CARDEROCK DIVISION

Network Surface Combatant RSDE Pilot Study

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Code: 823

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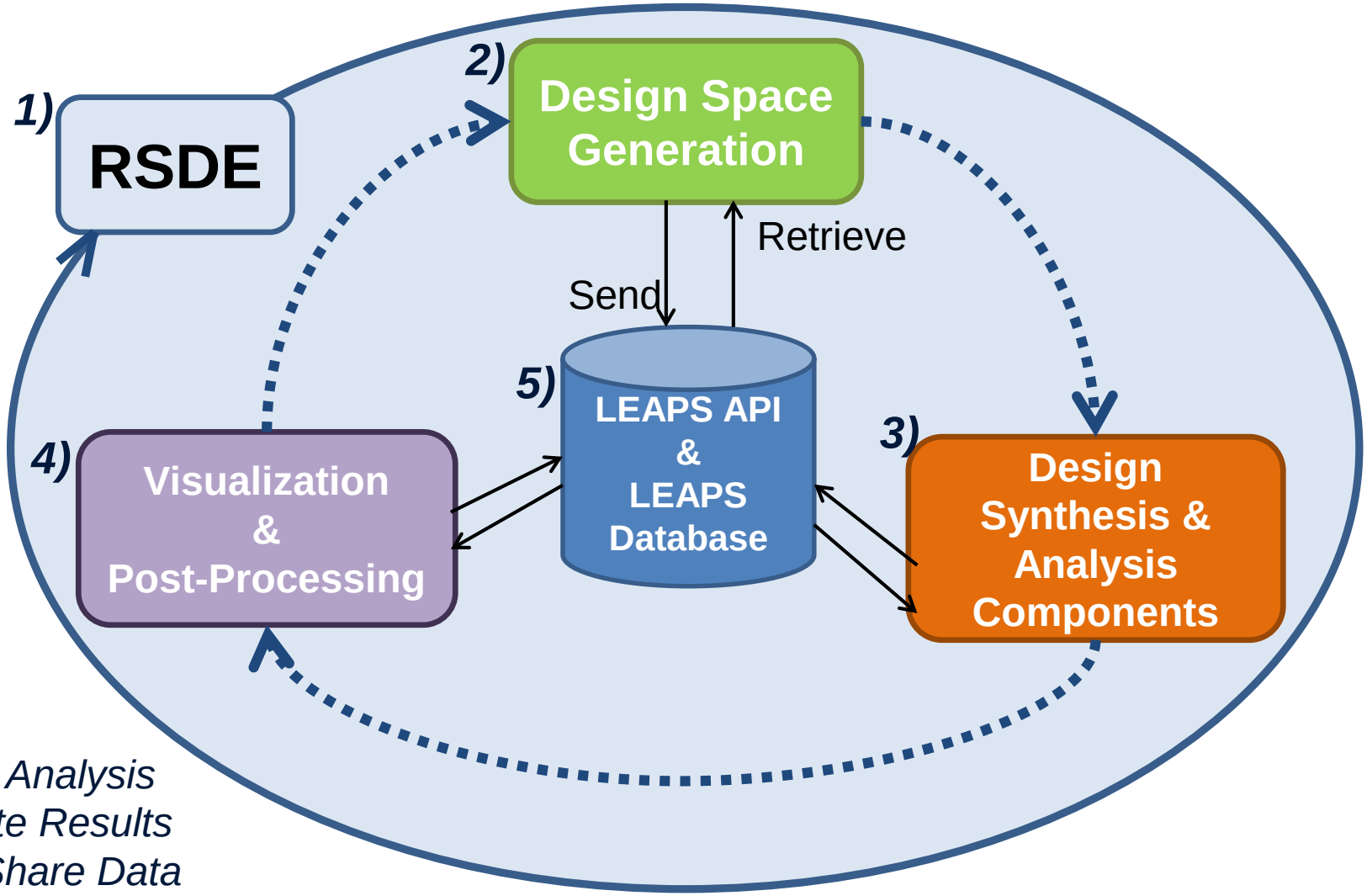
Study Objectives

- **Inform the setup of Future Surface Combatant AoA studies.**
  - Baseline designs from FSC wargame studies, trading reduced sensing capabilities for weapon systems
- **Familiarize NSWCCD Code 824 Future Ship and Submarines Concepts Branch with the use of RSDE for future studies and provide feedback to improve the software.**

RSDE Functional Product Architecture



1) *Interface*
2) *Sampling*
3) *Design & Analysis*
4) *Investigate Results*
5) *Store & Share Data*

Design Space Exploration

Designers provide **Baseline** + **Ranges** of inputs. Requirements, etc. {min,max}

