The Modernization of the Aegis Fleet with Open Architecture

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The Modernization of the Aegis Fleet with Open Architecture

Lockheed Martin Corporation, Cherry Hill, NJ, 08002

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Same as Report (SAR)
Topics
Things to talk about…

• **Background**
  – Aegis Overview
  – Capability Upgrade Evolution
  – Modernization Concept/Approach

• **Aegis Open Architecture**
  – Evolution to COTS Technologies and Products
  – Incremental/Spiral Development Approach

• **Aegis Modernization**
  – Overall Scope/Impact
  – Product Line Architecture
  – Integration of Common STM / TS Components

• **Summary**
Aegis – The Shield of the Fleet

Design Cornerstones
- Continuous Availability
- Surveillance Coverage
- Reaction Time
- Firepower
- Environmental Resistance

Self Defense
Area Air Defense
Long Range Air Defense
And BMD

ASCW High Diver
ASCW Sea Skim and Pop-up
CVN
DDG

BMD

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Aegis Capability Overview

12 Generations and Over 27 Years of Proven Success
Aegis Modernization Concept

I. Decouple Hardware and Software Upgrades Using COTS
   – Software Upgrades Every Two Years
   – Hardware Refresh Every Four Years

II. Build on Fielded Baselines

III. Integrate Navy Enterprise HW and SW Solutions

IV. Transition Aegis to Navy Objective Architecture

Benefits of Aegis Modernization Concept
   – More Capability to the Fleet Sooner
   – Foster Collaboration and Competition
   – Cost Savings from Commonality & Reuse
   – Minimal Lifetime Spares
   – Upgrades Backward Compatible

COTS & Open Architecture - While Maintaining Engineering Discipline
Aegis Open Architecture
# AWS Computer Architecture Evolution

<table>
<thead>
<tr>
<th>B/L 1/2/3</th>
<th>B/L 4/5</th>
<th>B/L 6 Ph I/III</th>
<th>B/L 7 Phase I</th>
<th>ACB08/TI08</th>
<th>ACB12/TI12</th>
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<tr>
<td>CG 47-64</td>
<td>DDG 51-78</td>
<td>DDG 79-90</td>
<td>DDG 91-112</td>
<td>CG 52-58</td>
<td>CG 59+</td>
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<td>CG 66 &amp; 69</td>
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<td>CG 52-58</td>
<td>CG 59+</td>
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<tr>
<th><strong>Processors</strong></th>
<th>UYK-7 → UYK-20</th>
<th>UYK-43 → UYK-44</th>
<th>UYK-43/44+ Adjunct COTS</th>
<th>COTS</th>
<th>Mainstream COTS</th>
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<td>NTDS Parallel NTDS Serial Ethernet</td>
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<td><strong>Displays</strong></td>
<td>UYH-4</td>
<td>UYQ-21/UYQ-70</td>
<td>UYQ-70</td>
<td>UYQ-70 ORTS Thin Clients</td>
<td>CDS</td>
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<td><strong>System Complexities</strong></td>
<td>UYK-43s B5P III TGC</td>
<td>SMP's ALIS Network</td>
<td>SMP's Fast Ethernet</td>
<td>Open Architecture Mainstream COTS Gig-Ethernet</td>
<td>Open Architecture COTS MMSP Product-Line</td>
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* Applicable to Baseline 5 Phase III Only
** Eliminated in Baseline 7 Phase IR

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COTS Technology and Products

Tech Insertion 00  2000  B7Phl  DDG 91-102
Tech Insertion 04  2004  B7PhlIR  DDG 103-112  LCS / NCS - Derivative
Tech Insertion 08  2008  ACB 08  CG 52-59

Non-LM Hardware

- Computing Platform
- VME Single Board Computer
- Network Switching
- SAN Storage
- Network File System
- Thin Client LCD Display
- Analog Hardware/Devices

Non-LM Software

- Real Time Operating System
  - Pub-Sub Communications
- High Availability Middleware
  - Enterprise System Management
- Human-Systems Software
  - Network Management Tools

