Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development

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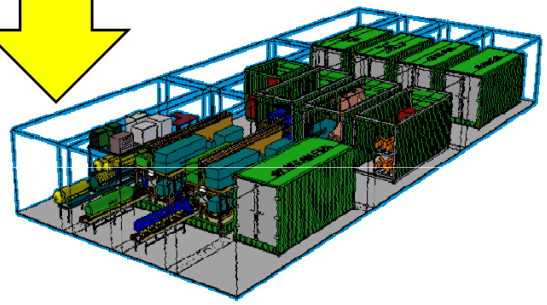
Overview

- Mission Module Definition, History, & Status
- Acquisition Approach
- Rapid Prototyping and other Advantages
- Transitioning to Production
- Lessons Learned
- Summary

Littoral Combat Ship (LCS)

- **Optimized for warfighting in the littorals**
  - Unique designs for unique environment
  - Fast, maneuverable, shallow draft
- **Targeted at critical capability gaps**
  - Reconfigurable single-mission focus
  - Mines; small fast surface craft; diesel submarines
- **Modular Open Systems Architecture approach**
  - Flexible system for dynamic battlespace
  - Advanced unmanned air, surface, and underwater vehicles
  - Onboard sensors, weapons, command and control
- **Naval and Joint Force multiplier**
  - Operational flexibility for sea superiority and assured access
  - Integral member of future surface combatant family of ships
  - Fully netted with the battle force

Littoral Combat Ship Interface Control Document



Navy Need: small, fast delivery vehicle with integrated focused mission package

Mission Packages Defined

MISSION MODULE
LCS MM Program - PMS 420

+

CREW & SUPPORT AIRCRAFT

=

MISSION PACKAGE

Mission Systems +

Support Equipment

Vehicles

RMMV

USV

Weapons

30MM Gun

AMNS

SSMM

Sensors

ALMDS

AQS-20A

COBRA

Support Containers
Support Equipment
Standard Interfaces

MPCE/MVCS Software

MPCE/MVCS Hardware

VTUAV

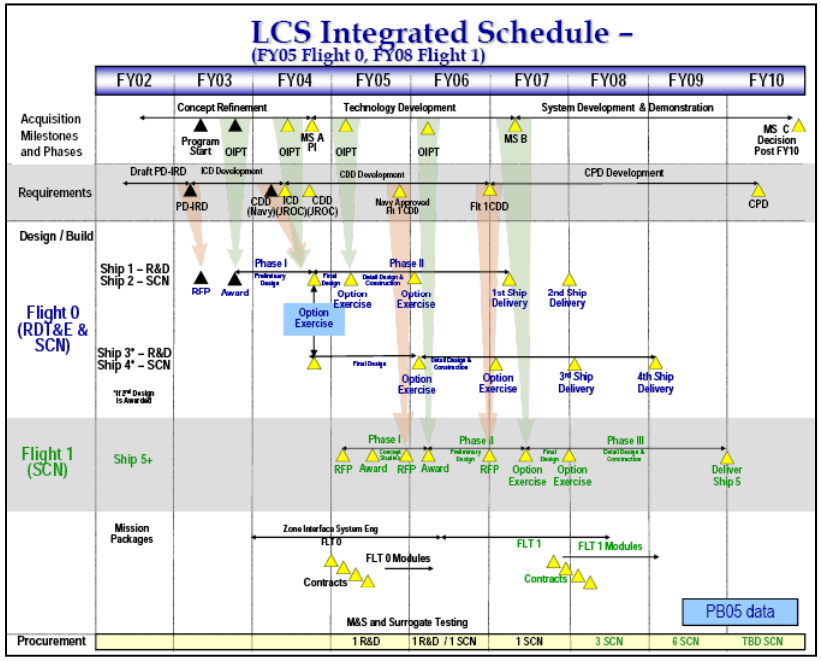
Crew Detachments
- Mission Modules
- Aviation