Run **RSDE**

Sample Point

***Included* Analyses:**

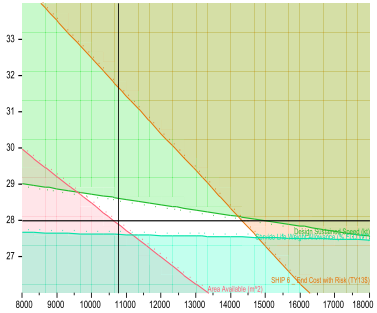
IHDE

SHCP-L

Etc…

Automatically Re-samples for additional design points

Visualizations & Behavior Models



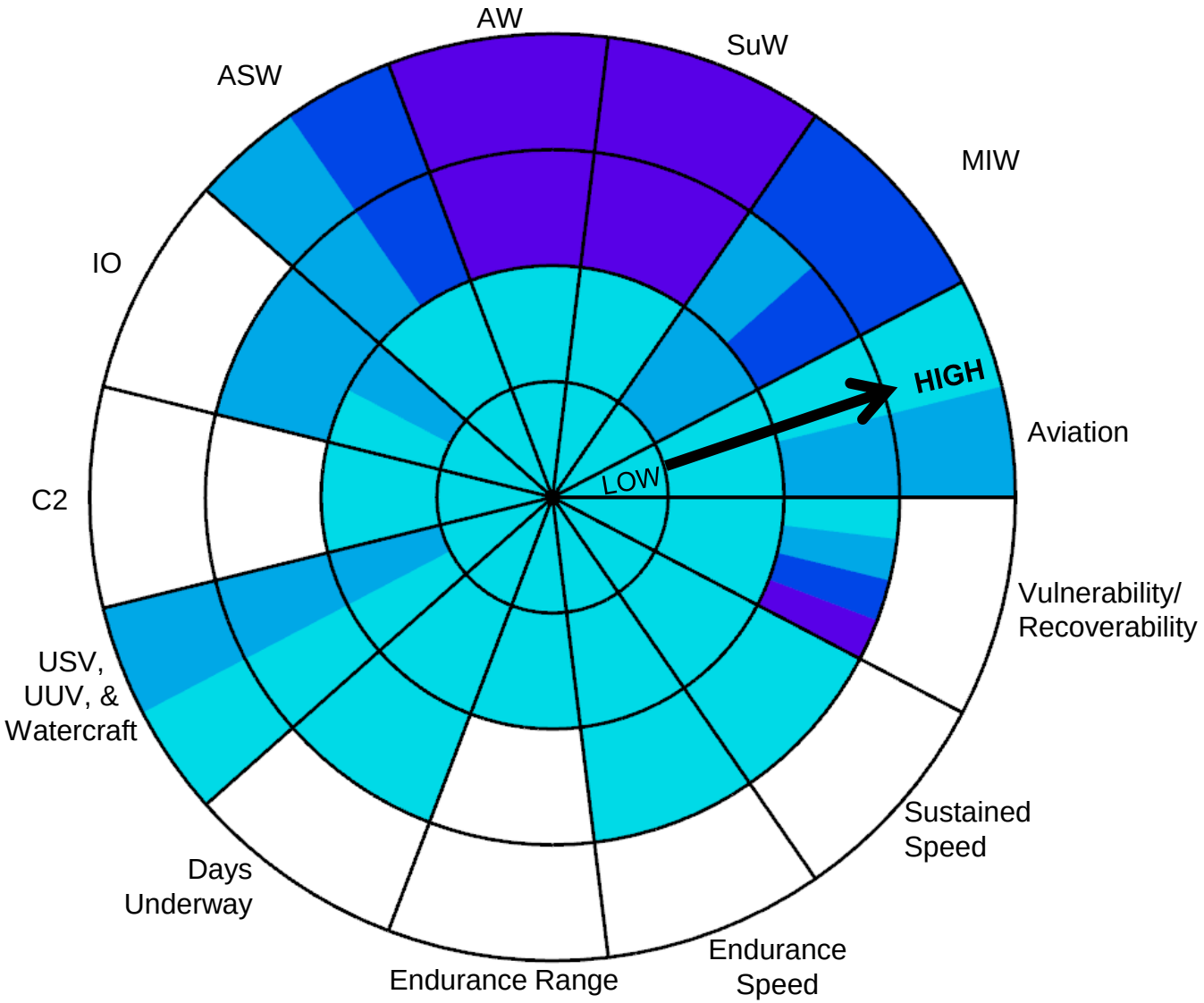
Set of Points

Output

Designs & Analyses

In LEAPS

Operational Design Space



Capability Source

- Standalone Capability
- Onboard UXV/Aviation
- Interface with Advanced/Deployed UXV
- Networked Track Received
- Outside of Design Space

