JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Challenges of EV in the NASA Environment

Alternative Approaches to the Application of QBDs in Detailed Design

NASA Cost & Schedule Symposium
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Dewey E. Barlow and Andrew Soukup
Dr. Charles Parker - Contributor

Dewey.barlow@jhuapl.edu
Andy.soukup@jhuapl.edu

Agenda

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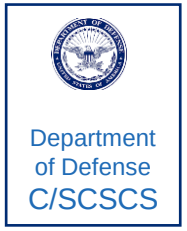
- Evolution of Invention to Mass Manufacturing
- Challenges of Implementing EV in the NASA Environment
- Problem Statement
- Alternative Approaches
- Proposed Solution
- Proposed Solution Mechanics
- Conclusion
- Contact Information

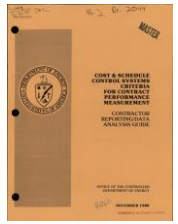
Brief History of Earned Value (EV)

60's			70's									80's										90's										2000's										2010's										2020's				
1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024



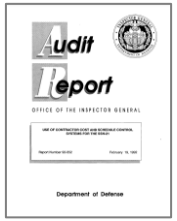
Cost/Schedule Control System System Criteria

Hughes Aircraft Certified (Apache)

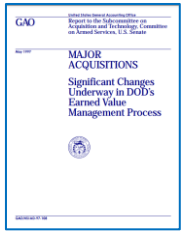


DOE C/SCC

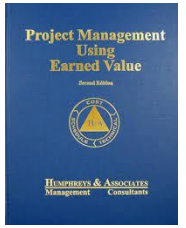
A-12 Avenger II $5B expended
0 produced



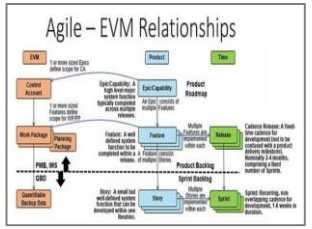
SN-21 Audit Report



32 Guidelines ANSI/EIA



The Bible

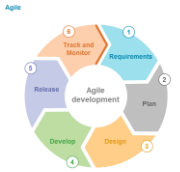


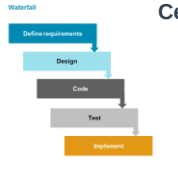
Agile EVM Struggle

JHU/APL System Certified

No EV on Agile

Agile Manifesto





As originally conceived, EVM was meant to provide timely, reliable management data reflecting performance on complex projects. In other words, a “good enough” snapshot of a moving train to inform management decisions. But as time passed, that objective increasingly was supplanted by a demand for more “accurate, timely” data, with emphasis on contractor compliance enforced by punitive contractual provisions. EVM’s original purpose—a timely, reliable management information system—is compromised to the extent it is redefined as an audit-oriented oversight system with punitive consequences for noncompliance. *DAU 2017*

Evolution - Invention to Mass Manufacturing

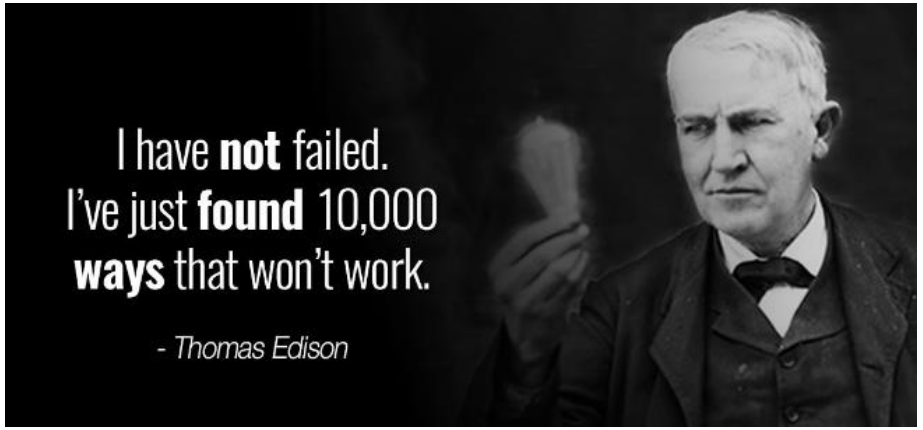
Invention

Pure Research & Development

Mass Manufacturing

Pure Manufacturing

Iterative Process



Linear Process

Challenges of Implementing EV in the NASA Environment

NASA explores the unknown in air and space, innovates for the benefit of humanity, and inspires the world through discovery.