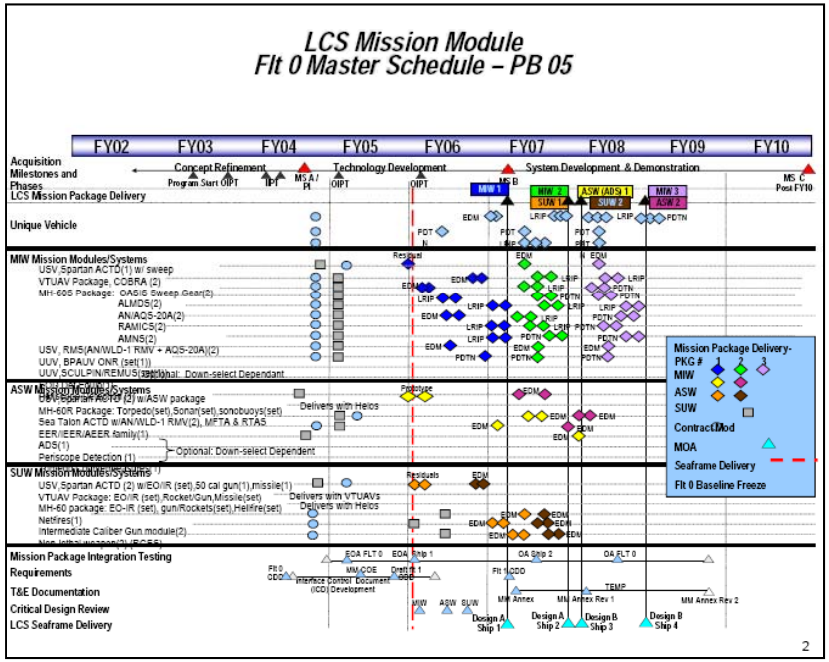
MH-60S

MPAS – Mission Package Application Software MPCE – Mission Package Computing Environment MVCS – Multi Vehicle Communication System

Original Schedule – Experiment to Production

- **LCS Program Began with a Very Aggressive Approach to Seaframe and MP acquisition –** '04 MS A, '07 MS B, '10 MS C, 5th Flt 0 ship delivered in '09, first 5 Flt 1 ship deliveries in '08-'09, etc.
- **Flight 0 was to be an experimental Seaframe to explore the LCS concept, production needs were to be defined/developed in Flight 1** – initial experimental designs were pushed into production with more contractor furnished equipment (CFE) than any other Navy ship.
- **MPs were designed around a come as you are approach with an overly optimistic assumption of Mission System technology maturity** – e.g. system delays have pushed delivery of Flt 0+ capability from '07-'08 to '16 for MCM.





LCS and MP Timeline Challenge

Milestones
System Deliveries/ Deployments
Specification/ Requirements Changes

2002
- Feb 02 – PMS 501 (PEO SHIPS) established

2003
- Mar 03 – PMS 420 (PEO LMW) established

2004
- Jan 04 – LCS Initial Capabilities Document
- May 04 – LCS Program Milestone (MS) A

2005
- May 04 – LCS Flt 0 CDD
- Jul 05 – LCS Flt 0 BL 1.1 ICD
- 05 – Sea Fighter enters service as an experimental littoral ship with modular capability