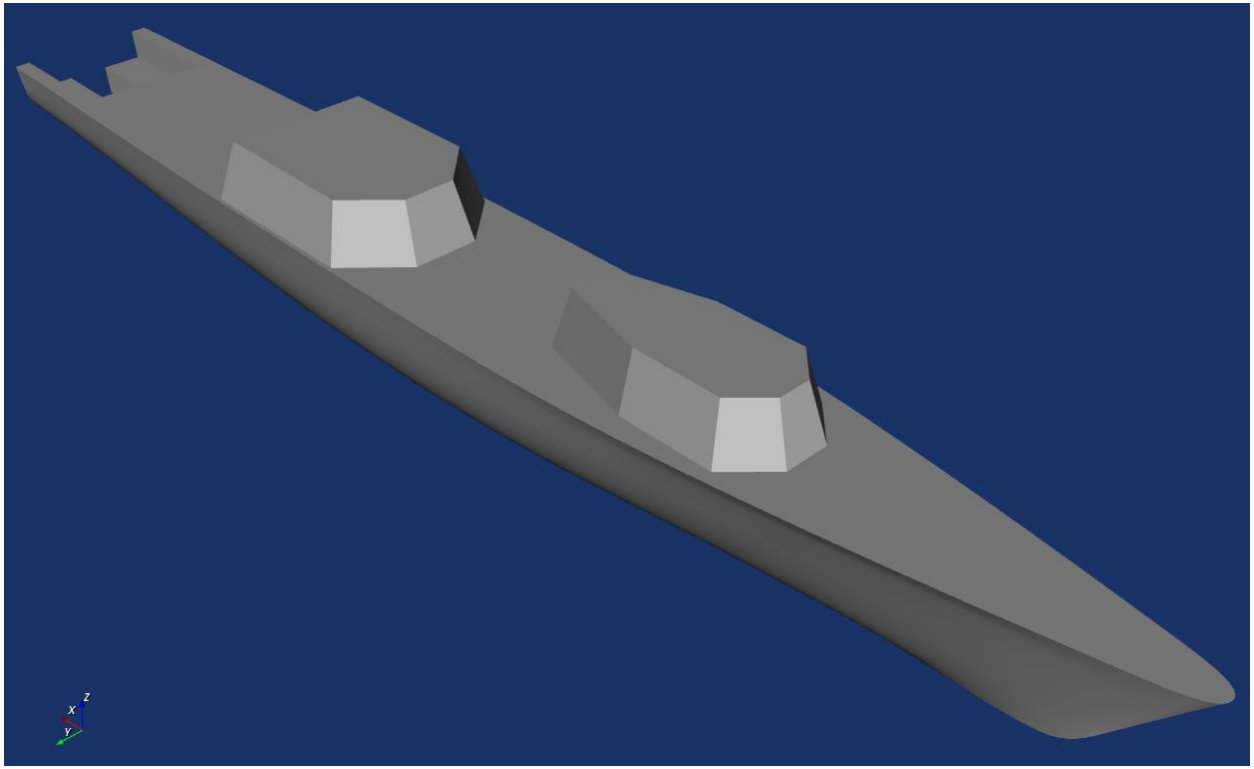
Major Study Trade-offs

- **Combat System Major Trade-offs:**
  - Fixed array vs. rotating array radar
  - Number of VLS cells (16 to 96)
  - Main gun size
  - Sonobouy system
- **Embarked Systems Trade-offs:**
  - Number of manned and unmanned aviation units
  - Number and size of small boats/equivalent USV & UUVs
  - Boat launch location
- **Naval Architecture Trade-offs:**
  - Length
  - Propulsion system type – mechanical vs. IPES
  - Engine separation – survivability
  - Auxiliary propulsion unit – survivability

Low Magnitude DSE Concepts

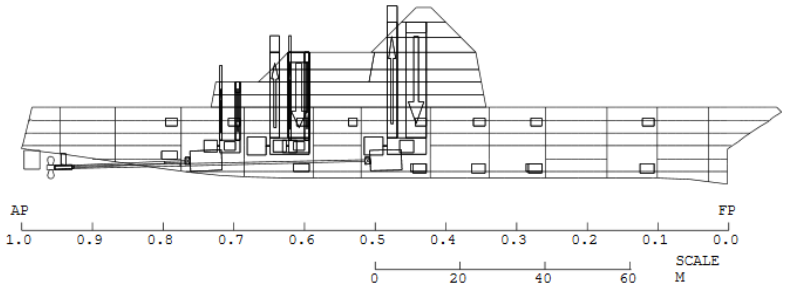
Description FAST Study Variant	Length Waterline	Propulsion	Engine Room Separation	VLS Cells	Relative CSEL Weight/Elec	Helo	UAV	Boats/USV/UUV
NSC Analog Patrol 1 Combatant	130m	2 shaft CODAG	No	32	Baseline	1	2x TERN UAV	2x 11m RHIB equivalent, stern launch
Euro Style Combatant Patrol 2 Combatant	123m	2 shaft CODAG	Yes	16	0.91 / 1.02	1	2x TERN UAV	2x 11m RHIB equivalent, side launch
IPES Small Surface Combatant Patrol 2 Combatant	117m	1 Shaft IPES + APU	No	16	0.91 / 1.02	1	2x TERN UAV	2x 7m RHIB equivalents, side launch
Small Destroyer Battle Group Escort Variant 5 w/ downsized radar	148m	2 shaft, 4 COGAG	Yes	96	1.71 / 3.04	1 or 2	3x TERN UAV	2x 11m RHIB equivalent, side launch
APU Destroyer Battle Group Escort Variant 6	155m	2 shaft IPES + APU	No	96	1.73 / 3.17	2	3x TERN UAV	2x 11m RHIB equivalent, launch method under evaluation
IPES Surface Combatant Patrol 1 Combatant	136m	2 shaft IPES	No	32	1 / 1	1	2x Tern UAV	2x 7m RHIB equivalents, side launch
1 Shaft Destroyer Battle Group Escort Variant 5 w/ downsized radar	141m	1 shaft GT + APU	No	96	1.71 / 3.04	2	3x TERN UAV	2x 11m RHIB equivalent, side launch

