST		VARIANCE		BUDGET	EST	VAR	% Cost	% Comp	EAC (AC/VP)	BC/VP (AC/VP)	BC/VP (BC/VP)	BC/VP (BC/VP)	
	WORK SCHED	WORK PERF	WORK SCHED	WORK PERF	SCHED	COST	WORK SCHED	WORK PERF	WORK SCHED	WORK PERF	SCHED	COST										
-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14									
a. My Program																						
	500,000	550,000	600,000	300,000	250,000	18,000,000	19,000,000	20,000,000	-2,000,000	-2,200,000	21,000,000	25,000,000	0	96.00%	80.00%	1.000	0.950	1.056				
b. COST OF MONEY																						
	5,000	5,500	6,000	1,000	2,000	85,000	90,000	100,000	-2,000	-4,000	120,000	130,000	0	0.48%	76.92%	1.000	0.900	1.059				
c. GEN & ADMIN																						
	150,000	165,000	200,000	80,000	9,000	5,000,000	6,000,000	7,000,000	-75,000	-350,000	6,000,000	7,000,000	0	24.00%	100.00%			0.857	1.200			
d. UNDISTRIBUTED BUDGET																						
													0									
e. SUBTOTAL (PMBaseline)																						
	655,000	720,500	806,000	381,000	261,000	23,085,000	25,090,000	27,100,000	-2,077,000	-2,554,000	30,120,000	32,130,000	0	120.48%	84.34%	1.000	0.926	1.087				
f. MANAGEMENT RESERVE																						
											200,000		0	0.80%								
g. TOTAL																						
	655,000	720,500	806,000	381,000	261,000	23,085,000	25,090,000	27,100,000	-2,077,000	-2,554,000	30,320,000	32,130,000	0	121.28%	84.34%	1.040	0.926	1.087				
a. My Program																						
	500,000	550,000	600,000	300,000	250,000	18,000,000	19,000,000	20,000,000	-2,000,000	-2,200,000	21,000,000	25,000,000	0	96.00%	80.00%	1.000	0.950	1.056				
AA WBS Element 1																						
	493,000	358,000	300,000	-152,400	78,600	14,000,000	14,665,000	15,440,000	-1,600,000	-1,779,000	18,500,000	19,200,000	0	74.00%	80.42%	1.020	0.950	1.048				
AAA WBS Element 11																						
	200,000	150,000	74,000	-48,000	73,000	3,000,000	3,100,000	3,150,000	-313,000	-400,000	4,000,000	4,100,000	0	16.00%	76.83%	0.947	0.984	1.033				
AAB WBS Element 12																						
	30,000	29,000	42,000	-4,000	-14,000	1,955,000	1,900,000	2,100,000	28,000	35,000	2,300,000	2,400,000	0	9.20%	87.50%	1.317	0.905	0.972				
AAC WBS Element 13																						
	15,000	13,000	22,000	-3,000	-8,000	100,000	105,000	110,000	1,000	3,000	300,000	300,000	0	1.20%	36.67%	1.026	0.955	1.059				
AAD WBS Element 14																						
	7,000	7,000	7,300	0	-300	50,000	55,000	60,000	0	0	100,000	100,000	0	0.40%	60.00%	1.125	0.917	1.137				
AAE WBS Element 15																						
	14,000	12,000	5,000	-1,500	8,200	200,000	205,000	240,000	1,300	1,600	400,000	500,000	0	1.60%	48.00%	0.750	0.854	1.123				
AAF WBS Element 16																						
	150,000	92,000	120,000	-73,000	-39,000	5,000,000	5,100,000	5,300,000	-400,000	-425,000	6,000,000	6,200,000	0	24.00%	86.48%	1.000	0.962	1.020				
AAG WBS Element 17																						
	5,000	5,000	600	0	5,000	1,000,000	1,200,000	1,300,000	-500,000	-548,000	1,500,000	1,600,000	0	6.00%	81.25%	1.000	0.923	1.200				
AAH WBS Element 18																						
	3,000	4,000	50	600	4,000	1,800,000	2,000,000	2,120,000	-310,000	-310,600	2,500,000	2,600,000	0	10.00%	81.54%	1.042	0.943	1.111				
AAJ WBS Element 19																						
	32,000	28,000	4,500	-3,500	24,000	150,000	180,000	210,000	-32,300	-40,000	250,000	250,000	0	1.00%	84.00%	1.055	0.857	1.200				
AAK WBS Element 1A																						
	10,000	9,000	7,000	-1,000	1,200	95,000	110,000	120,000	-15,000	-20,000	150,000	150,000	0	6.00%	80.00%	1.311	0.917	1.158				
AAL WBS Element 1B																						
	20,000	2,000	10,000	-19,000	8,500	200,000	250,000	260,000	-10,000	-15,000	500,000	500,000	0	2.00%	52.00%	1.042	0.917	1.250				
AAM WBS Element 1C																						
	7,000	7,000	0	0	7,000	450,000	460,000	470,000	-50,000	-60,000	500,000	500,000	0	2.00%	94.00%	1.311	0.879	1.022				
AB WBS Element 2																						
	7,000	192,000	300,000	452,400	171,400	4,000,000	4,335,000	4,560,000	-400,000	-421,000	5,500,000	5,800,000	0	22.00%	85.62%	0.940	0.951	1.084				

- EV Metrics across each WBS Element
  - % of Total Effort
  - % Spent / Complete
  - TCPI (>1 not good)
  - CPI (< 1 not good)
  - SPI (< 1 not good)
  - EACs Calcs (not shown)
- Variable WBS Level Reporting
- Use these to Assist in Dialogue on Technical and Schedule Progress (Format 1 to 5 links)
- Review Invoice Details relative to Progress shown here
- Create formal set of Monthly Questions

• Discuss / Provide Template prior to initial CPR Release



# R&D Project EV 'Lessons Learned'



- Understand Project Technical Objectives / Risks, Budget and Sensitivities as early as possible
- Spend as much time as needed to get the right WBS in place
- Complexities of Project and impacts to Budget are not known a priori
- Be mindful of 'products' from each WBS Element and which ones depend on them
- Stay engaged and keep highlighting issues
- R&D Projects do fail even with good EV



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# EV in R&D Projects Summary



- Successful R&D Projects start before Solicitations are issued
- Need explicit dialogue amongst Government and Contractor teams
- Important to Tailor WBS and Variable Reporting Levels
- Ensure critical technologies and risk 'cost drivers' are addressed over time
- Continuous Review and Discussion of EV Metrics is important for meeting R&D Projects' Objectives

Analysts need to understand the 'Program of Record' and how it relates to the planning, scheduling, budgeting, work authorization, and cost accumulation processes employed!



# Presenter Contact Data



Kirk L. Hoy & Kurt Willstatter

Summit Engineering Group

102 Paul Mellon Court, Suite 1

Waldorf, Maryland 20602

301-645-3535

301-645-3950 fax

[Khoy@summit-group.com](mailto:Khoy@summit-group.com)

[Kwillstatter@summit-group.com](mailto:Kwillstatter@summit-group.com)