CPCX
Combined Patrol Combatant

Total Ship Systems Engineering
Capstone Design Project
December 1995
CPCX Design Teams

**Navy Variant**
- Eric Anderson, LT USN
- Bob Armstrong, LT USN
- Jim Hurley, LT USCG
- Robert Jones, LT USN

**Coast Guard Variant**
- Jay Renken, LCDR USN
- John Comar, LT USCG
- Helen Kilty, LT USCG
- Thomas Jean, LT USN
PROBLEM STATEMENT

- Design a dual service combatant for Navy and Coast Guard use.
- Design two variants of one ship.
- Minimize cost and manning.
- IOC 2010
Design Process

Mission Need Statement (MNS)
Faculty Direction

Operational Requirements Document (ORD)

Functional Analysis

Feasibility Study

Preliminary Design
Design Philosophy

1. Meet or exceed ORD specifications
2. High Survivability/Maximum Mission Effectiveness
3. Reduced Manning/High Level of Automation
4. Low Maintenance/Improved Reliability
5. Improvement of Crew Habitability (Quality of Life)
Commonality Concept

Common Requirements

- USN Requirements
- USCG Requirements

Common Features of Variants

- USN Payload
- USCG Payload
# General Ship Description

<table>
<thead>
<tr>
<th>Navy</th>
<th>Coast Guard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length Overall</strong></td>
<td>398 ft</td>
</tr>
<tr>
<td>398 ft</td>
<td>398 ft</td>
</tr>
<tr>
<td><strong>Draft</strong></td>
<td>15 ft 11 in</td>
</tr>
<tr>
<td>15 ft 11 in</td>
<td>15 ft 9 in</td>
</tr>
<tr>
<td><strong>Beam</strong></td>
<td>51 ft</td>
</tr>
<tr>
<td>51 ft</td>
<td>51 ft</td>
</tr>
<tr>
<td><strong>Displacement</strong></td>
<td>3980 LT</td>
</tr>
<tr>
<td>3980 LT</td>
<td>3934 LT</td>
</tr>
<tr>
<td><strong>Endurance</strong></td>
<td>6600nm@14 kts</td>
</tr>
<tr>
<td>6600nm@14 kts</td>
<td>8900nm@14 kts</td>
</tr>
<tr>
<td><strong>Sustained Speed</strong></td>
<td>25 kts</td>
</tr>
<tr>
<td>25 kts</td>
<td>25 kts</td>
</tr>
<tr>
<td><strong>Crew</strong></td>
<td>110</td>
</tr>
<tr>
<td>110</td>
<td>106</td>
</tr>
<tr>
<td><strong>SHP</strong></td>
<td>28,800</td>
</tr>
<tr>
<td>28,800</td>
<td>28,800</td>
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</table>
Payload - Navy Variant

- **AAW**
  - X Band Phased Array Radar (XPAR)
  - 37 cell Vertical Launch System (VLS)
  - Rolling Airframe Missile (RAM) and Launcher
  - 2, 40mm multi-purpose guns

- **ASW**
  - Active Towed Array Sonar (ATAS)
  - 2 Surface Vessel Torpedo Tube mounts (SVTT)

- **ASUW**
  - Panther Helicopter - Combat Version of HH-65
  - 5” 54 MK 45 gun

- **EW**
  - SLQ-32 (V3)
Payload - Navy Variant
Continued

- **Mine Warfare**
  - SH-100 mine sonar

- **Communications**
  - Joint Maritime Command Information System
  - Advanced Combat Direction System
  - Cooperative Engagement Capability
  - Tactical Data Links

- **Operations Other than War**
  - 2 Davit launched small boats
Payload - Coast Guard Variant

- **AAW**
  - X Band Phased Array Radar (XPAR)
  - Rolling Airframe Missile (RAM) and Launcher
  - 2, 40mm multi-purpose guns

- **ASW**
  - Not a mission area

- **ASUW**
  - **Dolphin Helicopter HH-65**

- **EW**
  - SLQ-32 (V3)

- **Mine Warfare**
  - SH-100 mine sonar
Payload - Coast Guard Variant

Continued

- **Communications**
  - Joint Maritime Command Information System
  - Advanced Combat Direction System
  - Cooperative Engagement Capability
  - Tactical Data Links

- **Operations Other than War**
  - 2 Davit launched small boats
  - 2 Stern launched small boats
  - Crane and buoy handling equipment
  - Added fuel capacity
Mission Need Statement
(Faculty Direction)

