



Acquisition Research Program:
Creating Synergy for Informed Change

Creation of a System of Systems Portfolio Management and Technology Selection Methodology

Rich Volkert (SSC P)

Tom Sondi (NG)

Lance Harper (NG)

Carly Jackson (SSC P)

Art Van Nostrand (NG)

Peter Gentile (NG)

Kenneth Michaud (PE)

Overview

- System of Systems Management
 - Acknowledged SoS Example Mission Modules Program
- Systems Engineering Management and Insight in SoS Programs
 - SRL Used to Determine SoS Maturity Analysis
 - Requirements Management & the Drive Towards Commonality in a SoS World
 - Cost Prediction and Monitoring of SoS
 - Understanding and Influencing SoS Reliability
- Expanding the tool set – Technology Trades & SoS Performance Predictions
 - Technology Insertion & SoS Analysis
 - Technology Analysis and Insertion Tool Development
 - Prediction of Performance Using a Performance Level Monitoring Methodology
- Conclusion



NORTHROP GRUMMAN

PIONEERING EVOLUTION



Acquisition Research Program: Creating Synergy for Informed Change

Naval Postgraduate School
Monterey, CA

SoS Acquisition Challenges

- SoS acquisition management - a significant increase in complexity over traditional system acquisition
- Development requires that significant numbers of technologies be integrated to one another
- Challenges traditional development monitoring tools and cost models
 - need to capture integration complexity
 - level of effort required to connect individual components
- Unintended Consequences - high degree of inter-linkage between components can cause unintended impacts to overall system performance
 - components are modified from original use
 - Technology change: replaced throughout the system life cycle

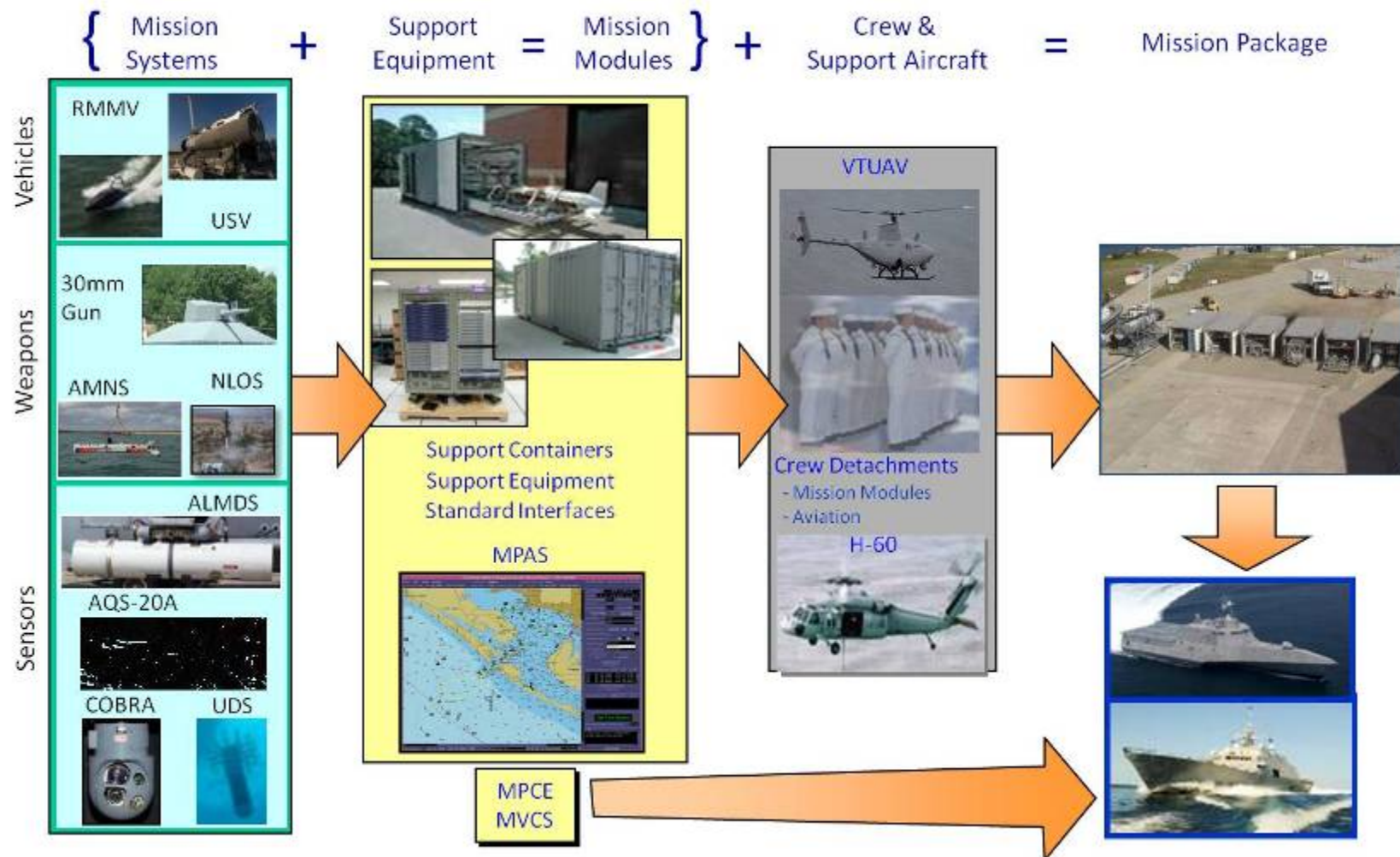
The result of this acquisition management paradigm shift has been significant schedule and cost overruns in SoS programs



PMS 420 Tasking- Providing Focused Warfighting Capabilities



What is a Mission Package?

