CONCEPT EXPLORATION

LESSONS LEARNED

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Agenda

• Introduction
• New Ship Studies
• Modified Repeat / Conversion Studies
• Systems Engineering
• Future Research Opportunities
Introduction - What is JCC(X)?

• Mobile, self-sustaining sea based battle management capability

• An in-theater command and control headquarters should land-based facilities become unavailable, constrained or threatened

• A replacement for existing maritime command and control ships
Command Ships Today
...At A Glance

**USS CORONADO**
(AGF-11)
- 3rd Fleet, San Diego
- CREW: 25 OFF / 31 CPO & 389 ENL
- CJTF/MCC: 263 OFF/77 CPO & 420 ENL

**USS LASALLE**
(AGF-3)
- 6th Fleet, Gaeta
- CREW: 24 OFF / 32 CPO & 404 ENL
- CJTF/MCC: 193 OFF/ 27 CPO & 365 ENL

**USS MOUNT WHITNEY**
(LCC-20)
- 2nd Fleet, Norfolk
- CREW: 42 OFF / 42 CPO & 605 ENL
- CJTF/MCC: 362 OFF/45 CPO & 321 ENL

**USS BLUE RIDGE**
(LCC-19)
- 7th Fleet, Yokosuka
- CREW: 40 OFF / 44CPO & 650 ENL
- CJTF/MCC: 358 OFF/36 CPO & 499 ENL
What are the Required Capabilities?

- Capable of hosting an embarked Combined Joint Task Force (CJTF) Commander and component staffs
  - Hotel Services
  - Flexible Mission Space
  - Robust C4ISR Suite based on Commercial Off-The-Shelf (COTS) technology
- Mobile
  - Speed
  - Range
- Survivable
- Interoperable with Joint services, allied and coalition forces, and Non-Government Organizations (NGO) as needed
Concept Exploration Activities

- Conduct an Analysis of Alternatives
  - Find out what the product should do
- Develop Operational Requirements (ORD)
  - Precisely define user’s expectations
- Develop Acquisition Documentation
  - Gain approval to proceed into development
- Develop System Requirements and Procurement Documentation
  - Includes P-SPEC, RFP, SOW, etc
  - Place next development stage under contract
- Develop Cost Estimates
  - Support Budgeting Process (PPBS)

A ship design is no longer a product of Concept Exploration
Ship Studies
A tool for Developing Requirements

Key Ship Design Drivers
- Size of Staff
- MSC vs Navy Crew
- Survivability
- Speed

Alternatives
- Type of Platform
  - New Design Ships
  - Modified Repeats
  - Conversions
  - SLEPS
- C² Capability
  - Dedicated Command Ship
  - Part of a Distributed Option
• AOA is interested in Cost vs Capability
• The incremental cost of a particular capability depends on the order in which capabilities are added
• Averaging cost of adding a capability across multiple ship concepts provides a better metric
• JCC(X) new ship studies employed a systematic examination of the impact of design variables under study
Planning New Ship Studies

“Parallel - Serial Process”

Design Space Study 1  Design Space Study 2  Design Space Study 3

Select Baseline(s)  Update Baseline(s)  Update Baseline

Planning  Requirements  Design  Costing  Performance  CONOPS

“Classic” Design Spiral is too slow!
New Ship Concept Study

Study Guide Development

- Manning Estimation
- IPS characterization

C4ISR Suite Definition

ASSET Modeling

- Adjust IPS

TSS Analysis

- Costing

Assess CONOPS

\[ TSS = \text{Total Ship Survivability} \quad IPS = \text{Integrated Power System} \]
Challenges in Comparing Ship Concepts

- Changing Sets of Assumptions
- Naval Architects and the Learning Curve
- The “Artistic” component of Naval Architecture
  - Lack of Reproducible Results
- Synergistic effects of different feature sets
- Operator error
- Synthesis Tool bugs ...
  (undocumented features)