World View

Navy Guidelines

Coast Guard Guidelines
World View
(Faculty Direction)

- Oceanic Naval warfare is unlikely
- Operations Other than War (OOW) are likely employments for U.S. ships
- Regional conflicts are likely between third world nations
- Tight Defense Budget
- Consolidation of roles of the armed forces
- Law Enforcement at sea will become more frequent and will be conducted against more heavily-armed criminals
Navy Guidelines
(Faculty Direction)

- Deployable and Fleet Compatible
- Operate in Littoral Environments
- Independent as well as Battle Group Operations
Coast Guard Guidelines
(Faculty Direction)

- Detect, Intercept, and Defeat Well-Equipped Drug Smugglers and Pirates
- Interdict Illegal Immigration and Smuggling
- Perform Search and Rescue
Operational Requirements Document

Design Constraints
Specific Design Requirements
Projected Threat Summary
Design Constraints

Cost

Displacement

Convertibility
Specific Design Requirements

- Common
- Navy
- Coast Guard
Projected Threat Summary

- Law Enforcement - Independent Operations
- Low Intensity Conflict - Independent and Group Operations
- Major Regional Conflict (MRC) - Force Operations
# Functional Analysis

## Functional Areas
- Detect
- Control
- Engage

## Warfare Areas
- AAW
- ASuW
- ASW
- Strike
- MIW
- ELT
- OOW
- EW
Combat System Elements

- Radars
- Passive Sensors
- Sonars
- Guns
- Missiles
- Small Boats
- Mine Hunting Devices
- Architecture
Combat System Evaluation

- Measures of Effectiveness
- Combat System Suite Options
- Payload selection
Measures of Effectiveness

Navy
- Strike
- Air Engagement
- Sub-Surface Engagement
- NGFS
- Patrol Area
- Convertibility
- Boarding

Coast Guard
- Air Engagement
- Patrol Area
- Convertibility
- Boarding
Strike Effectiveness

\[ MOE = \frac{N_m \times R \times P_T}{CEP \times CS \times N_k} \]

Nm = number of strike missiles
R = range of missile (km)
Pt = ability to target
CEP = circle error probability
CS = ship cost (M$)
Nk = number of missiles needed for kill
Combat System Suite Selection

- Functional Analysis & System Tradeoff Study
- 3 Combat System Suite Options/Variant
- MOE Analysis
- Final Suite Selection
Payload - Navy Variant

- **AAW**
  - X Band Phased Array Radar (XPAR)
  - 37 cell Vertical Launch System (VLS)
  - Standard, Enhanced Sea Sparrow, Harpoon and Tomahawk
  - Rolling Airframe Missile (RAM) and Launcher
  - 2, 40mm multi-purpose guns

- **ASW**
  - Active Towed Array Sonar (ATAS)
  - 2 Surface Vessel Torpedo Tube mounts (SVTT)

- **ASUW**
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Payload - Navy Variant Continued

- EW
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  - 2 Davit launched small boats
Payload - Coast Guard Variant

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Continued

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Combat Systems Architecture

- Fiber Optic Ring BUS
- Distributed Data Processing
- MM I Modules
  - Detect & Track
  - Correlate
  - Command & Decision
  - Weapons Control
- Two CICs in Separate Enclaves
Architecture Advantages

- Survivability
- Automatic Readiness Assessment, Fault Detection, and Localization
- Embedded Training and Support Service Management
# Naval Architecture

<table>
<thead>
<tr>
<th>NAVY</th>
<th>Coast Guard</th>
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<tr>
<td>LBP</td>
<td>380'</td>
</tr>
<tr>
<td>Beam</td>
<td>51’</td>
</tr>
<tr>
<td>Hull Depth (amidships)</td>
<td>30’</td>
</tr>
<tr>
<td>Draft</td>
<td>15’11’</td>
</tr>
<tr>
<td>Prismatic Coef., Cp</td>
<td>.576</td>
</tr>
<tr>
<td>Max Section Coef., Cm</td>
<td>.796</td>
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<tr>
<td>Waterplane Coef., Cwp</td>
<td>.733</td>
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## Stability

