Virginia Tech
DD-21 Destroyer Concept

David Woodward
Ben Spina
Jon Law
Steve Darsie
Andrew Girdler
Jessica Smoldt
Mission Needs Statement

- Dominance in independent and joint ops
- Mission and Threat Analysis
- Non Material Alternatives
- Material Alternatives
  - Evaluate the impact of speed on concept design
MNS, cont.

Constraints

- Sustained speed of at least 40 knots
- Optimize effectiveness vs. cost
- Reduce manpower
- Minimize production time
- Maximize survivability
- Satisfy pollution laws
Required Operational Capabilities

- Amphibious Readiness Group (ARG) Escort
- Carrier Battle Group (CBG)
- Mine Counter Measures (MCM)
- Non-Combatant Ops / Humanitarian (NCO)
Concept Exploration Model

- Three Hulls
  - Transport Factor used in choices
    - Evaluate hull forms in terms of load capacity vs. speed
  - Mercier-Savitsky
    - Regression formulas produced for resistance data
  - FastShip Atlantic
    - Resistance from existing data of model testing
  - SS United States
    - Resistance from existing data of ship
Concept Exploration Model, cont.

- Propulsion Choices
  - Waterjets
  - Surface piercing propeller
  - Conventional propeller

-Weapons and Missions Options
Baseline Concept Design

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<tr>
<th></th>
<th>HI</th>
<th>BBH</th>
<th>BCD</th>
<th>BBL</th>
<th>LO</th>
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<tr>
<td>LBP [ft]</td>
<td>598.48</td>
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<td>Beam [ft]</td>
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<td>Lightship [LT]</td>
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<td>Full load displacement</td>
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<td>FL Vertical CG [ft]</td>
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<td>Range</td>
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<td>Sustained speed</td>
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<td>Maximum speed</td>
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<td>42.22</td>
<td>43.8</td>
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<td>C folo [$M]</td>
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<td>OMOE</td>
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<td>0.559</td>
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Hull Form and Structure
Hull Form Development

- FastShip Atlantic Offsets
- Scaled in HECSALV
- Read offsets into Fastship program
- Surface fit to offsets
Structural Design and Analysis

- Three watertight sections of the hull
  - One centered at midships
  - One section forward and one aft of midships
- Tested in Maestro
  - Moments and Shear Forces from HECSALV
- Materials
  - Composite deckhouse to reduce weight
  - Standard steel construction for hull
Maestro Model, Internal Structure
Maestro Model, Adequacy Parameter Minimum Values
Resistance, Power and Mechanical Arrangements
Resistance and Power

- LM-6000
- Waterjets large enough to provide power
  - Not currently available
  - Scaled by inlet diameter vs. kilowatts
Waterjet Arrangement
WATERLINE IS 4.9 FEET FROM TRANSOM BASELINE

54'-11 1/16''

62'-0''

15'-0''

53'-11 3/4''

FRONT

LEFT

BOTTOM

ISOMETRIC
Resistance and Power Requirements

- NAVCAD software used to calculate Resistance, $P_E$, Fuel Consumption, and Efficiency
- Fuel Consumption at endurance speed of 35knts: 2554.78 gph
- Propulsive Efficiency at 35knts: 69.75%
- $P_E$ at 35knts: 83362.41 hp
- $P_E$ at top speed: 149616.54 hp
Mechanical and Electrical

- Dewatering systems of waterjets
- Forward Emergency Generator
- PDSS generators
- Smart Ship Technology to enhance survivability
Dewatering Concept Design

BALL VALVE

RUNS TO MAIN HEADER
Dewatering System
Machinery Room
Space, Arrangements and Manning
Space and Arrangements

- Radar Cross Section
  - Every surface at 10 degrees
- Heat Signature
  - Exhaust system
- Deckhouse placement
- Helo deck placement
- Internal module arrangements
Arrangements: Profile View
Arrangements: Deckhouse

Plan
Arrangements: Hull Plan
Arrangements: Berthing
Weights, Centers and Seakeeping Analysis
Loading and Centers

- Total Weight = 6223 LT
- LCG = 215 feet aft of FP
- VCG = 22.1 feet above BL
- TCG = 0.06 feet (Port)
Seakeeping Limit Criteria by Subsystem

- **Helo**
  - Vertical velocity = 6.5 ft/sec at landing spot
  - Roll = 5 degrees

- **Personnel**
  - Vertical acceleration = 0.4g at bridge
  - Transverse acceleration = 0.2g at bridge
  - Roll = 8 degrees
Seakeeping Limit Criteria, cont.