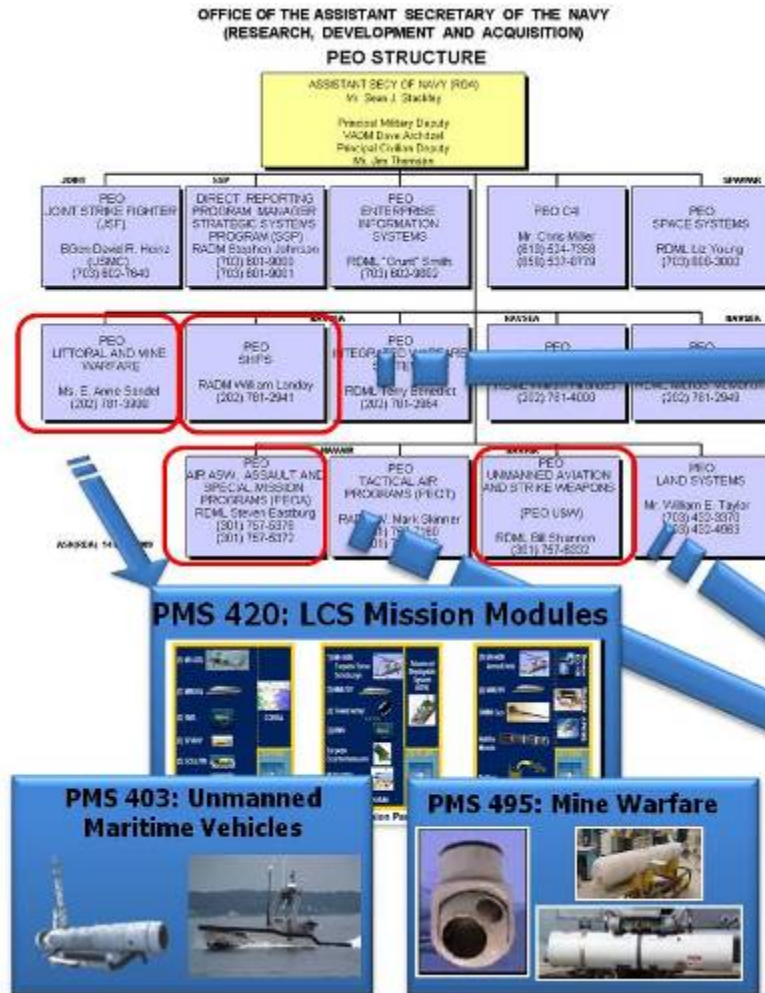


Program Office Role and Needs

- PEO LMW / PMS 420 is responsible for the development, acquisition, and sustainment of modular, swappable Mission Modules to be used on the Littoral Combat Ship (LCS)
- Mission Modules leverage considerable amounts of technology from existing programs of record, while also requiring development of new integration software and components
- Keys aspects of the project include not only monitoring the status of technology development, but also the maturity of the numerous integrations between those technologies and external interfaces
- This has resulted in a very complex and diverse System of Systems (SoS) engineering activity with a need to obtain quick and accurate snapshots of development maturity status, risks, and performance



SoS Organizational Challenges



PEO SHIPS/The LCS program office (PMS 501) exercises technical and programmatic oversight of the industry teams via a comprehensive team representing all systems engineering disciplines.

PMS 501: Littoral Combat Ships



PEO A (NAVAIR) is responsible for the acquisition of air ASW, assault & special mission programs.
PEO U&W (NAVAIR) is responsible for the acquisition of unmanned aviation and strike weapons.

PMA 299: MH-60 Helicopters PMA 266: Unmanned Air Systems



Coordination of Multiple Independent Programs to meet PMS 420 Needs



Acquisition Research Program: Creating Synergy for Informed Change

Naval Postgraduate School
Monterey, CA

SoS Developmental Challenges - Incremental Development

Increment 1 MP 1 in 2007 and MP 2 in 2009	Increment 2 MP 3 in 2012 and MP 4 in 2013	Increment 3 MP 5 in 2014 and MP 6 in 2015	Increment 4 BASELINE MP 7+ in 2016	TRL
RMMV (x2)	RMMV (x2)	RMMV (x2)	RMMV (x2)	8
AN/AQS-20A (x3)	AN/AQS-20A (x3)	AN/AQS-20A (x3)	AN/AQS-20A (x3)	8
AMNS (EDM x1)	AMNS (x1)	AMNS (x1)	AMNS (x1)	7
ALMDS (x1)	ALMDS (x1)	ALMDS (x1)	ALMDS (x1)	7
USV w US3 (x1)	USV with US3 not ready for procurement due to developmental and programmatic issues	USV w USS (x1)	USV w USS (x1)	6
Surf/ beach zone detection capability introduced with VTUAV/ COBRA	COBRA (x1)	COBRA (x1)	COBRA (x1)	8
Influence mine sweep capability is increased with the MH-60/ OASIS		OASIS (x1)	OASIS (x1)	6
Near-surface neutralization				