Invention
Pure Research & Development

Mass Manufacturing
Pure Manufacturing

Iterative Process

We Are Here

Linear Process

Attempting to Implement EV Here has no value

Application of EV in the NASA environment is challenging since elements of our development process are innovative, iterative, agile, and non-linear

Earned Value Methodology was Born Here and has Been Proven to be Effective

Challenges of Implementing EV in the NASA Environment

- Flight Software (FSW)
- Ground Software (GSW)
- FPGA Design/Development
- Firmware Design/Development
- **Detailed Design**
- Flight Parts Procurement
- Thermal Design
- Test and Tailor/Rework

There are many challenges associated with implementing earned value in the NASA environment. Our focus is on the Application of EV in Detailed Design hereafter.

Problem Statement

Detailed design presents an EV challenge because changes in design result from testing at the part, component, board, board interface, box, subsystem/instrument, and system interface level over the course of six to eight months while the Engineering Model (EM) is being assembled and tested.

This iterative design process is reactive to test anomalies that are unknown prior to the performance of the tests. Although past experience has shown that some level of design change will occur during detailed design, it is difficult to predict the level of design change, or at what point in the process the anomalies will occur that spur the design change.

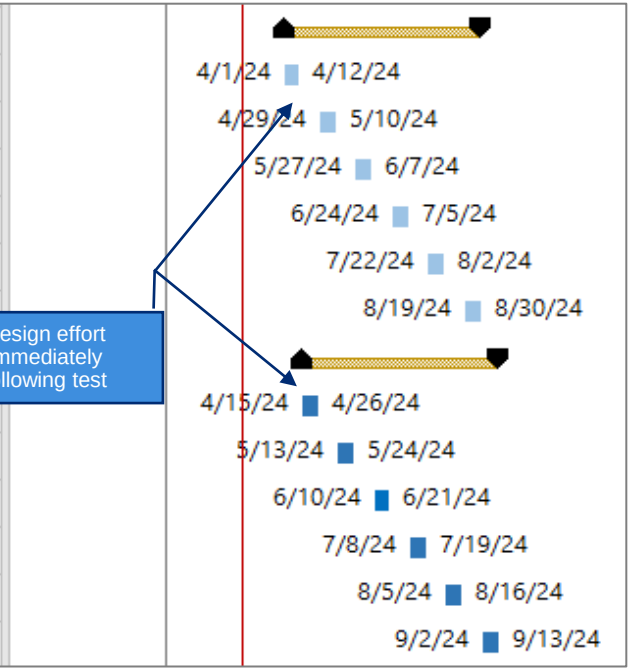
If we plan detailed design as a single 6-8 month activity with a percent complete EV type at the board/component level we are required to establish Quantifiable Backup Data (QBDs) for each detailed design activity to ensure that the claimed percent complete is objective.

If we do not know if, and at what point, the test anomalies/redesign will occur how do we establish QBDs?

Alternative Approach - Distributed Design Sprints

Insert design sprint activities immediately after each test

EM Test Program	**110d**	**0%**	**4/1/24**	**8/30/24**
Slice Testing	10d	0%	4/1/24	4/12/24
Slice Interface Testing	10d	0%	4/29/24	5/10/24
Box Level Testing	10d	0%	5/27/24	6/7/24
Box Level Environmental Testing	10d	0%	6/24/24	7/5/24
Subsystem/Instrument Level Testing	10d	0%	7/22/24	8/2/24
Subsystem/Instrument Level Environmental Testing	10d	0%	8/19/24	8/30/24
Detailed Design	**110d**	**0%**	**4/15/24**	**9/13**
Slice Testing Update	10d	0%	4/15/24	4/26/24
Slice Interface Testing Update	10d	0%	5/13/24	5/24/24
Box Level Testing Update	10d	0%	6/10/24	6/21/24
Box Level Environmental Testing Update	10d	0%	7/8/24	7/19/24
Subsystem/Instrument Level Testing Update	10d	0%	8/5/24	8/16/24
Subsystem/Instrument Level Environmental Testing Update	10d	0%	9/2/24	9/13/24