Smaller Footprint and Reduced Processor Costs
Incremental Development
“Build a little ... test a lot”

- Spiral-1
  - OA Radar
  - DDG 96
  - At-Sea Demo

- Spiral-2
  - OA Display
  - WSMR
  - OA Weapons

- Spiral-3
  - DDG 103-112
  - ACB 08

- Tech Insertion 08
  - CG 52-59

- Completed Modular Designs
  - 2007

- Fielding Modular Design foundation
  - 2008-2011

- Open Architecture Foundation for Baseline 9 Developments

- Focused on Radar, Weapons
- Model-Centric Development (UML)
- Modern Languages (C/C++, Java)
- Non-Proprietary Interfaces
### Where We are Today

**Aegis LAN Interconnect System (ALIS III)**

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<tr>
<th>Technical Assessment</th>
<th><strong>SPY</strong></th>
<th><strong>Open C2</strong></th>
<th><strong>Weapons/Fire Control</strong></th>
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<td>Display</td>
<td>C&amp;D</td>
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<td></td>
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<td>Closed</td>
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<td>CG-62/DDG-51 2012</td>
<td>Hardware</td>
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<tr>
<td></td>
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<td>Open</td>
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### Continuously Advancing the Aegis Combat System Forward
Today’s Aegis Combat System
Surface Warfighting Electronics Architecture

Detect/Control/Engage View

System/Subsystem View

- Federated, Tiered Architecture
- Efficient ACS Capability changes
- Well-Define Components and API’s

Supports Operational and Navy Business Model Objectives
Aegis Modernization
Roadmap to Aegis Modernization (AMOD)

AMOD Advanced Capability Build 12
(DDG configuration)
Tech Insertion (TI) 12
Aegis BMD 5.0
ACS Element Upgrades
NIFC-CA
JTM Alignment
MMSP
SM-6

AMOD Advanced Capability Build 12
(CG configuration)
TI12
ACS Element Upgrades
NIFC-CA
JTM Alignment
SM-6

AMOD ACB12 (TI12)

Aegis BMD Block 06/08
Aegis BMD 4.0.1
Improved Discrimination
Improved Track Handover
Enhanced LoT
Integrated IR/RF KA
SM-3 Blk IA and IB

Aegis BMD Block 04
Aegis BMD 3.6
LRS&T, Engagement and LoT
Multi-Mission
Integrated Mission Planning
SM-3 Blk I and IA

Aegis BSP

COTS Based Infrastructure

Increased Battlespace and Multi-Mission Interoperability

CR0/CR1

B/L 7 Phase I
COTS architecture

CG MOD ACB08 (TI08)

ACB08
OA Spiral 3
ACS Element Upgrades
TI 08

B/L 7 Phase IR
OA Display Improvements
CIWS Block 1B Fratricide Avoidance
CEC 2.1 (Mode 5)
COTS Refresh 1
AMOD Technical Scope

- **BMD 4.0.1 Functionality and SM-3**
- **NIFC-CA and SM-6**
- **JTM Alignment**
- **Aegis Weapon System COTS Refresh 3**
- **Aegis Combat System Upgrades**
- **HM&E Upgrades**

- **Sea-Based Ballistic Missile Defense**

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Way Ahead … Baseline 9

- Fielding Modular Software
- Open Standards
- Collaborative Peer Review Environment
- Full Government Purpose Data Rights
- Leveraging small business innovation
- Established Two Technology Centers

Modular Design Foundation

“ACB 08”

Steering and Priming The SBIR Process

USS Bunker Hill CG-52

Integrate 3rd Party

Technology Collaboration Center

Applying S&T Investments Capability Based Plan – Baseline 9 Aligned

ACB 8.1

Baseline 9 A/C

Baseline 9 B/D/E...