Future MCM MP Increments are subject to POR schedule slips that aren't under PMS 420 direct control

COBRA



OASIS mounted on helo



BAMICS mounted on helo



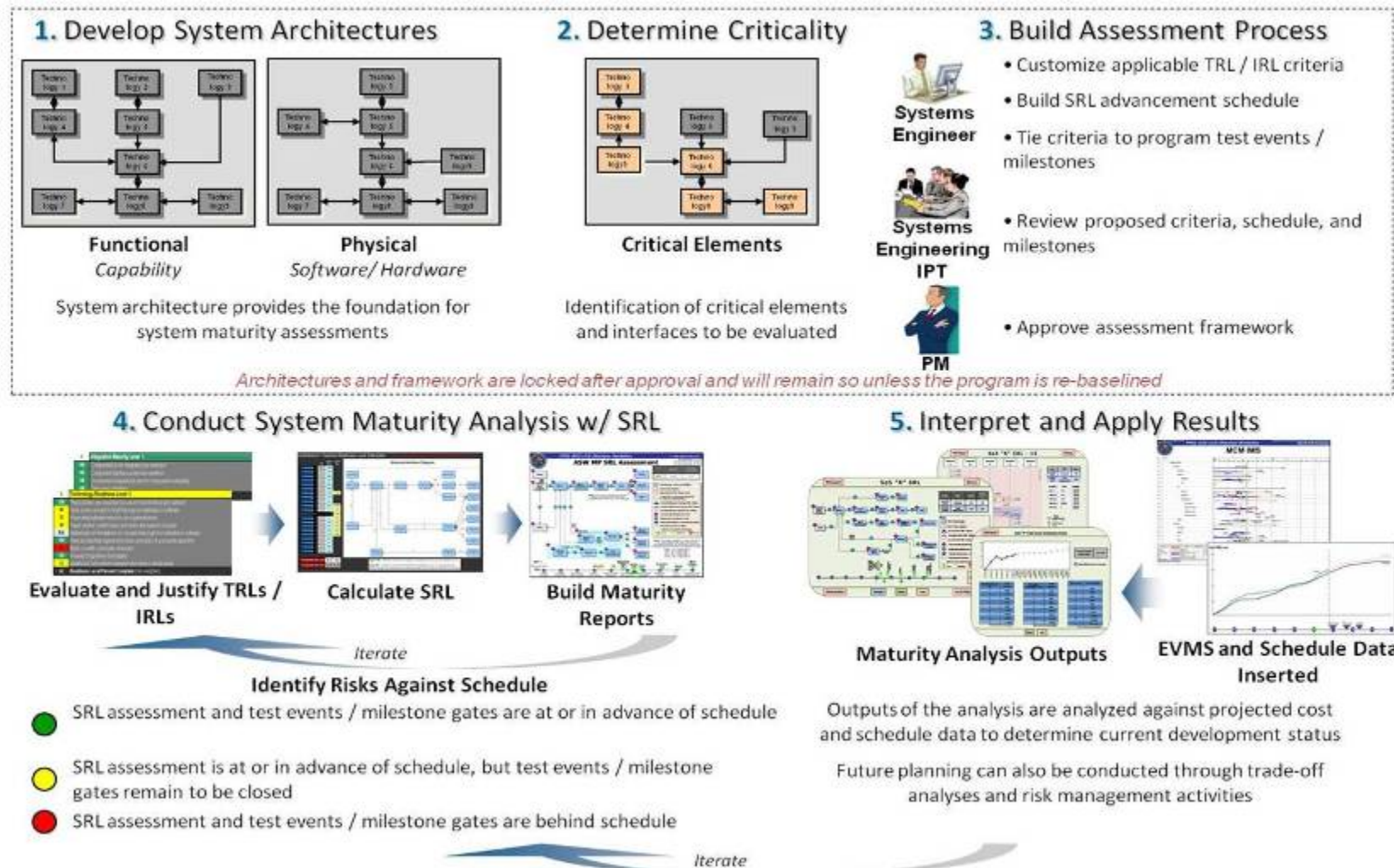
SoS Challenges – Modularity and Commonality throughout the SoS