Need to Identify and Control Errors
Controlling Errors in Concept Comparisons

- Develop Study Guides
  - Document Assumptions and Processes
- Limit impact of the Learning Curve
  - Conduct Studies in Blocks
  - Use the same design team
- Use “Design of Experiments” to define concept requirements and analyze results
- Automate comparison of synthesis tool (ASSET) results to identify anomalies
- Use regression analysis to identify potential discontinuities
Presenting Results: Contour Maps

<table>
<thead>
<tr>
<th>Manning</th>
<th>MSC</th>
<th>Navy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survivability</strong></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Large</td>
<td>Fast</td>
<td>Slow</td>
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<tr>
<td>Medium</td>
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<td>Small</td>
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<td>Slow</td>
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</tbody>
</table>

Staff Size Speed:
- Greater than 18,000 m tons
- 15,000 to 18,000 m tons
- 12,000 to 15,000 m tons
- Less than 12,000 m tons

Light Ship Displacement Trends often more important than actual values.
**Presenting Results:**

Cost Capability Curves

*Ship Survivability*

- Range for ships with less threat exposure
- Range for ships with significant threat exposure

- Probability of Survival

- Cost of Additional Features

- Optimal Configuration for given cost
- Sub-Optimal Configuration for given cost
Modified Repeat / Conversion Studies

- More Difficult than new design
  - Hard to obtain accurate technical data
- To keep study costs down ...
  - Eliminate less promising candidates using compelling arguments instead of modeling
  - Limit modeling to the minimum required to show cost effectiveness
- Modified Repeats are generally not cost effective if¹:
  - The mission of the baseline ship is significantly different, or
  - More than two hulls are required

JCC(X) studies showed that Modified Repeats and Conversions, while sometimes competitive, are not clearly more cost effective than new designs.

Note 1: Covich and Hammes, 1983
Conversion Example
Destroyer/Submarine Tender

Advantages
• Large Low Mileage Ships
• Technically Feasible
• 73% of light ship is “free”
  ➢ Hull
  ➢ Machinery
  ➢ Electric plant

Disadvantages
• Precision scrapping of 27%
• New work is inefficient
  ➢ Waterfront vice Shop
• Resulting ship unattractive
  ➢ Poor Seakeeping
  ➢ Single Screw Steam Plant
  ➢ Low sustained speed (19 kts)
  ➢ Forced Fit solution
  ➢ 15 year old hull
  ➢ Cost rivaling a new ship

Study Based on Industrial Efficiency
Not on detailed ship modeling
Classic Systems Engineering Process

Requirements Analysis

Functional Analysis / Allocation

System Analysis and Control (Balance)

Synthesis

Verification

Functional Analysis / Allocation

Synthesis

Verification

Actual Practice

Analysis of Operational Req., Policy and Imposed Req.

Identify Derived Requirements

Identify Derived Requirements

Functional Analysis / Allocation

Synthesis

Verification

Product Baseline

Process continues for each successive Product Baseline
• Three types of Requirements
  ø Direct - “owned” by the customer
    - ORD
    - Policy, Practices, and customs
  ø Derived - “owned” by the designer
  ø Imposed - come from external organizations

• Requirements Traceability Tools should:
  ø Identify the type of requirement
  ø Identify the source of the requirement
    - Direct - which document (ORD, Instruction, etc)
    - Derived - which configuration items
    - Imposed - which document (Law, standard, etc)

Need to know who has Change Authority for each Requirement
Future Research Opportunities

- Experimental Design Tools
  - Need tools to identify which design tools should be used and how they link
- Genetic Algorithms
  - Eliminate “Learning Curve” to develop optimal configuration for each concept
- Error Analysis Tools and Procedures
  - Currently no way of knowing whether modeling errors are significant
  - Build error analysis into existing tools
- Requirements Risk Analysis
  - Identify Requirements that are likely to change and use risk management tools to address the problem
    - Margin Policy
    - Open Systems Architectures