National Security Cutter Analog

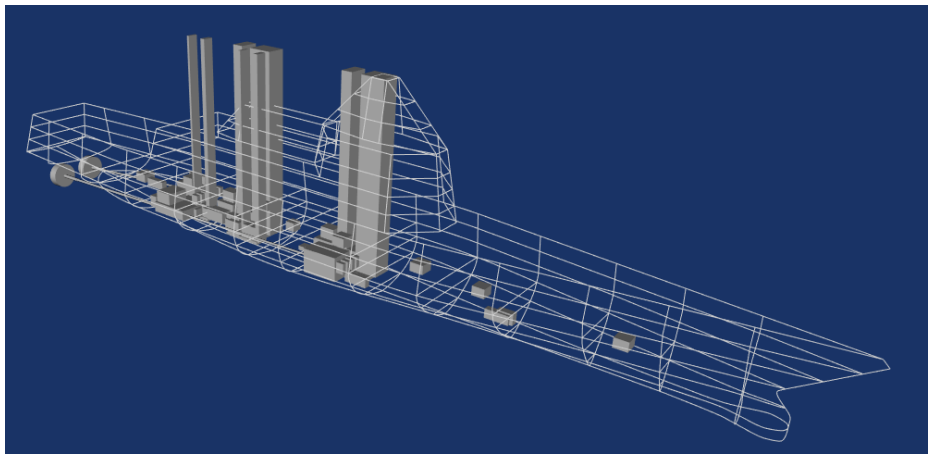


FAST Study Design Variant	Length Waterline	Propulsion	Engine Room Separation	VLS Cells	Helo	UAV	Boats/USV/UUV
Patrol 1 Combatant	130m	2 shaft CODAG	1 bulkhead separation	32	1	2x TERN UAV	2x 11m RHIB equivalent, stern launch