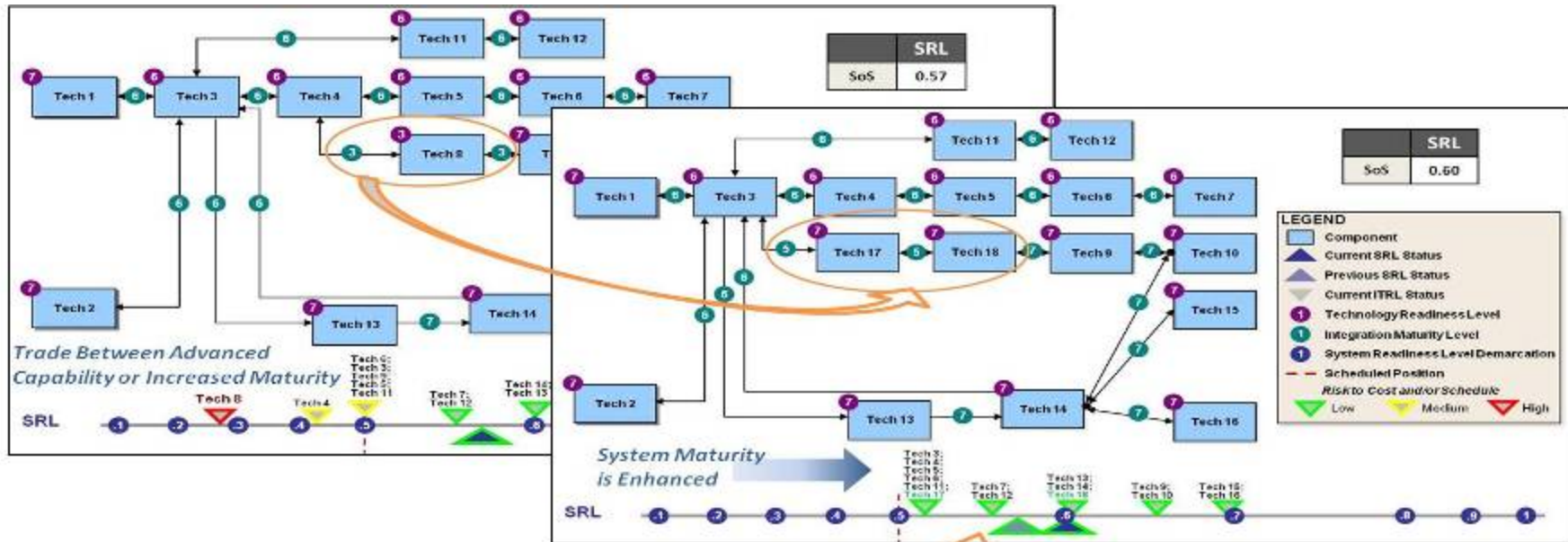
Improved Commonality viewed as key to LCC reductions and towards Improved multi-functional capability



System Maturity Model (SMM) Methodology



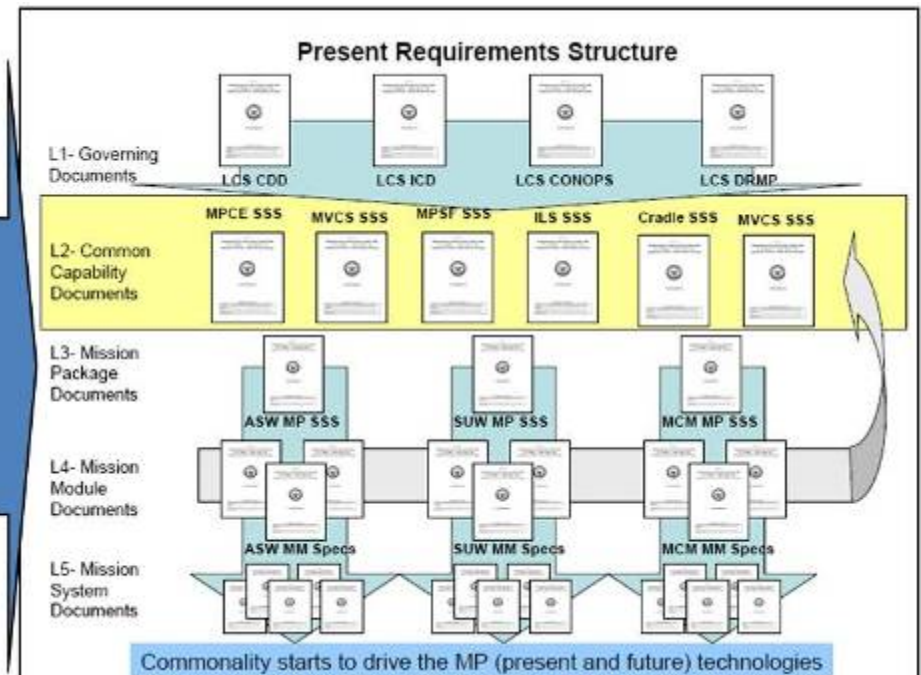
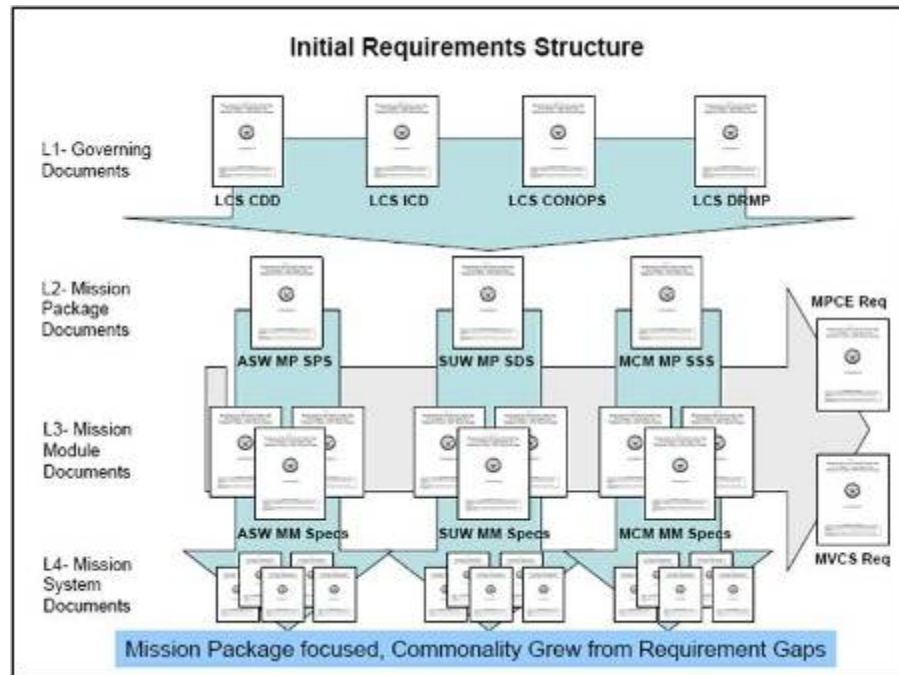
Taking Action to Enhance Performance