2006
- Oct 05 – LCS Flt 0 BL 1.2 ICD
- Sep 06 – LCS 1 Christening

2007
- Sep 07 – MCM MP 1 Delivery

2008
- Jun 08 – LCS Flt 0+ CDD
- Jul 08 – SUW MP 1 Delivery

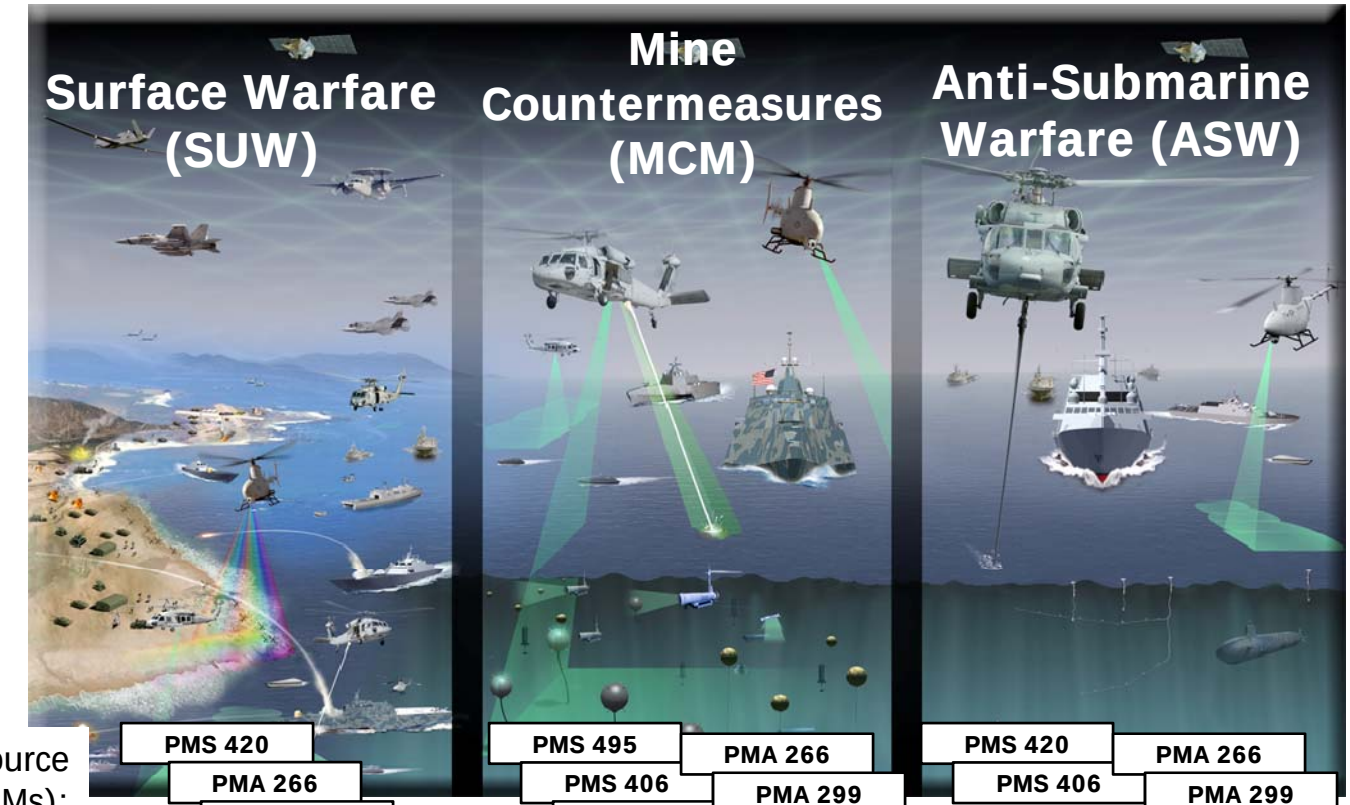
2009
- Dec 08 – LCS Program MS A Prime
- Sep 08 – ASW MP 1 Delivery
- Oct 08 – LCS 2 Christening
- Dec 09 – LCS Flt 0 BL Rev A 1.2 ICD
- Aug 09 – MCM MP 2 Delivery

2010
- Feb 10 – LCS 1/SUW MP 1 Early Deployment
- Mar 10 – SUW MP 2 Delivery

2011
- Oct 10 – LCS Program MS B
- Jul 11/12 – Mission Modules MS B/C

... Mission Packages will achieve Flt 0+ Full Capability in:
- MCM MP 7 (2016)
- SUW MP 5 (2014)
- ASW Spiral Bravo (TBD)

PMS 420 Acquisition Approach Relies Heavily on using Navy Warfare Centers as Lead System Integrators (LSIs)



Participating Acquisition Resource Managers (PARMs):

Surface Warfare (SUW)	Mine Countermeasures (MCM)	Anti-Submarine Warfare (ASW)
PMS 420	PMS 495	PMS 420
PMA 266	PMA 266	PMA 266
PMA 299	PMS 406	PMS 406
	PMA 299	PMA 299
	PMS 403	

Warfare Centers are MP Lead System Integrators, and will assume TDA roles post MP development:

Surface Warfare (SUW)	Mine Countermeasures (MCM)	Anti-Submarine Warfare (ASW)
NAVSEA WARFARE CENTERS NSWC Dahlgren	NAVSEA WARFARE CENTERS NSWC Panama City	NAVSEA WARFARE CENTERS NUWC Newport

SPAWAR Systems Center PACIFIC

Production and integration is handed off to Northrop Grumman for LRIP:

NORTHROP GRUMMAN

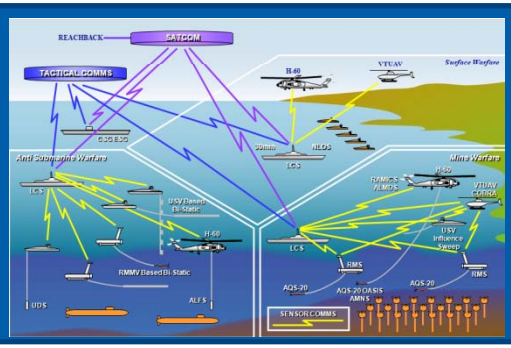
Warfare Centers are Able to Rapidly Mature Prototype Concepts and Support Transition to Production via Existing Contract Vehicles

Contract Modifications are not necessary for Warfare Centers to Implement Innovative Solutions

The "come as you are" approach baselined the ADS Mission Module Radio, however this solution went away when the Advanced Deployable System (ADS) was terminated.

SSC Pacific helped to initiate an SBIR for a Net-Centric Comms in FY04, which evolved into...

... the RT-1944/U a networked radio solution – ***a critical enabler of the LCS MM Concept.***



The Maritime Security Module was added to the SUW MP in Jun '08. NSWC DD and SSC Pacific answered the call, designing and building a prototype MSM for the LCS 1 Early Deployment (Feb '10).

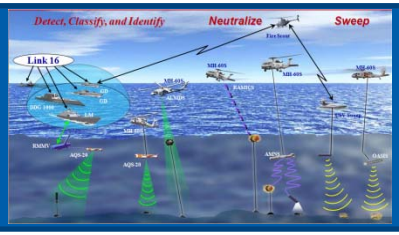

VBSS


Berthing


Cocaine seized during LCS 1 Early Deployment

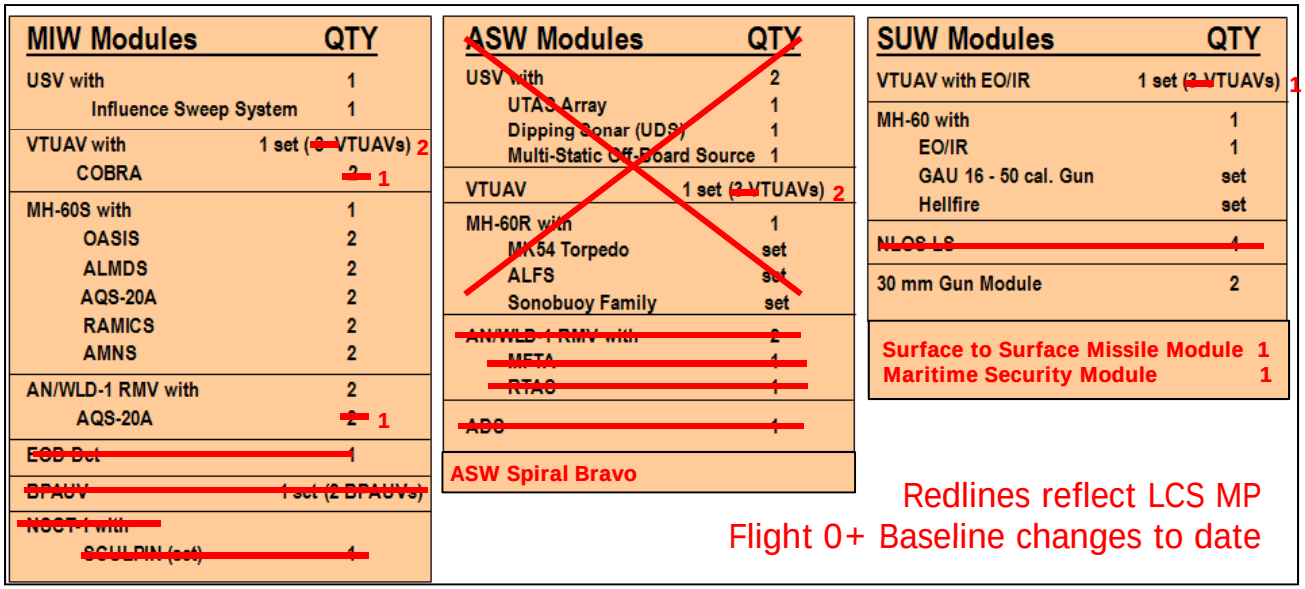
NSWC PC is working to develop experimental tactics, such as the "pruning" technique to achieve minehunting KPPs.