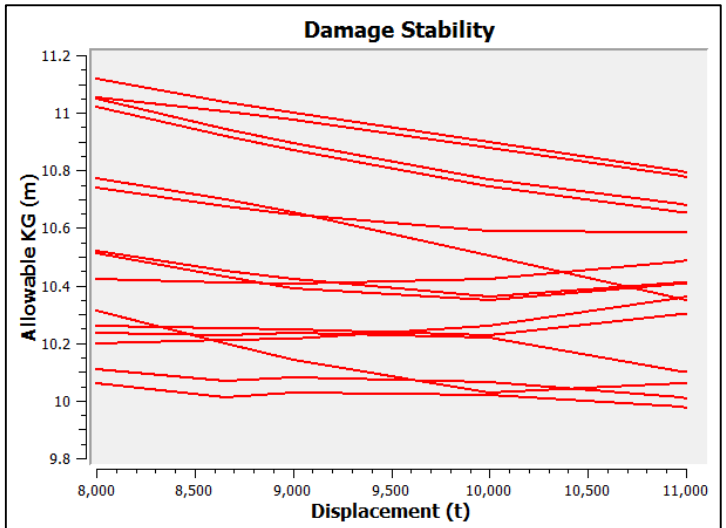
Automated Damage Stability



ASSET 6.3



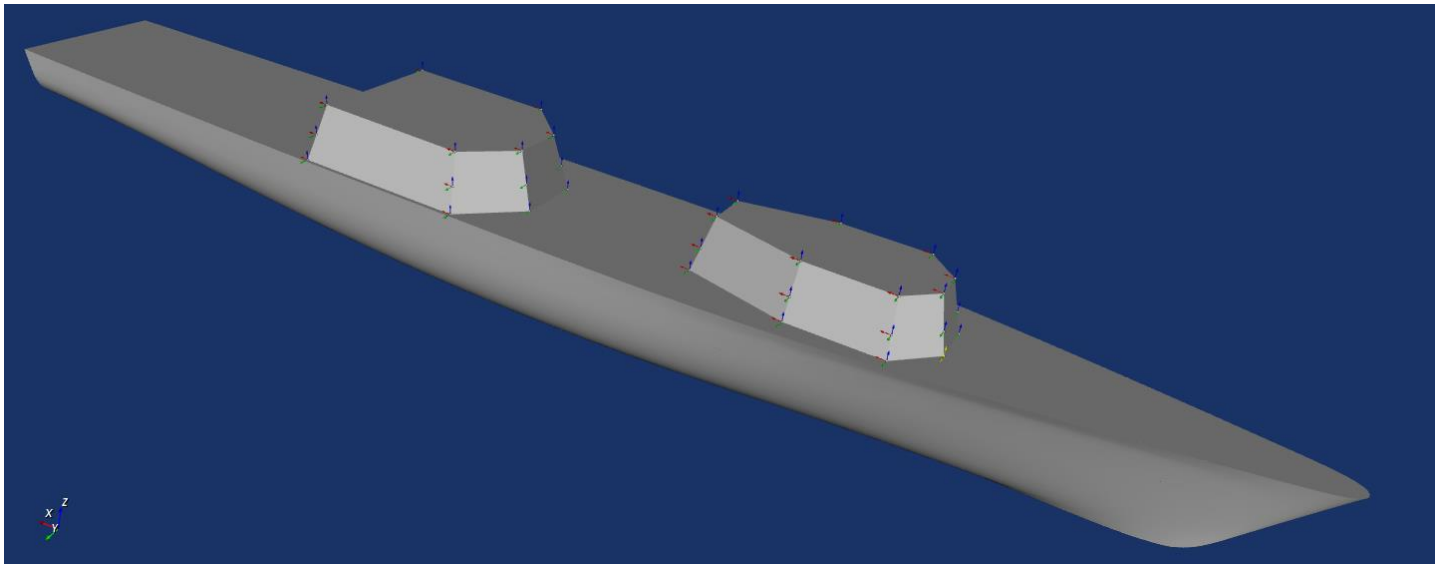
RSDE 3.0



	Flooding Scenario	isplacemer	Allowable KG	Limiting Criteria	Calc Status
1	STBD, Centered at x = -7.604	8000.0	11.054	Area Ratio	VALID
2	STBD, Centered at x = -7.604	8658.1	11.005	Area Ratio	VALID
3	STBD, Centered at x = -7.604	9000.0	10.975	Required GZMax-GH	VALID
4	STBD, Centered at x = -7.604	10000.0	10.879	Required GZMax-GH	VALID
5	STBD, Centered at x = -7.604	10977.7	10.780	Required GZMax-GH	VALID
6	STBD, Centered at x = -7.604	11000.0	10.777	Required GZMax-GH	VALID
7	STBD, Centered at x = 4.246	8000.0	11.118	Area Ratio	VALID
8	STBD, Centered at x = 4.246	8658.1	11.037	Required GZMax-GH	VALID
9	STBD, Centered at x = 4.246	9000.0	11.000	Required GZMax-GH	VALID
10	STBD, Centered at x = 4.246	10000.0	10.901	Required GZMax-GH	VALID
11	STBD, Centered at x = 4.246	10977.7	10.796	Required GZMax-GH	VALID

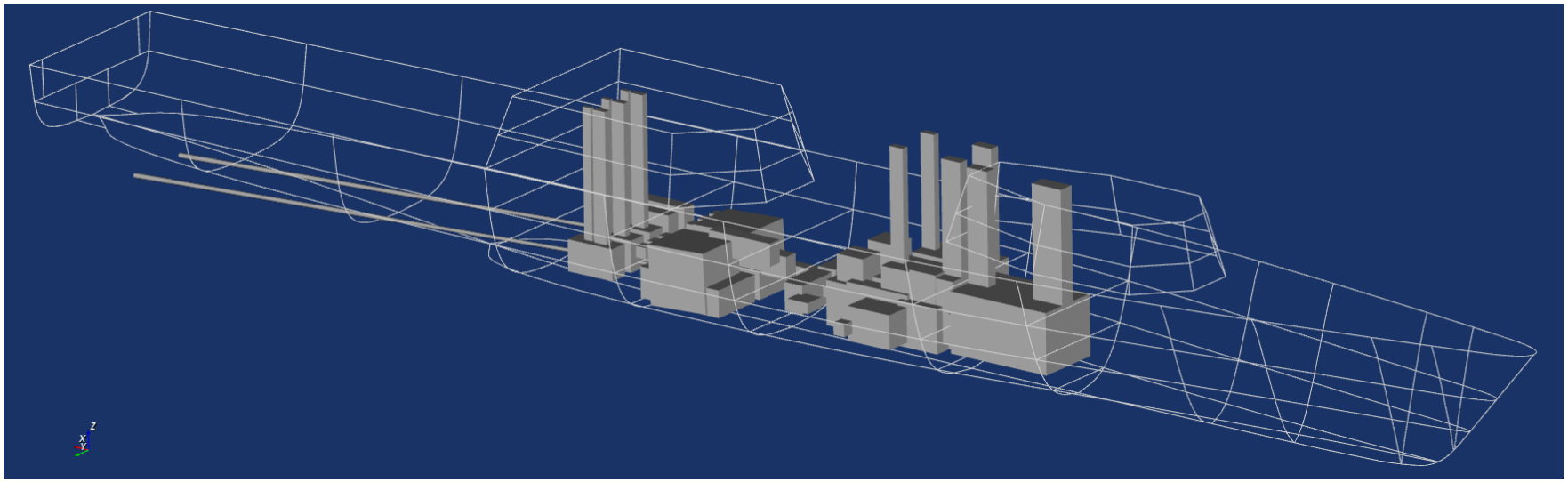
Automated 15% LBP Damage Scenario Analysis