- Areas of product risk to end SoS performance become identifiable.
- Impact of technology trade options quickly understandable



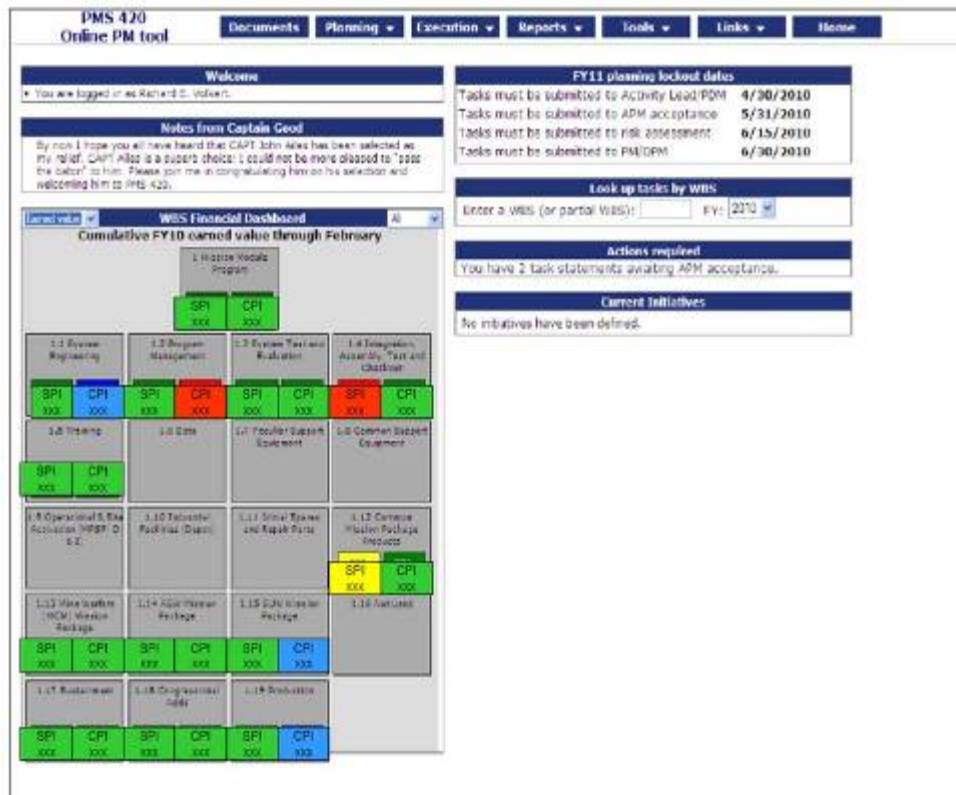
Implementing Effective Requirements Management & the Drive Towards Commonality



- Establishment of a Cross Organization Requirements Database
- Enforced CM process involving all SE stakeholders
- Implementation of a Cultural Change towards Common Solutions