Using existing systems in different ways to improve performance without major system upgrades or modifications.



Navy Warfare Centers are suited to meet the Aggressive MP Development Schedule and Respond to Changing Requirements

LCS MP Flight 0+ Baseline (circa 2005):



	Pros:	Cons:
Warfare centers are not bound by contracts, less formal "funding documents" are used to define tasks.	Labs can adjust early and often to design changes with less cost/ schedule impact.	Less accountability, scrutiny, insight into delivered products.
Design Expertise	Labs are experienced with rapid prototyping and can leverage existing contracting mechanisms, facilities, etc.	Lab designs are not production-ready. Engineering drawings are delivered to Industry with red, green, and blue lines.

Lessons Learned: Implement Commonality Amongst Disperse Product Lines

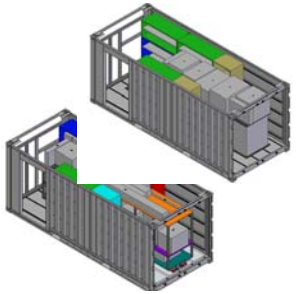
Mission Package Computing Environment (MPCE) H

MPCE provides local IT infrastructure and interfaces with the TSCE on the seaframe.

Multi-Vehicle Communication System (MVCS) HW/SW

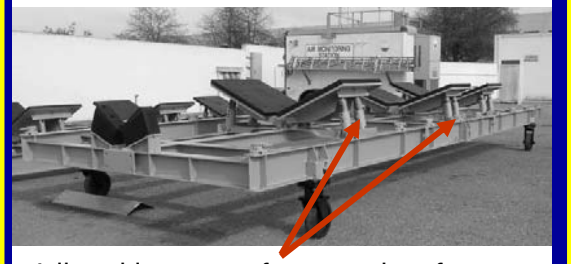
MVCS establishes a common interface for UxV data links and network comm services.

Aviation Support Containers



Common Aviation SCs across MPs

Common Cradle

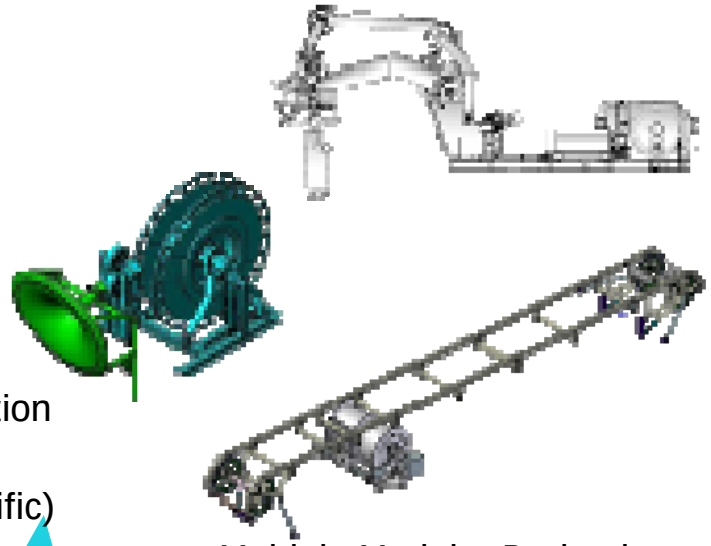


Adjustable support frames to interface with ASW USV (tri-hull) and MCM USV (monohull) and Navy Standard 11-m RHIB

- Three separate capability areas would typically be administered via 3+ separate contracts.
- Using the Warfare Centers as LSIs gives the freedom to implement commonality without multiple contract modifications.

Lessons Learned: Contract Vehicles Enable Rapid Prototyping

- ASW MP System Performance Specification
- ASW USV SSS
- BAA (SSC Pacific)
- Source Selection
- Contract Award



Multiple Modular Payloads

Systems Engineering must be rigorous to support Rapid Development AND the Transition to Production:

- Contract Vehicles must be in place to enable Rapid Prototyping.
- System/Sub-system Specification Documents must be fully developed.
- The USV needed to support multiple, modular, payloads, the LSI must actively manage the interfaces well and constantly.