In lieu of 6-8 month single design activity (PCT with QBDs) establish pockets of distributed design sprints (0100 or 5050)

Alternative Approach - Distributed Design Sprints

Advantages

- Plans effort where it is likely to be expended
- Shorter 10-20 day design sprints can be 0100 or 5050 to avoid PCT with QBDs

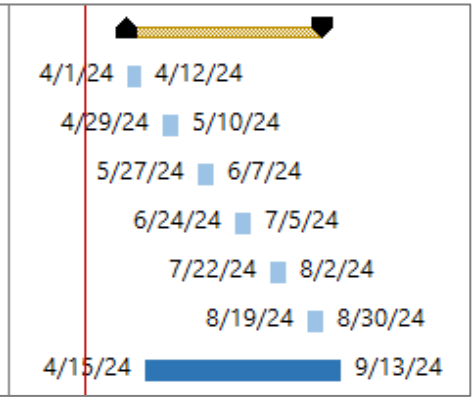
Disadvantages

- The activity count would increase substantially
- Added administrative cost of schedule planning and management
- Implies a level of accuracy that does not exist - level of effort of each distributed design activity is still unknown

Adding more granularity does not ensure additional accuracy but it does ensure additional cost

Alternative Approach - QBDs Based on EM Test Program

EM Test Program	**110d**	**0%**	**4/1/24**	**8/30/24**
Slice Testing	10d	0%	4/1/24	4/12/24
Slice Interface Testing	10d	0%	4/29/24	5/10/24
Box Level Testing	10d	0%	5/27/24	6/7/24
Box Level Environmental Testing	10d	0%	6/24/24	7/5/24
Subsystem/Instrument Level Testing	10d	0%	7/22/24	8/2/24
Subsystem/Instrument Level Environmental Testing	10d	0%	8/19/24	8/30/24
Detailed Design	**110d**	**0%**	**4/15/24**	**9/13/24**



Quantifiable Backup Data	Weight
Slice Testing Update	10%
Slice Interface Testing Update	15%
Box Level Testing Update	15%
Box Level Environmental Testing Update	25%
Subsystem/Instrument Level Testing Update	15%
Subsystem/Instrument Level Environmental Testing Update	20%
	100%

6-8 month single design activity (PCT with QBDs where QBDs are based on EM Test Protocol)

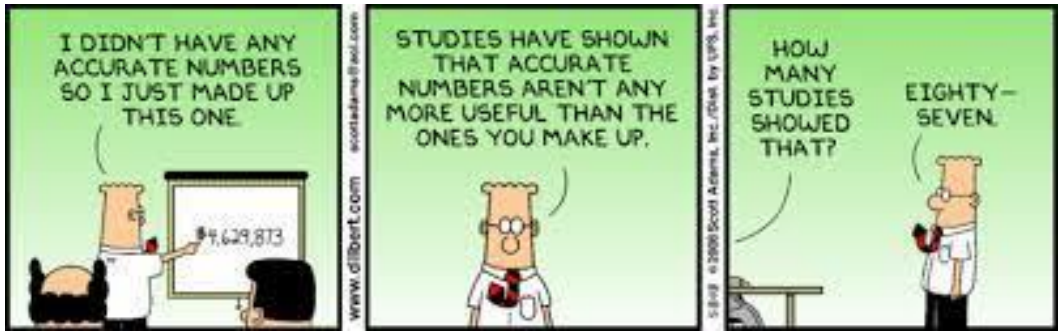
Alternative Approach - QBDs Based on EM Test Program

Advantages

- Earns performance where work is likely to be expended
- Single design activity at the board level - eliminates need for added activities and complexity

Disadvantages

- Added administration of verifying test completion
- Completion of test does not equal completion of design update
- Added administration of QBDs
- Implies a level of accuracy that does not exist - level of effort of each distributed design activity is still unknown



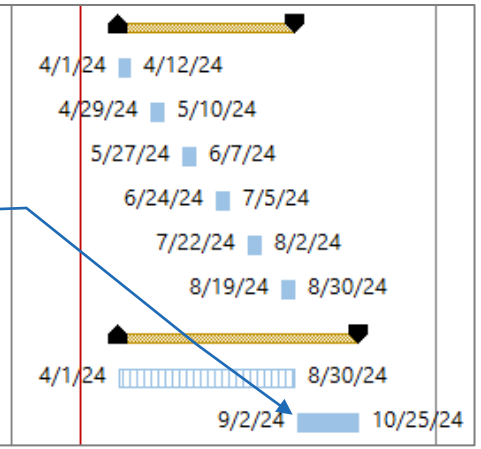
If we do not know if, and at what point, the test anomalies and redesign will occur how can we establish QBDs?