Deckhouse Modeling



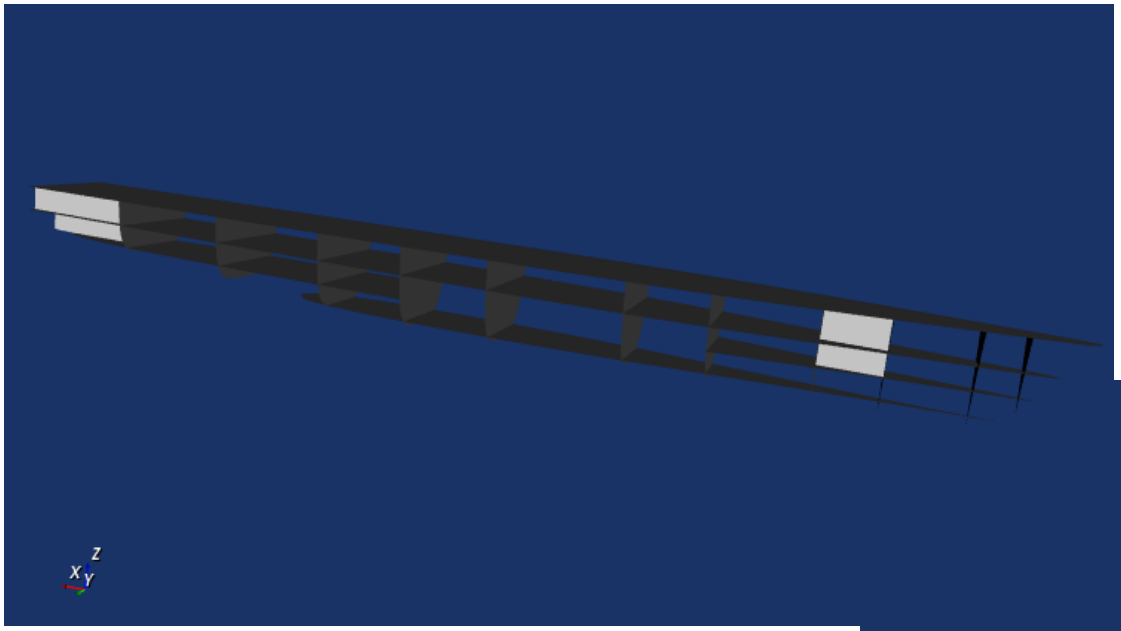
- **Deckhouses created based on constraint points**
- **Constraint points tied to design features e.g. the intersection of a deck and bulkhead or other constraint points**
- **Constraint points will be variables in RSDE 3.1 Design Space Explorations**

Ship Systems Arrangements

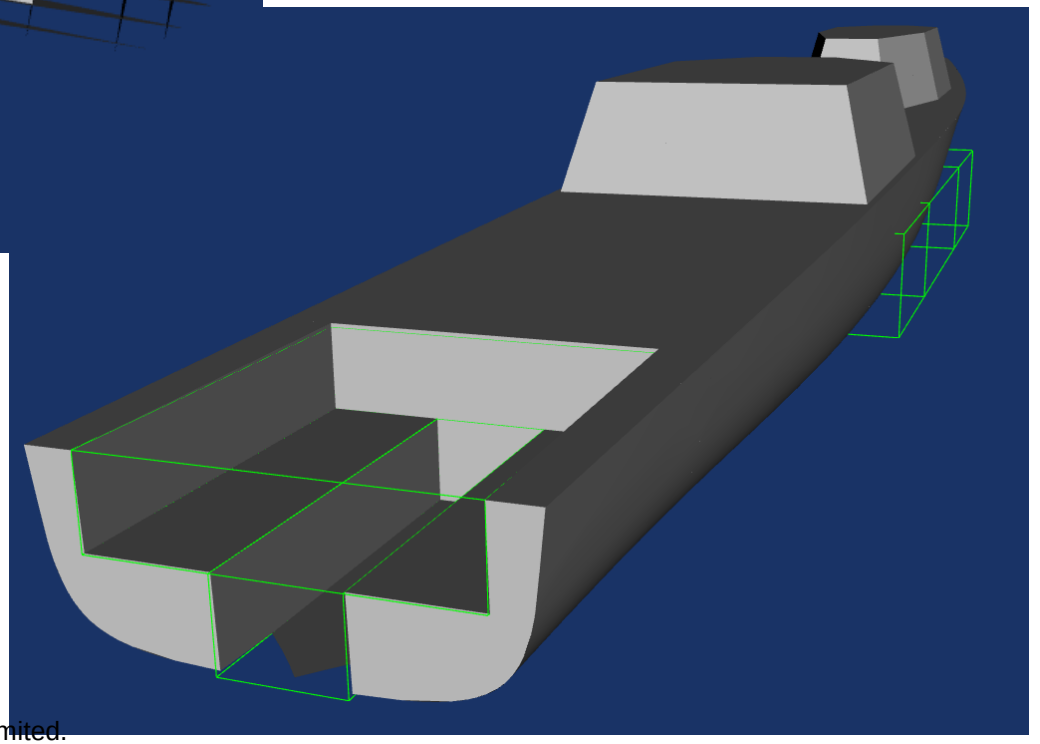


- **Machinery arrangement shown above is <u>NOT</u> representative of actual engine room arrangement**
  - Developing & documenting process for modeling machinery arrangements that are beyond scope of RSDE machinery theory
  - Large set of machinery components are represented in model
  - Increased control over placement of components