- **VLS**
  - Vertical acceleration = 0.6g at launcher outboard corner
  - Transverse acceleration = 0.7g at launcher outboard corner
  - Roll = 17.5 degrees

- **All**
  - Pitch = 3 degrees
Mission Systems

- Anti-Aircraft Warefare
- Anti-Surface Warefare
- Anti-Sub Surface Warefare
- Advanced C4-I system
- Mine Countermeasures
- Naval Surface Fire Support
- Sensor and Electronic Warefare
- Strike Warefare
Weapons Systems

- VLS Missiles
- Advanced Gun System
- 2 Lamps MK III Helos
- Phalanx CIWS
**Advanced Gun System**

- **NEED**
  - VOLUME OF FIRES & SUSTAINABILITY
  - IMPROVED LETHALITY
  - INCREASED RANGE

- **SOLUTION**
  - EXPAND ON USA / USMC 155MM
  - ADVANCED GUN SYSTEM

- **COMPLEMENTARY PROGRAM**
  - LEVERAGES EXISTING ORDNANCE TECHNOLOGIES
    - 5" ERGM
    - ARMY XM982 155MM PROJECTILE
    - SADARM / UNITARY WARHEADS
    - ARMY CRUSADER Program

- **Meets DD 21 ORD requirements:**
  - Twin 155MM guns
  - 750 rounds/barrel
  - 100NM range
  - Advanced Handling System => reduced manning
  - Flush deck => reduced signature
  - Reduced maintenance
Hydrostatics, Intact and Damage Stability
Hydrostatics and Stability

- **Intact stability**
  - DDS 079-1
  - Two loading cases for each of three stability requirements
    - Beam Seas and Rolling
    - High Speed Turning
    - Topside Icing

- **Damage stability**
  - DDS 079-1
  - 54.75 foot opening required (12.5% of LBP)
Hydrostatic Curves
Beam Seas and Rolling, Full

BEAM WIND with ROLLING STABILITY EVALUATION
(per U.S. Navy DDS079-1)

<table>
<thead>
<tr>
<th></th>
<th>Available</th>
<th>Required</th>
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<tbody>
<tr>
<td>Wind Heeling Arm Lw</td>
<td>2.458 ft</td>
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<tr>
<td>Maximum Righting Arm</td>
<td>12.744 ft</td>
<td>4.097 ft</td>
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<tr>
<td>Capsizing Area A2</td>
<td>165.4 ft-deg</td>
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<tr>
<td>Righting Area A1</td>
<td>483.5 ft-deg</td>
<td>231.5 ft-deg</td>
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</tbody>
</table>

[Tab] for tabular summary; [Esc] when done
Limiting Case Damage Stability

FREE-FLOATING DAMAGED CONDITION

SECTION AMIDSHIPS (Looking Forward)

RIGHTING ARM CURVE

Press [Esc] to proceed
Final Concept Design

- **Concept Baseline**
  - LBP = 437.4 ft
  - Beam = 67.7 ft
  - Draft = 19.09 ft
  - Disp. = 5870 LT
  - Range = 4000 nm
  - Sustained Speed = 41.96 knots
  - Manning = 73

- **Final Concept Design**
  - LBP = 438 ft
  - Beam = 67.7 ft
  - Draft = 19.14 ft
  - Disp. = 6223 LT
  - Range = 4000 nm
  - Sustained Speed = 43+ knots
  - Manning = 92

- **Cost Estimates**
  - Lead Ship = $1.3 Billion
  - Follow Ship = $900 Million
Conclusions and Future Work

Assessment of DD-21
- Ship is stable, but stiff
- Low profile for reduced radar cross-section
- Can adequately protect the areas assigned
- Waterjet arrangement will need to be tested
- Quality of life has been improved

Recommended improvements
- Testing of hull type
- Further research of waterjet technology and improvements
- Improve weight distribution to improve seakeeping
Final Concept Design
Questions?

Thank you for your time