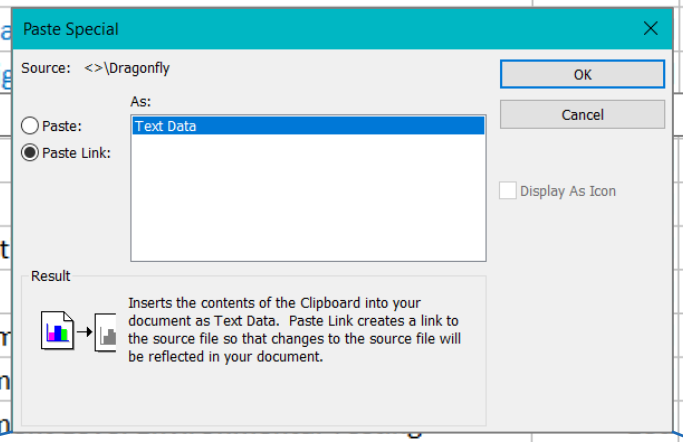
Alternative Approach – Apportioned to EM Test Program

Fixed Duration	**EM Test Program**	**110d**	**0%**	**4/1/24**	**8/30/24**
Fixed Duration	Slice Testing	10d	0%	4/1/24	4/12/24
Fixed Duration	Slice Interface Testing	10d	0%	4/29/24	5/10/24
Fixed Duration	Box Level Testing		0%		
Fixed Duration	Box Level Environm		0%		
Fixed Duration	Subsystem/Instrum		0%		
Fixed Duration	Subsystem/Instrument Level Environmental Testing	10d	0%	8/19/24	8/30/24
Fixed Duration	**Detailed Design**	**150d**	**0%**	**4/1/24**	**10/25/24**
Fixed Units	Detailed Design (Ha		0%	4/1/24	8/30/24
Fixed Duration	Final Detailed Desig		0%	9/2/24	10/25/24

Detailed Design Performance is Apportioned to EM Test Execution

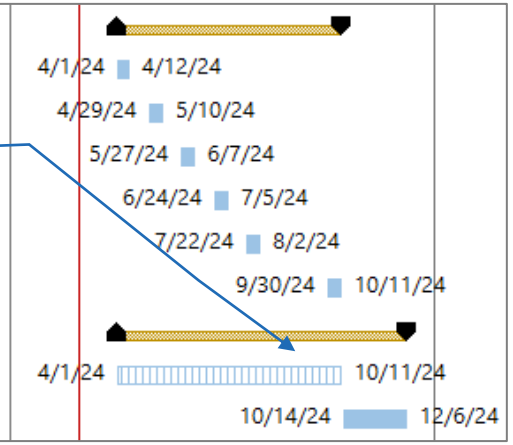
Final Design Activity Can Be Weighted More Heavily to Ensure We Do not Over-Earn





Fixed Duration	**EM Test Program**		**0%**	**4/1/24**	**10/11/24**
Fixed Duration	Slice Testing			4/1/24	4/12/24
Fixed Duration	Slice Interface Test		0%		
Fixed Duration	Box Level Testing		0%		
Fixed Duration	Box Level Environm		0%		
Fixed Duration	Subsystem/Instrum		0%	7/22/24	8/2/24
Fixed Duration	Subsystem/Instrum		0%	9/30/24	10/11/24
Fixed Duration	**Detailed Design**	**180d**	**0%**	**4/1/24**	**12/6/24**
Fixed Units	Detailed Design (Hammock Task)	140d	0%	4/1/24	10/11/24
Fixed Duration	Final Detailed Design	40d	0%	10/14/24	12/6/24

