U.S. Navy interest in IEEE P2030.4

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Agenda

- The Fleet Today
- Complexity of Naval Warship Design
- Naval Electrical Power Systems as a Microgrid
- Navy Machinery Control Systems and P2030.4
- Conclusion
Status of the U.S. Navy

• Navy Personnel
  – Active Duty: 317,587
    (52,814 Officers, 260,300 Enlisted)
  – Midshipmen: 4,473
  – Ready Reserve:
    109,038 [As of Oct 2012]
  • Reserves currently mobilized:
    4,569 [as of 13 Nov 2012]

• 287 Ships and Submarines
  – Deployed:
    105 (35% of total)
  – Underway for Local Ops / Training:
    20 (6% of total)

• 3700+ Aircraft
Battle Force Composition

11 Aircraft Carriers

14 Ballistic Missile Submarines

4 Guided Missile Submarines

54 Attack Submarines

102 Surface Combatants

34 Combat Logistics Ships

29 Amphibious Warfare Ships

32 Support / Mine Warfare Ships

7 Naval Reserve Force, Active (NRFA) Ships

Maritime Strategy

- Forward Presence
- Deterrence
- Sea Control
- Power Projection
- Maritime Security
- Humanitarian Assistance and Disaster Response
Challenges of Warship Acquisition

Very low quantities, high unit cost, long lives
No prototypes, first ship(s) must be fully operational
Combat / weapons systems developed concurrently
Government assumes responsibility for meeting requirements
Extremely high parts count (in the order of 10 million)
Minimal commercial shipbuilding industrial base
Intense Congressional/OSD oversight
Terrestrial vs. Marine Power Systems

Terrestrial Power Systems
• Structure – generally radial
• Large numbers of generators, busses, transmission lines, loads
• Constant frequency – linearized about an operating point
• Load flow analysis
• Market Implications

Marine Power Systems
• Structure – zonal / mesh
• Small numbers of generators, busses, transmission lines, loads
• Large transients, often not linearizable
• Frequency domain analysis
• No Market Implications

Traditional Electric Power Systems have distinct differences from Marine Power Systems
Definition of a Microgrid: An integrated energy system consisting of distributed energy resources and multiple electrical loads operating as a single, autonomous grid either in parallel to or “islanded” from the existing utility power grid.

Integration of Distributed Energy Resources, the CERTS Microgrid Concept,” Lawrence Berkeley National Lab, 2003

Characteristics of Microgrids

- Distributed
- Autonomous
- Reconfigurable
- Small
- Detachable from Macrogrid

Ships are the original Microgrid
Today’s Focus
Notional Ship Distributed MCS Architecture

Traditional MCS Development and Ship Acquisition

MILESTONE

SHIP REQUIREMENTS

REQUIREMENTS

FUNCTIONAL AREA ANALYSIS

ROM STUDIES

IDENTIFY CRITICAL TECHNOLOGIES

CONCEPT & FEASIBILITY STUDIES

AOA CAPABILITIES DEV

PRELIMINARY & CONTRACT SHIP DESIGN

SUB-SYSTEMS DEVELOPMENT

PRELIMINARY DESIGN REVIEW (PDR)

CRITICAL DESIGN REVIEW (CDR)

SHIP DESIGN

SHIP REQUIREMENTS

CD

A

B

2018

MCS Specified

MCS Purchase Initiated

MCS Installed

MCS Tested

Shipboard

MCS Delivery to Shipyard

Requirements Timeline (Years):

1-3

ICD 1-3

2-4

CDD 4-7

ICD - INITIAL CAPABILITIES DOCUMENT
CDD - CAPABILITIES DEVELOPMENT DOCUMENT
AOA - ANALYSIS OF ALTERNATIVES
PDR - PRELIMINARY DESIGN REVIEW
CDR - CRITICAL DESIGN REVIEW
MCS - MACHINERY CONTROL SYSTEM

MCS capability limited by what can be accomplished in allocated time.
Open Architecture
(an alternative approach)

Naval Open Architecture:

- Business practices
- Technical practices

Produce Systems:

- Based on open standards
- Published interfaces

OA CORE PRINCIPLES

- Modular, Loose Coupling, High Cohesion
- Design Disclosure and Data Rights
- Enterprise TOC Reduction and Reuse
- Transparency and Peer Reviews
- Competition and collaboration
- ROI and Strategic Investments

Can a qualified third party add, modify, replace, remove, or provide support for a component of a system, based only on openly published and available technical and functional specification of the component of that system.
Open Architecture applied to MCS

• Classic approach
  – Independently designed and acquired for each ship class.
  – Furnished by the ship builder
    • Typically subcontracted
  – Functionality limited by the available time.

• Open Architecture approach
  – Create a general MCS functional decomposition
  – Define the MCS Objective Architecture
  – Define supplier market boundaries
  – Apply initially to a specific ship class
  – Evolve the family of systems through Product Lines
  – Establish a framework for incorporating innovation
  – Manage a library of reusable modules for modification and redelivery for following ship classes

Naval Open Architecture:
- Business practices
- Technical practices

Produce Systems:
- Based on open standards
- Published interfaces

Because components of Smart Grid will be acquired and developed by many different parties, the control and automation systems should be developed according to an open architecture that enables the introduction of common functions across multiple systems and platforms in a way that achieves high levels of modularity, extensibility, portability and scalability.

This guide provides industry-wide common approaches to the design, implementation and life cycle management of Smart Grid control and automation systems, in a manner that promotes conformance to the smart grid interoperability reference model (SGIRM), hence reducing the number of infrastructures that might otherwise result from competing architectures.

Additionally, this recommended practice facilitates the following:

- Modular design and design description,
- Reusable application software,
- Interoperable control and automation applications,
- Secure information exchange,
- Life cycle affordability, and
- Competition and collaboration.

This guide supports its users by giving them guidance in the selection or development of computational capabilities, information systems, networks, protocols, frameworks, middleware, resource management, software and operating systems, using both established and evolving industry standards. Standard practices will be leveraged to enhance interoperability, operational effectiveness, and the ability to insert future technologies.
Navy interest in P2030.4

- Establish an MCS open architecture
  - Initially for electrical power system
  - Eventually adapt to remainder of ship systems
- Expand an industrial base to one that can serve both smart-grid utility applications and naval ships
- Enable the insertion of increased capability over time into shipboard MCS
- Reduce the cost of designing, building, and modernizing shipboard MCS
Conclusion

- Naval warships are complex engineered products
- Warships are the original micro-grid
- Current MCS development methods are expensive and limit functionality
- An OA approach promises to improve Total Ownership Costs while improving functionality
- P2030.4 is well aligned with the Navy’s goals.