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<tr>
<th>USN</th>
<th>Parameter</th>
<th>USCG</th>
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<tbody>
<tr>
<td>7.67'</td>
<td>GMT</td>
<td>7.68'</td>
</tr>
<tr>
<td>.150</td>
<td>GMT/Beam</td>
<td>.151</td>
</tr>
<tr>
<td>18.34'</td>
<td>KG</td>
<td>18.41'</td>
</tr>
<tr>
<td>5.075'</td>
<td>@ 45.97 deg.</td>
<td>5.125'</td>
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Hull, Mechanical, and Electrical Options

- Mechanical Drive Vs Electric Drive
- Single Shaft Vs Multi Shaft
- Level of Automation
- Type of Prime Mover (Gas Turbine or Diesel)
- Power Distribution (Conventional, Power off Main Bus, Propulsion Derived Ship Service)
- Compartmentalized Auxiliaries Vs Centralized Auxiliaries
Hull, Mechanical, and Electrical Selection

- 2 Diesels, 2 Gas Turbine prime movers using Combination Diesel and Gas Turbine (CODAG) configuration
- Electrical Drive Transmission
- 2 Shafts
- 2 Fixed Pitch Propellers driven by Fixed Podded Propulsors
- Common Ship Service and Power Distribution System
- Remote Monitoring and Automation
- Zonal Electrical Distribution
# Manning

<table>
<thead>
<tr>
<th>Department</th>
<th>Crew</th>
<th>Department</th>
<th>Crew</th>
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</thead>
<tbody>
<tr>
<td>Ship Support</td>
<td>13</td>
<td>Ship Support</td>
<td>14</td>
</tr>
<tr>
<td>Combat Sys</td>
<td>52</td>
<td>Combat Sys</td>
<td>31</td>
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<tr>
<td>Engineering</td>
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<td>Engineering</td>
<td>34</td>
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<tr>
<td>Air Det.</td>
<td>11</td>
<td>Air Det.</td>
<td>6</td>
</tr>
<tr>
<td>Operations</td>
<td></td>
<td>Operations</td>
<td>21</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>110</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>106</strong></td>
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Convertibility
(four week shipyard availability)

<table>
<thead>
<tr>
<th>Navy</th>
<th>Coast Guard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 5 inch Gun</td>
<td>1. Buoy handling Crane</td>
</tr>
<tr>
<td>2. VLS launcher</td>
<td>2. Fuel Tank, Buoy Handling Equipment</td>
</tr>
<tr>
<td>3. ATAS</td>
<td>3. Two Additional RHI’s</td>
</tr>
<tr>
<td>4. Torpedo Space</td>
<td>4. Prisoner Containment Space</td>
</tr>
<tr>
<td>5. Missile Illuminators</td>
<td></td>
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Survivability

- Signature Reduction
- Redundancy
- Uninterruptable Power Supply
- CEC
Signature Reduction

- Radar Cross Section (RCS)
- Infrared
- Acoustic Noise
Redundancy

- Two Physically Separate CICs
- Two Engine Rooms separated by three bulkheads
- DC Zonal Electrical Distribution
- Ring Information Network with multiple redundant rings
- Distributed Combat System Data Processing
Uninterruptable Power Supply

- 30 Ton Battery provides 1500 KW of hold-up power
- Allows for Prime Mover restarts without loss of Combat System continuity
- Continued Operation of Combat Systems after complete loss of Main Engineering Spaces
Cooperative Engagement Capability

- Common Composite “Big Picture”
- Queued Search
- Queued Engagement
- Fire On Remote
## Summary of Ship Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Navy</th>
<th>Coast Guard</th>
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<tbody>
<tr>
<td><strong>Endurance</strong></td>
<td>6000nm@14kts Required</td>
<td>8000nm@14kts Achieved</td>
</tr>
<tr>
<td></td>
<td>6600nm@14kts Achieved</td>
<td>8900nm@14kts</td>
</tr>
<tr>
<td><strong>Average Cost</strong></td>
<td>$450 million Required</td>
<td>$375 million Achieved</td>
</tr>
<tr>
<td></td>
<td>$422 million Achieved</td>
<td>$309 million</td>
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<tr>
<td><strong>Displacement</strong></td>
<td>4000LT Required</td>
<td>4000LT</td>
</tr>
<tr>
<td></td>
<td>3980LT Achieved</td>
<td>3934LT</td>
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Further Study

- Single Mast
- Coast Guard over buying sensors
- Upper limit of cost and weight margins
Conclusion

- Dual Service Combatant
- Meets the operational requirements of both Navy and Coast Guard
- Ease of Convertibility
- Not “Littorally Challenged”
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Combined Patrol Combatant

Total Ship Systems
Engineering
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