Start and Finish of Design Linked to Start and Finish of EM Test Program



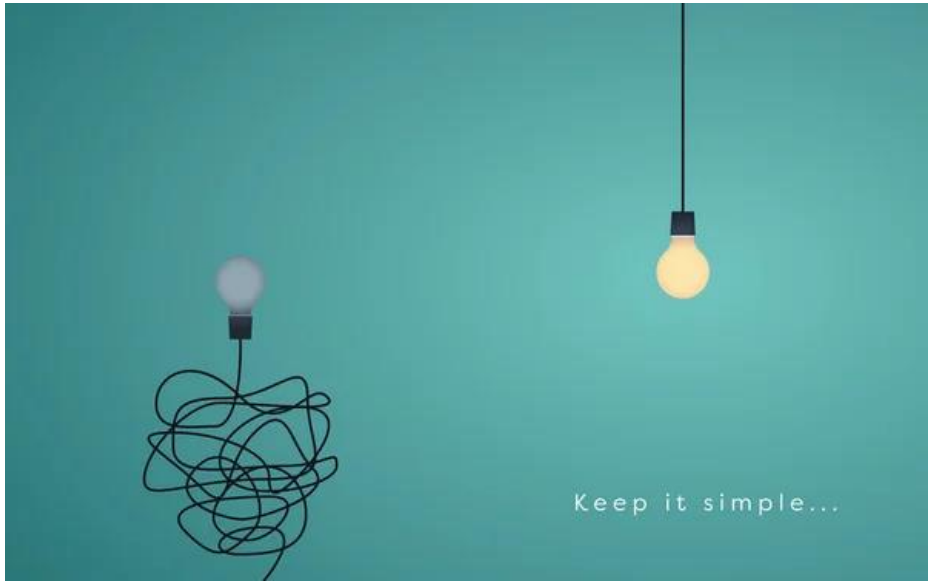
Alternative Approach – Apportioned to EM Test Program

Advantages

- Earns performance where work is likely to be expended
- Simple solution to a more complex problem
- Final design activity can be weighted to avoid over-earning
- Eliminates administration of QBDs

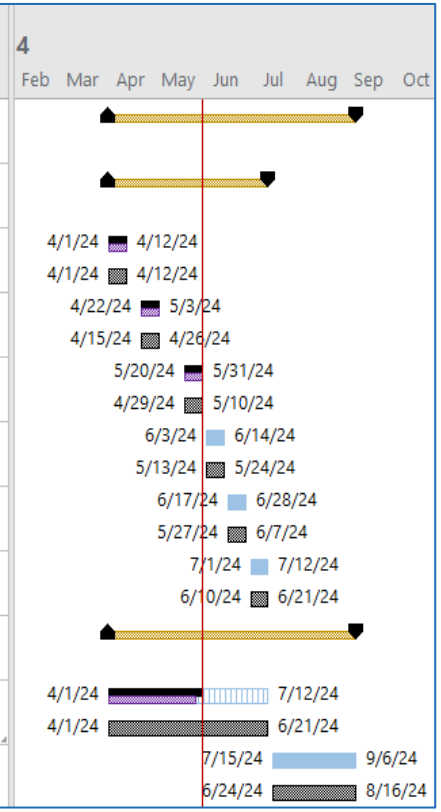
Disadvantages

- Doubles the number of design activities
  (1 automatically updates)
- Added administration of dynamic links



Proposed Solution Mechanics

APL01 - APL WBS	APL03 - WP #	APL04 - EV Type	APL24 - EV Weigh	APL25 - EV Calculation	Design Delta Gate	Name	Duration	% Complet	Physical % Complet	Start	Finish
			200	**55**		**NASA Presentation**	**115d**	**43%**	**0%**	**4/1/24**	**9/6/24**
			100	**55**		**EM Test Program**	**75d**	**50%**	**0%**	**4/1/24**	**7/12/24**
55G	WP01	0100	20	20		Slice Testing	10d	100%	100%	4/1/24	4/12/24
55G	WP01	0100	15	15		Slice Interface Testing	10d	100%	100%	4/22/24	5/3/24
55G	WP01	0100	20	20		Box Level Testing	10d	100%	100%	5/20/24	5/31/24
55G	WP01	0100	25	0		Box Level Environmental Testing	10d	0%	0%	6/3/24	6/14/24
55G	WP01	0100	10	0		Subsystem/Instrument Level Testing	10d	0%	0%	6/17/24	6/28/24
55G	WP01	0100	10	0		Subsystem/Instrument Level Environmental Testing	10d	0%	0%	7/1/24	7/12/24
			100	**0**		**Detailed Design**	**115d**	**39%**	**0%**	**4/1/24**	**9/6/24**
55J	WP01	APP	60	0		Detailed Design (Hammock Task)	75d	60%	55%	4/1/24	7/12/24
55J	WP01	5050	40	0		Final Detailed Design	40d	0%	0%	7/15/24	9/6/24