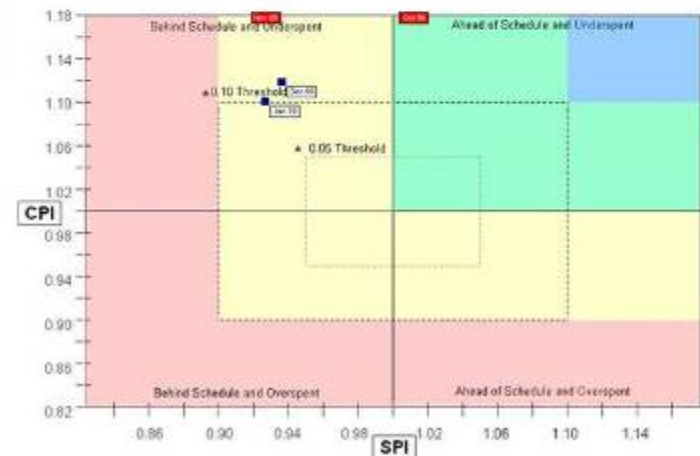
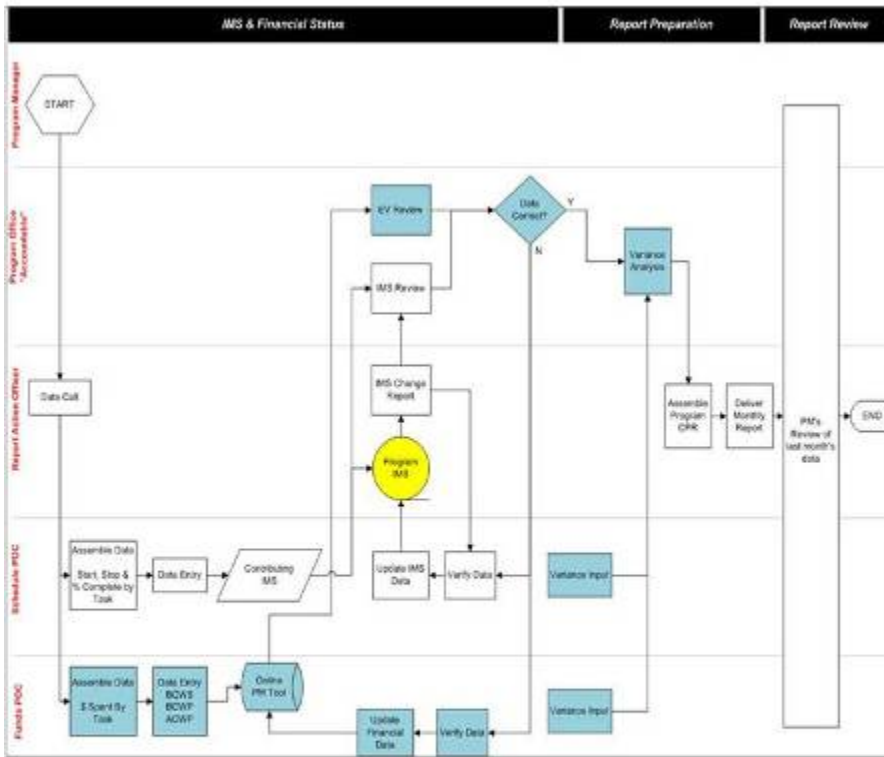
Going Beyond EVMS-Electronic Task: Management & Tracking



Program Management tool providing the entire program management team visibility into and the ability to track funding and tasking allocations by year, color, type, and organization from start of task definition through funding approval



Going Beyond EVMS-Electronic Task: Management & Tracking



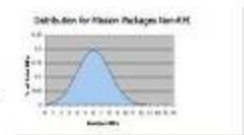
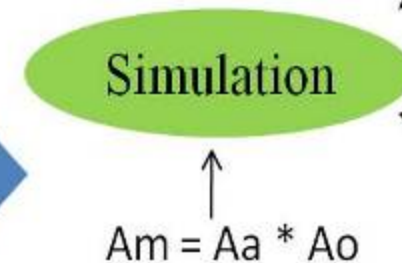
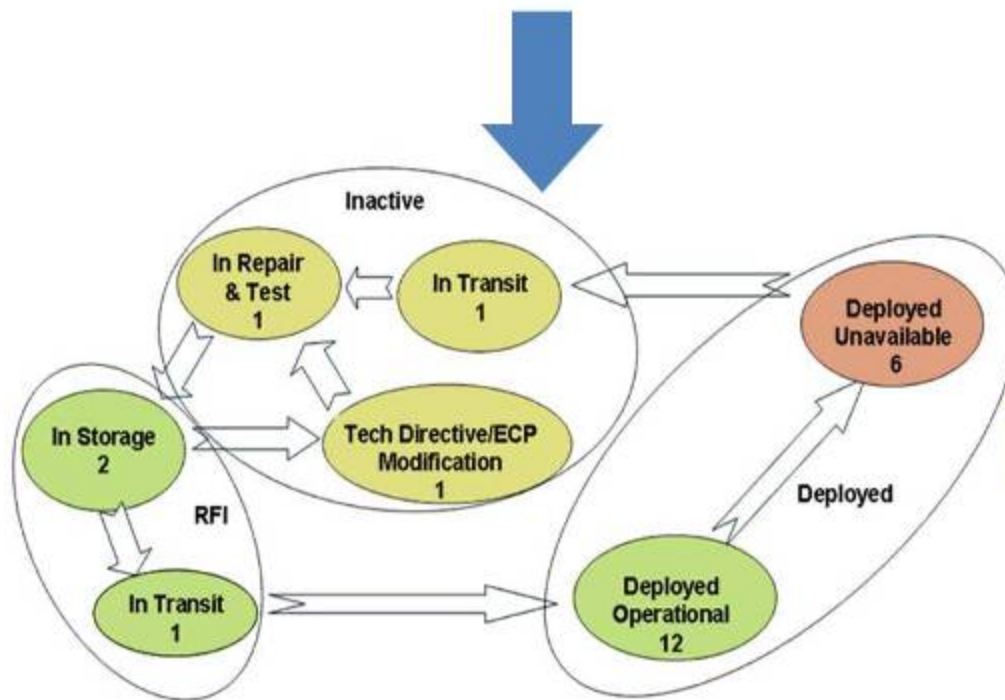
Translating complex management data into displayable and actionable information