Lessons Learned: Elegant Engineering vice Producibility
A Tale of Two Aviation Support Container Designs

Base Support Container:



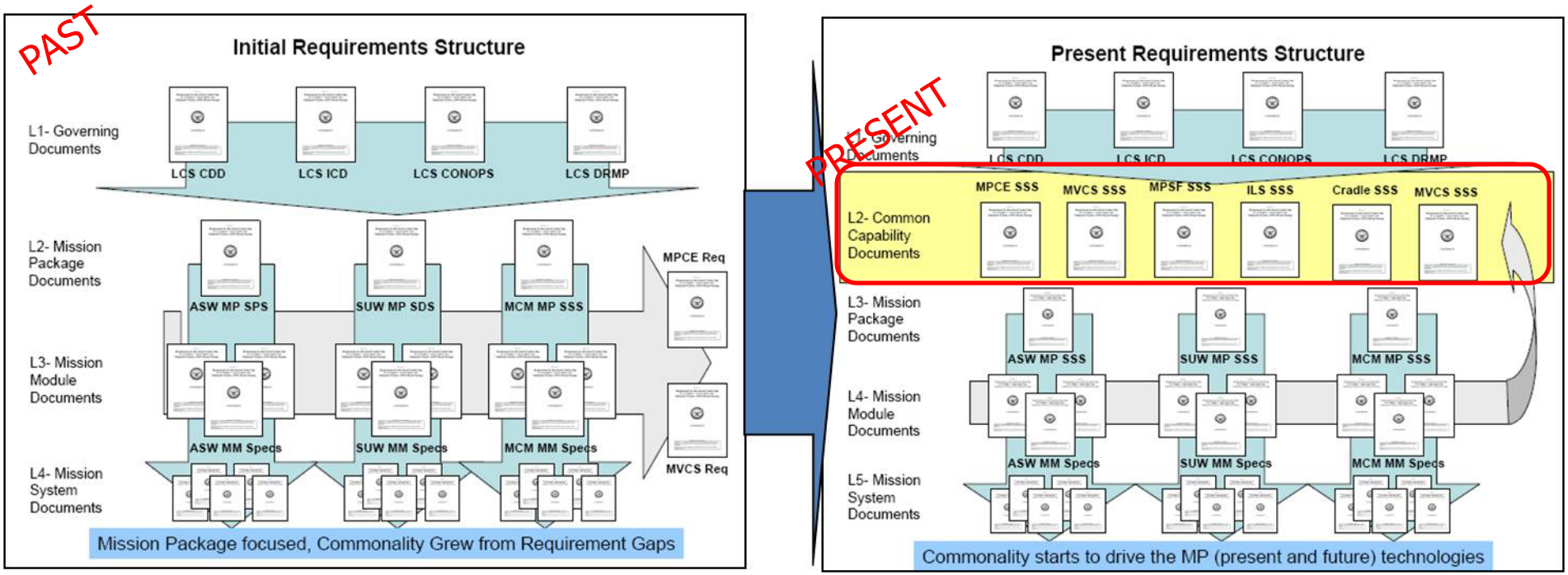
MH-60S (MCM) Support Containers:


- **Automated, mechanized shelving**
- **External access to heavy items**

MH-60R (ASW) Support Containers:

- **Open Shelf Design**
- **Reconfigurable Shelving**
- **Low Maintenance → Low LCC ($)!!**

Lessons Learned: Implement Effective Requirements Management and Drive Towards Commonality Early in the Design Process



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

Lessons Learned: Define and Control the Technical and Processes from the Start

- Requirements Management
  - **Originally Bottom Up:** Each warfare center developed separate Specification documents (one each a SRS, SPS, SSS) with little to no coordination or commonality
  - **Morphing into Top Down:** Level II Spec documents are developed. Each warfare center is reworking their Specification documents into a SSS in accordance with a DID.
- Systems Engineering
  - Define SE process up front and implement (ESOH, Safety, CM, IA, etc.)
  - Each warfare center used their local expertise and business rules to implement ESOH, Safety, CM, and IA for the prototype Mission Packages.
    - e.g. Each warfare center developed separate Systems Engineering Plans. PMS 420 recently developed an overarching SEP document, providing coordinated guidance and alleviating the warfare centers need to produce separate documents.
  - As PMS 420 enters T&E phases and nears production phases, PMS 420 had to define and implement up a centralized ESOH, Safety, CM , and IA processes, many of which are still maturing.