Detailed Design Performance is Apportioned to EM Test Execution (can be set up in Cobra)
Note that slips in EM Test Program are automatically reflected in the Detailed Design Hammock Activity

Conclusion

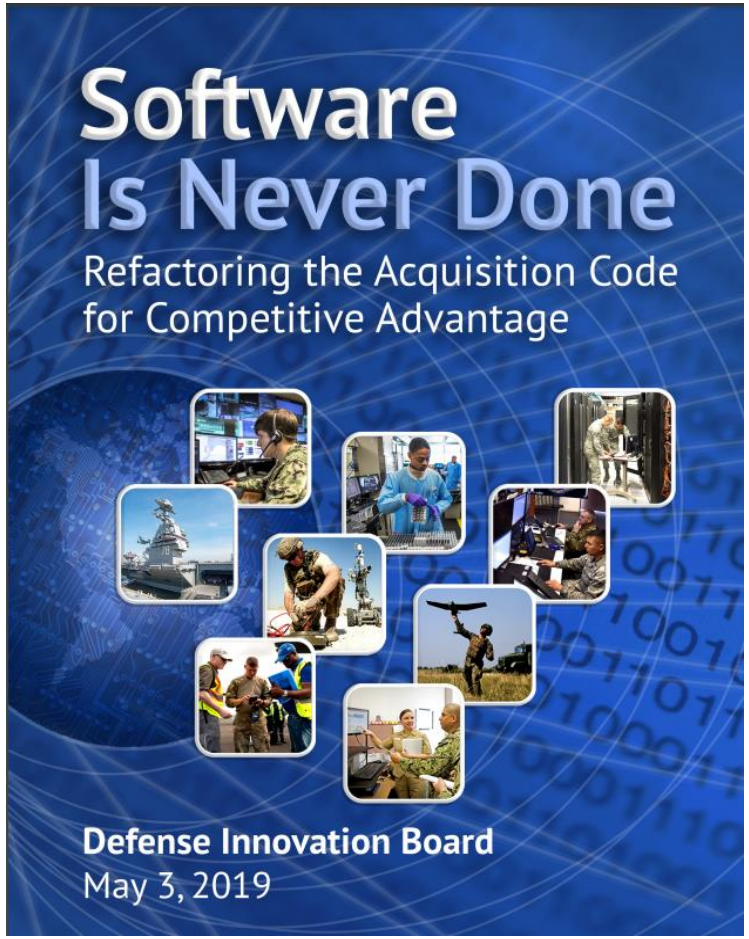
There are many challenges associated with EV implementation in the NASA environment. There are innovative solutions to these challenges but we need to be flexible in our approach. We have an opportunity to tailor our EVM Systems to the NASA environment to reduce cost and optimize value, but to do so, NASA leadership must be willing to challenge the norm and adopt more flexible practices that add value without adding cost.

The Defense Innovation Board (DIB) recently released a report on Software Acquisition (based in part on JHU/APL software development processes and metrics) that reinforced prior recommendations to eliminate EVM on software programs using agile methods. Change is on the horizon.

D4.4	Modify DoDI 5000.02, DoDI 5000.75, and DoDI 5105.84 to reflect use of updated methods and remove earned value management (EVM) for software programs.	A&S	Q1 FY20

Related recommendations from previous studies

DSB87	Rec 19: DoD should develop metrics and measuring techniques for software quality and completeness and incorporate these routinely in contracts.
DSB87	Rec 20: DoD should develop metrics to measure implementation progress.
Sec809	Rec 19: Eliminate the Earned Value Management (EVM) mandate for software programs using agile methods.



Contact Information

- Dewey E. Barlow
  - 443-630-9389
  - Dewey.barlow@jhuapl.edu
- Andrew Soukup
  - 240-592-2987
  - Andy.Soukup@jhuapl.edu

JOHNS HOPKINS

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