Understanding and Influencing SoS Reliability

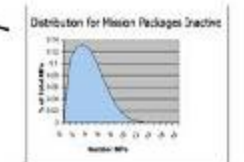
-From Flight 0+ CDD June 2009, Focused Mission Package Annexes: Required A_m :

(U) CCJO Key Characteristics	(U) Key Performance Parameter	(U) Development Threshold	(U) Development Objective
(U) Resilient/ Persistent	6.4.3 (U) ASW Mission Package Materiel Availability	(U) 0.64	(U) 0.712

CDD Requirement	Target A_a	Target A_o	Target A_{10}
Threshold .64	0.887	0.738	0.655
Objective .712	0.887	0.809	0.718



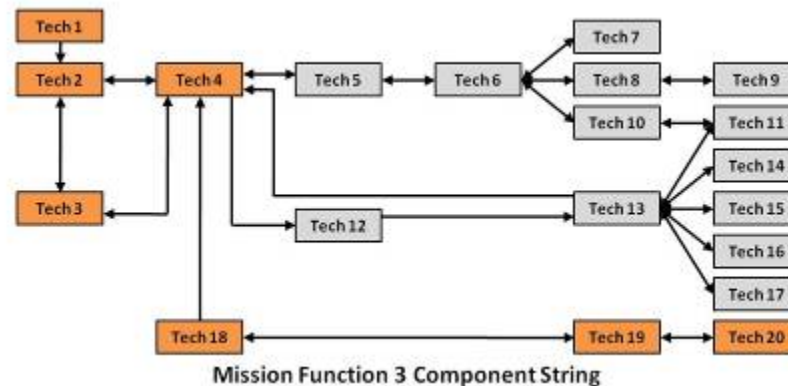
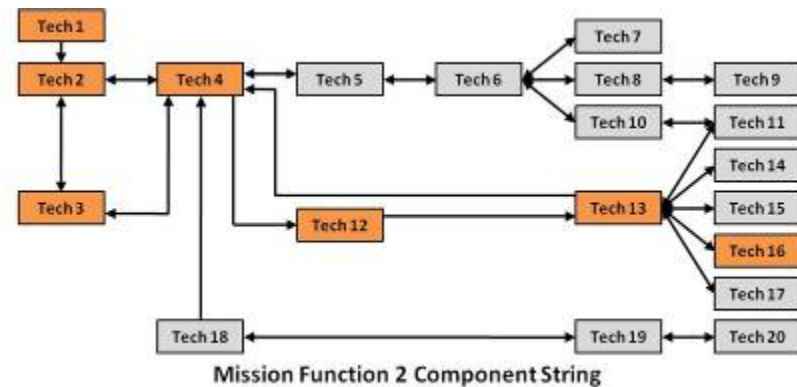
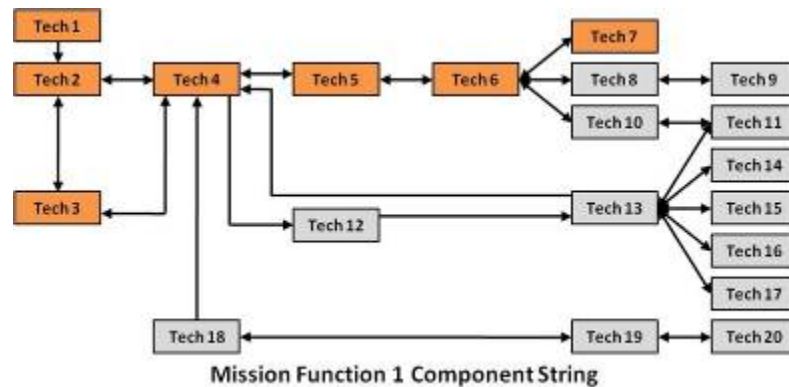
Ave = 6, Std. Dev. = 2



Ave = 3, Std. Dev. = 3



Understanding and Influencing SoS Reliability

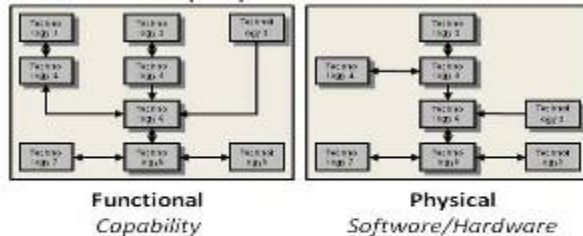


- Operational strings are analyzed to identify the components required to execute independent mission functions of the system
- An assessment of the string to achieve a Mission A_0 contribution is performed
- Common components (nodes) which form a critical function in more than one mission function are identified, operational time is calculated for each mission it touches over the deployment cycle
- Allocation of the Mission A_0 decomposes to an A_0 requirement at the component and Lowest Replaceable Unit (LRU) level



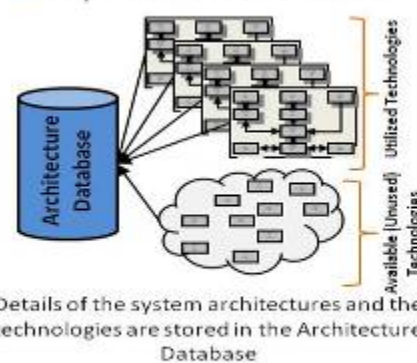
Future Steps: Evaluating Technology Analysis and Insertion

1. Develop System Architectures



System architecture provides the foundation for system maturity assessments (SRL, CRL, etc.)