Lessons Learned: Prepare for the Transition to Production

- Define CM processes up front and implement.
  - If left uncoordinated, Warfare Centers will use local business rules to develop separate Configuration Management Plans and Databases.
    - As PMS 420 enters T&E phases and nears production phases, PMS 420 defined and implemented up a centralized CM processes, providing coordinated guidance/repository and alleviating the warfare centers need to produce separate documents/ maintain separate databases.
  - Engineering drawings are delivered from warfare centers with red, blue, and green lines.
    - Significant rework is needed to rework the drawings into production-ready products and to represent the as-built configurations.
- System/Sub-system Specification Documents must be fully developed.
  - Typically the only technical document provided to system developers – part of the SOWs.

Summary: Lessons Learned

- Implement Commonality Across Disperse Product Lines
  - Reduces cost and schedule
- Contract Vehicles Must be in Place to Enable Rapid Prototyping
  - Warfare centers
- Motivate Labs to Design toward Producible Designs – Minimizes Redesign
- Implement Effective Requirements Management and Drive Towards Commonality Early in the Design Process
  - Establishment of a Cross Organization Requirements Database
  - Enforced CM process involving all SE stakeholders
  - Implementation of a Cultural Change towards Common Solutions
- Define and Control the Technical and Processes from the Start
  - Implement Effective Requirements Management
  - Define and Implement Common SE Processes up front

Questions?

Back-up

Abstract

Conference: 13th Annual NDIA Systems Engineering Conference, Oct 25 – 28 2010, San Diego, CA.

Authors: Rich Volkert (SSC Pacific), Carly Jackson (SSC Pacific), Cecil Whitfield (PMS 420)

Title: The Use of Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development

Abstract: Over the last several decades, the nature of acquisition has seen significant changes. The delivery of capabilities has shifted from a systems focus to the development and fielding of system-of-systems (SoS). The defense industry has seen significant consolidation while experiencing one of the largest military buildups in US history. The governments acquisition workforce has declined due to aging and reductions in force following the ending of the cold war. Acquisition efforts have been under significant pressure to deliver products faster and in an environment that's under severe fiscal and performance pressure. One of the results of these pressures and a changing business philosophy resulted in the government outsourcing of the role of Lead Systems Integrator (LSI) to Prime Contractors for major defense projects in the 80's and 90's. Due to several of these programs suffering major acquisition challenges, the decision was made to return this span of control to within DoD. This policy was directed in the Defense Authorization Act. The question then became that with the decline in the acquisition workforce over the last several decades was the government up to accepting the challenge and could it produce? The Littoral Combat Ship (LCS) Mission Modules Program Office (PMS 420) provides an opportunity to see some of the challenges and advantages of retaining the LSI role within the government and to identify areas where investment are required to assist the government in effectively accomplishing this role. The briefing will review the history of how the warfare centers became involved in the development of the Mission Packages, the roles and responsibilities assigned to those centers, and how those roles and responsibilities have changed as the Mission Modules program has matured. The advantages and challenges of using a warfare center to assist in rapid development activities will be reviewed and the challenges of transitioning roles as efforts mature from development and integration to production is presented.

From a System to an Acknowledged System of Systems

Table 2-1. Comparing Systems and Acknowledged Systems of Systems

Aspect of Environment	System	Acknowledged System of Systems
Management & Oversight		
Stakeholder Involvement	Clearer set of stakeholders	Stakeholders at both system level and SoS levels (including the system owners), with competing interests and priorities; in some cases, the system stakeholder has no vested interest in the SoS; all stakeholders may not be recognized
Governance	Aligned PM and funding	Added levels of complexity due to management and funding for both the SoS and individual systems; SoS does not have authority over all the systems
Operational Environment		
Operational Focus	Designed and developed to meet operational objectives	Called upon to meet a set of operational objectives using systems whose objectives may or may not align with the SoS objectives
Implementation		
Acquisition	Aligned to ACAT Milestones, documented requirements, SE with a Systems Engineering Plan (SEP)	Added complexity due to multiple system lifecycles across acquisition programs, involving legacy systems, systems under development, new developments, and technology insertion; Typically have stated capability objectives upfront which may need to be translated into formal requirements
Test & Evaluation	Test and evaluation of the system is generally possible	Testing is more challenging due to the difficulty of synchronizing across multiple systems' life cycles; given the complexity of all the moving parts and potential for unintended consequences
Engineering & Design Considerations		
Boundaries and Interfaces	Focuses on boundaries and interfaces for the single system	Focus on identifying the systems that contribute to the SoS objectives and enabling the flow of data, control and functionality across the SoS while balancing needs of the systems
Performance & Behavior	Performance of the system to meet specified objectives	Performance across the SoS that satisfies SoS user capability needs while balancing needs of the systems

Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008

System of Systems Challenges

SoS increases the complexity, scope, and cost of both the planning process and systems engineering, and introduces the need to coordinate inter-program activities and manage agreements among multiple program managers (PMs) as stakeholders who may not have a vested interest in the SoS. The problems that need to be addressed are large and complex and are not amenable to solution by better systems engineering alone. Without a solid governance and management approach for an SoS, independent authorities who oversee the multiple governance processes of DOD are unlikely to accept guidance from a systems engineer they do not control, placing the systems engineer in an untenable position in attempting to support an SoS. An administrative/governance structure that addresses these realities will enable SoS SE to be more effective in all phases of the processes as outlined in this document. This document acknowledges these issues but does not make any recommendations for changes to existing management and control structures to resolve inter-system issues,

Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008

System of System (SoS) Organizational Challenges

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PMS 420: LCS M

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 air ASW, assault & special mission programs.

PMA 299: MH-60 Helicopters

PMA 266: Unmanned Air Systems

PEO U&W (NAVAIR) is responsible for unmanned aviation and strike weapons.

PMS 403/406: Unmanned Maritime Vehicles

PMS 403 is responsible for the the RMMV.

PMS 406 is responsible for Unmanned Maritime Vehicles, incl. the MCM and ASW USVs.

PMS 495: Mine Warfare

PMS 495 is responsible for the acquisition of mine warfare systems.

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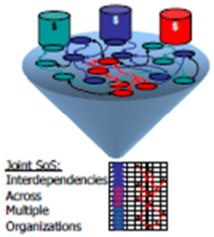
SoS Management Challenges

Acknowledged System of Systems Challenges

- **Management and Oversight:** SoS systems engineers (SE) must be able to function in an environment where the SoS manager does not control all of the systems that impact the SoS capabilities and stakeholders have interests beyond the SoS objectives.
- **Management and Oversight:** SoS SE must balance SoS needs with individual system needs.
- **Implementation:** SoS SE planning and implementation must consider and leverage the development plans of the individual systems.
- **Implementation:** SoS SE must address the end-to-end behavior of the ensemble of systems, addressing the key issues which affect that behavior.



"The problems that need to be addressed are large and complex and are not amenable to solution by better systems engineering alone. Without a solid governance and management approach for an SoS, independent authorities who oversee the multiple governance processes of the DOD are unlikely to accept guidance from a systems engineer they do not control"

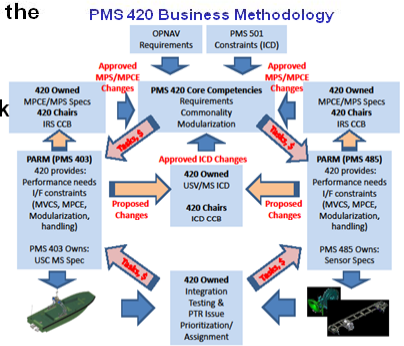
Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008 21

"Acknowledged" SoS have recognized objectives, a designated manager, and resources, but the constituent systems retain their independent ownership, objectives, funding, and development and sustainment approaches. It is one of four SoS types identified in *DoD System Engineering Guide for SoS, V1.0*, Aug 2008.

→ *Successful development and implementation of an "Acknowledged" SoS is dependent on collaboration between the SoS' and the constituent systems' SE and PM teams.*

How is the LCS Mission Module Program Addressing Acknowledged SoS Issues?

- **Ensuring System Maturity**
  - Monitoring the readiness of all technologies and integrations within the SoS environment
- **Enforcing Commonality**
  - Developing solutions which can work across the program to save time and money while increasing flexibility
- **Estimating SoS Availability**
  - SoS RMA defined: Am, Ao, Mission Availability, LCS MM perspective
- **Estimating SoS Performance**
  - Monitoring performance through KPPs/TPMs from a SoS persective



PMS 420 is working at the forefront of SoS acquisition developing novel methodologies that provide SoS technical and management insight.

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