MM Signal Processor

- Capability Improvements
- BMD Merger
- NIFC-CA
- JTM / ATAC

2010

Field Capability Through Modernization

2012

2014-2016

Balancing Capabilities with Complex Combat System Integration Foundation Established for Transition to Objective Architecture
Implementing Open Architecture
Layered Architecture Foundation

Infrastructure:
- Common Services and APIs
- Flexibility to Support Forward-Fit and Back-Fit

Common Computing Environment:
- Standards-based Interfaces to network
- Commercial Mainstream Products and Technologies

Componentized Objective Architecture:
- Common Reusable Components
- Platform Specific Components
- Data Model
- Extensible to the Future

Decouple Hardware (H/W) from Software (S/W)

Upgrading Hardware and Software Independently
Top Level Objective Architecture
“Component View…”
Joint Track Management Alignment

Overview

• Align AMOD and SSDS Track Management to a Common Architecture
  – Provide Consistent Functional Allocation, Data Representation and Attributes
  – Incorporate Reusable System Track Manager and Track Server Components

• Provides Hierarchical Track File (System Level – Source Level)

• Provides Standard Interfaces
  – Track Server Standard Access Interface for Client Applications
  – Track Manager Integrates Track Data Sources via Common Interface;
    Extensible for New Track Data Sources

• Provides Two Complete Versions of Live Training Tracks:
  – Allows Training Override of Multiple Attributes
  – Training Tracks Can be Physically Relocated From Live Location

• Provides Dual Ownship – Tactical and Training:
  – Allows Training View to be Repositioned with No Impact to Tactical View

Aligning the Architecture for Future:
Common Components Across Ship Classes
SI/DA Scope

- **Implement Common Track Server**
  - Replace Existing PDM Component
  - Implement configurable track server – support multiple track sources
  - Standardize services and APIs
  - Integrate PDM, DDG-1000 and SSDS track server design concepts
  - Ensure resulting component will work for both AMOD and SSDS

- **Consolidate System Track Manager**
  - Implement JTM hierarchical design approach
  - Consolidate STM and MNF
  - Improve track file and data xfer (e.g., capacity, types, attributes, …)
Component Framework Services

Key
- Common Components
- COTS
- Component Framework Services
- Aegis C2/System Services

STM

TS

Future Common Components

Component Framework Services
Common STM and TS Components

Task Allocation…

**LM Tasks:**
- Update AMOD System Specs (A-level, B1, B5)
- Provide Legacy Aegis Requirements (e.g., STM, PDM, MNF) to SI/DA
- Validate Aegis Requirements Covered by Enterprise SRS’s
- Remove STM/TS Functionality from Existing Components
- Modify C&D Sensor Managers IAW Functional Allocation (Design, Code, and Test)
- Modify Aegis Track Server Clients (Design, Code and Test)
- Design, Code and Test Aegis-Specific Component Framework
- Integrate STM/TS into AMOD
- Provide TOR/CPCRs
- Verify System Performance

**AMOD System**

**SI/DA Tasks:**
- Develop Enterprise SRSs for STM and TS from Aegis and SSDS
- Develop UML Models
- Auto-generate IDD and Interface Code from UML Models
- Design, Code and Test STM and TS Components
- Provide Interim and Final STM/TS Components to LM
- Implement CM and Change Control of STM/TS
- Implement CPCR Fixes to STM/TS Components
- Support Integration of STM/TS into AMOD
- Support SQT of STM and TS

**LM and Third party Joint Tasks:**
- Establish linked classified development environment
- Establish and Track Progress and Dependencies via Joint IMS
- Participate in Navy-led Data Model and Component Framework Working Groups
- Support Functional Allocation
- Support Definition of Data Model, TS APIs, and Common Service APIs
- Support Definition of Enterprise-level Processes and Artifacts
- Support Enterprise ETRs and Enterprise SSR
- Support Enterprise CCB and Prioritization/Adjudication of TORs/CPCRs

**Legend**
- New/Modified AWS
- New Common

Allocation and Governance Was Essential
Objective Architecture
Roles and Responsibilities...