Structural Arrangement Flexibility

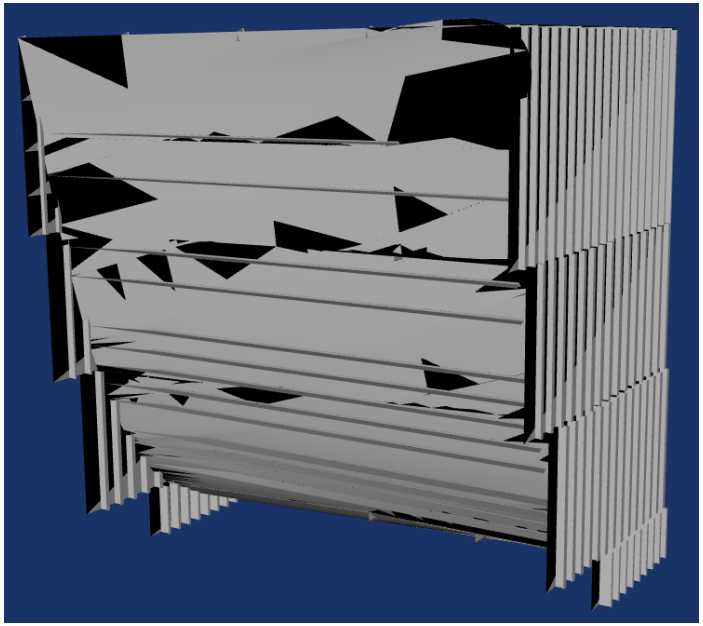


Simplified placement and removal of transverse and longitudinal bulkheads

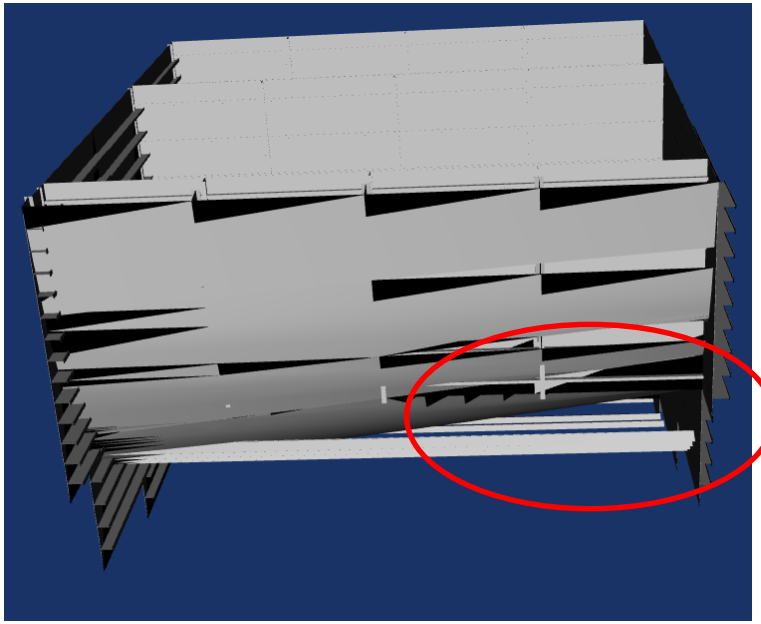


Ability to remove hull shell structural members to model stern launch areas

3D Structural Models



3D structural models are now used for weight estimation



Structural theory assumes linear stiffeners, leading to gaps

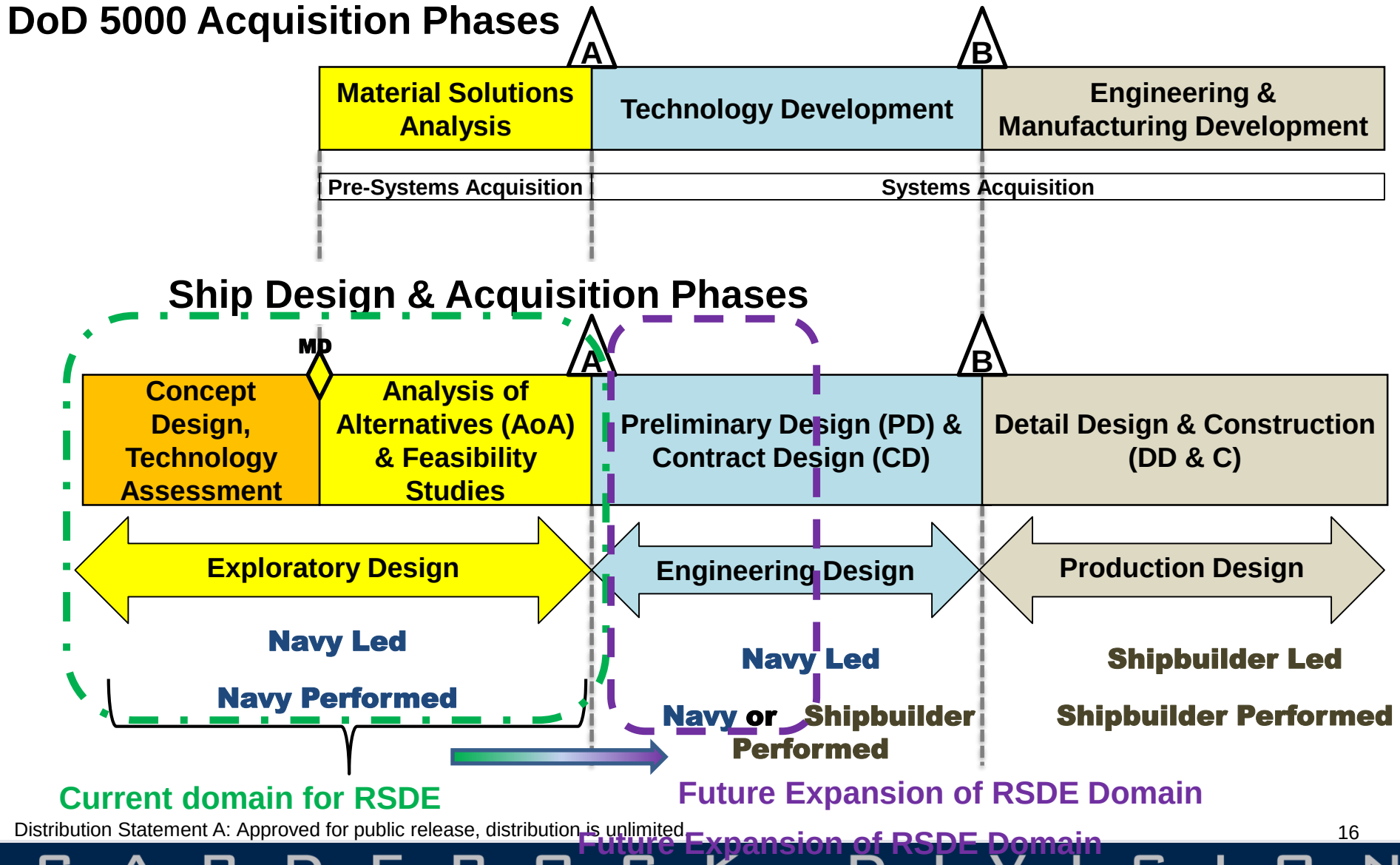
Findings: Design Perspective

- **Mission requirements as defined in capability concept wheel appear to be feasible**
  - Modeling mission systems to the level of detail that is necessary for mission effectiveness analysis is challenging
  - Traditional Naval Architectural disciplines are strengths of RSDE
- **Initial damage stability analysis shows smaller hulls will have issues with meeting damage stability flooding criteria due to large engine room and weapons systems spaces within the hull**
  - Embedded SHCP-L damage stability module allows designers to design to damage stability requirements at beginning of design rather than test against requirements at end of design
- **Adding unmanned vehicles has a significant impact on manning**