2. Populate Architectures



3. Define Trade-Off Analysis Criteria

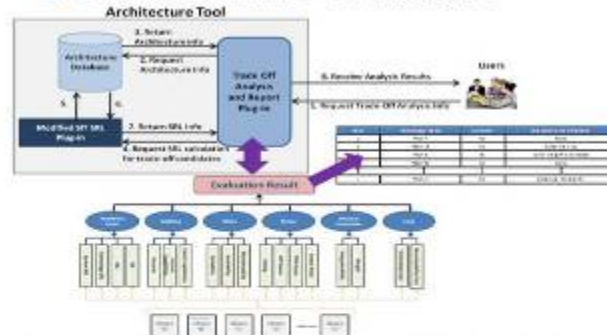


4. Define Analysis Criteria Weightings



Weighting values are selected based on the programs current focus and direction

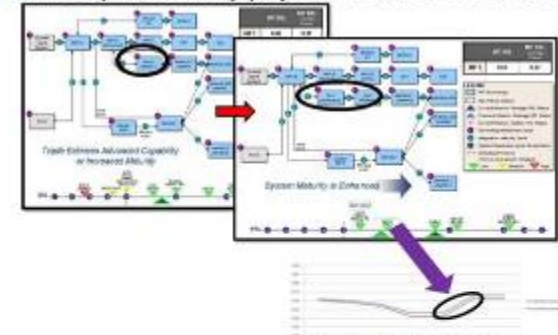
5. Calculate Trade-Off Analysis



Data of the currently utilized and available technologies are compared in the analysis

Results are displayed in ranked order, with known issues for each technology displayed

6. Interpret & Apply Calculated Results



Outputs of the analysis are used to make decisions that will impact the future iterations (and technology refreshes) of the Mission Packages

Iterate

Iterate



Future Steps: Performance Level Assessment

1. Map Technologies to KPPs and Maturity

Goal: Predict the ability of a complex systems to achieve required performance

1. Map the Systems to their impacts on key performance parameters
2. Map the maturity development of the Systems to the SoS development schedule

Notional Systems of Systems				
Capability/KPP	KPP Impacted			
	Search	Detect	Classify	Engage
Tech 1	X	X	X	
Tech 2		X	X	
Tech 3	X	X	X	X
Tech 4				X
Tech 5	X	X		

Notional Maturity					
Capability/KPP	MP Impacted				
	MP1	MP2	MP3	MPn	MPn+1
Tech 1	PRD	PRD	PRD	PRD	PRD
Tech 2	PRD	PRD	PRD	PRD	PRD
Tech 3	PRD	PRD	PRD	PRD	PRD
Tech 4	PRD	PRD	PRD	PRD	PRD
Tech 5	PRD	PRD	PRD	PRD	PRD

Detail	Task 1	Task 2	Task 3
T _{1,1}		X	
T _{1,2}	X	X	
T _{1,3}		X	X
T _{1,4}			X

3. Develop a relationship between system usage satisfying a KPP in a SoS and its maturity (in terms of a weighted value) against anticipated performance

Statement A: Approved for Public Release, Distribution is Unlimited

- Low cost, computation simple methodology for rapidly gaining insight into SoS Performance
- PLM may provide insight into incremental capability compared with performance requirements.
- Evaluation tool for new capabilities prior to their being incorporated

2. Implement impact of SoS CONOPS usage options

4. Adjust for usage impact under various employment options
6. Use predictions of improved maturity (SRL) over time to derive a predicted growth path of performance for SoS

$$\begin{aligned} \text{CONOPS}_{A,n} &= \beta T_{1,n} + \gamma T_{2,n} \\ \text{CONOPS}_{B,n} &= \delta T_{1,n} + \varepsilon T_{2,n} + \gamma T_{3,n} \\ \text{CONOPS}_{C,n} &= \theta T_{1,n} + \eta T_{3,n} \end{aligned}$$

5. Average the results from individual employment options to obtain insight into ability to achieve obtainment of the desired performance parameter

6. Use predictions of improved maturity (SRL) over time to derive a predicted growth path of performance for SoS

KPP_{SEARCH} = (CONOP_A, CONOP_B, CONOP_C) - AVG(CONOP_A + CONOP_B + CONOP_C)

Statement A: Approved for Public Release, Distribution is Unlimited

3. Conduct Variance Analysis

7. Use estimates of performance and maturity to define predictions of performance
8. Use variances of the usage rates to establish bands of performance based on varying usage options of the individual systems/modules

9. As data is gathered, updated predictions/calculations to verify if development is proceeding as desired

Statement A: Approved for Public Release, Distribution is Unlimited



Concluding Thoughts

- System of Systems (SoS) implementation is an exceptional integration challenge.
 - Managing multiple interfaces well and constantly is key.
- Effective employment of modular MPs is feasible with:
 - Modularity, open business model, and open systems architecture supported by financial and programmatic tools that address complexity.
- PMS 420 is at the forefront of SoS acquisition.
 - New methodologies are being developed to provide technical and program management insight



QUESTIONS?