Product Line Development

- ADD
- Track Data Model
- Message Definitions
- TS APIs
- Infra SVCs APIs
- Vehicle Control DM
- Sensor Mgmt DM

Objective

- ETR
- CM
- Govern
- Templates

Prescriptive

- Peer Review
- Cross-Program Change Control
- Cross-Program Review Boards
- Decisions
- Style and Format

Govern - Controlled

Component Developer

Component SRS

- Analyze/Define System
- Integrate Components
- Verify System

SSDS

Aegis

CSEA

- Architecture Precepts / Patterns
- Component Responsibilities / Interfaces
- Functional Allocation
- System Use Cases / Threads
- Common Data Groups

- Perform System Modeling
- Allocate Requirements and Performance Budgets
- Develop System Specs
- Flow down Reqmts to Software Components
- Support Developer Peer Reviews
- Integrate into System Configuration
- Support T&E through Sell-off
AMOD C&D Component Architecture
Message Processing...

Source/Comms Management
- JTT
- SPY
- GWS
- LAMPS (WCS)
- SPQ-9B (CG Only)
- SPS-67 (DDG Only)
- CEP
- C2P
- SGS/AC
- IFF
- EWS
- ASW

System Track Management
- MTF
- DIP
- BMF
- SPF
- GTF
- LEF
- QBF
- RCF
- CEF
- LIF
- IAF
- EWF
- ASF

Display Management
- DIF
- TS
- DDF
- CLM
- DXR
- IPC
- CSM
- NVF
- EF
- NM
- EWF

Engagement Management
- HIF
- EMF
- EFF
- DMF
- ICF
- DCF
- IDA

Common Messages Across Ship Classes
One IWS Track Data Model: ~130 Messages
What We Learned

Process
- Documentation
- Design/Integration Tools
- Software Development
- Test Environment

People
- Skills / Expertise
- Organization

Technical
- Architecture
- Functional
- Performance

Programmatic
- Dependencies
- Risks
- Earned Value

Lessons Learned Address Multiple Perspectives
Aegis Open Architecture

Summary

- COTS Infrastructure
  - Separation of Application/Infrastructure
  - Commercial Standards
  - Commodity Products

- Component-Based Software
  - Component-Based Designs
  - Layered Architecture
  - Configurable Test Environments

- Open Business/Common Components
  - Objective Architecture
  - Open Business Practices
  - Open Disclosure / Gov’t Purpose Data Rights
  - Increase Number of Players/Opportunities

Timeline:
- 1994
- 2000
- 2006
- 2012-2016

Ships:
- DDG-91+
- CG-62-73
- DDG-51+ / DDG 113
- CGM
- CG-52+

Programs:
- B7Phl
- Aegis Open Architecture
- Increased Capabilities
  - AAW/BMD
  - JTM
  - SM-6
  - NIFC-CA
  - SBT
Glossary

<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ACB08</td>
<td>Advanced Capability Baseline 2008</td>
<td>LAN</td>
<td>Local Area Network</td>
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<td>ACB12</td>
<td>Advanced Capability Baseline 2012</td>
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<td>ACS</td>
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<td>ADD</td>
<td>Architecture Definition Document</td>
<td>MMSP</td>
<td>Multi-Mission Signal Processor</td>
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<td>Aegis</td>
<td>(not an acronym) Greek Shield of Zeus</td>
<td>MS</td>
<td>MicroSoft</td>
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<td>NIFC-CA</td>
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<td>AMOD</td>
<td>Aegis MODernization</td>
<td>OA</td>
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<td>API</td>
<td>Application Programming Interface</td>
<td>OAET</td>
<td>Open Architecture Enterprise Team</td>
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<td>ASCM</td>
<td>Anti-Ship Cruise Missile</td>
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<td>BL</td>
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<td>BMD</td>
<td>Ballistic Missile Defense</td>
<td>PIM</td>
<td>Platform Independent Model</td>
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<tr>
<td>C2</td>
<td>Command and Control</td>
<td>PSEA</td>
<td>Platform System Engineering Agent</td>
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<td>CCB</td>
<td>Configuration Control Board</td>
<td>PSM</td>
<td>Platform Specific Model</td>
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