  - 1 UAV can require up to 7 additional crew
- **Impact of different RHIB launch locations has not be studied yet, but can be analyzed using embedded Ship Motions Program module**

Findings: Tool Perspective

- **The initial learning curve of using the new RSDE software was steep but as new training materials and software updates have become available the process has rapidly improved.**
- **Near term updates to RSDE allow for reuse of information between models streamlining the model development process.**
- **The study has familiarized members of NSWCCD Code 824 Future Ship and Submarines Concept Branch with RSDE for use in future studies and has provided the RSDE Development Team (Code 823) useful feedback for improving the software.**
  - Dr. Alexander Gray (823) – RSDE Product Lead
  - Pedro Muslera (823) – RSDE Implementation Team
  - Drake Platenberg (824) – FSC Baseline Development Task
  - James Lovenbury (824) – UUV Design Tool Development
  - Nick Mullican (823) – RSDE Development Team
  - Mark A. Parsons (823) – Ph.D. Student at Virginia Tech researching Concept Effectiveness and Vulnerability Analyses with Dr. Alan Brown

The Future of RSDE

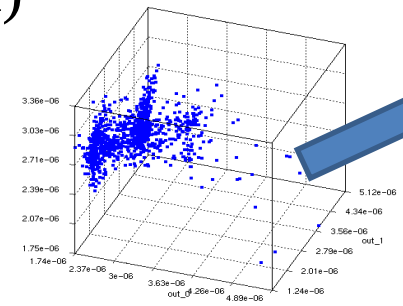


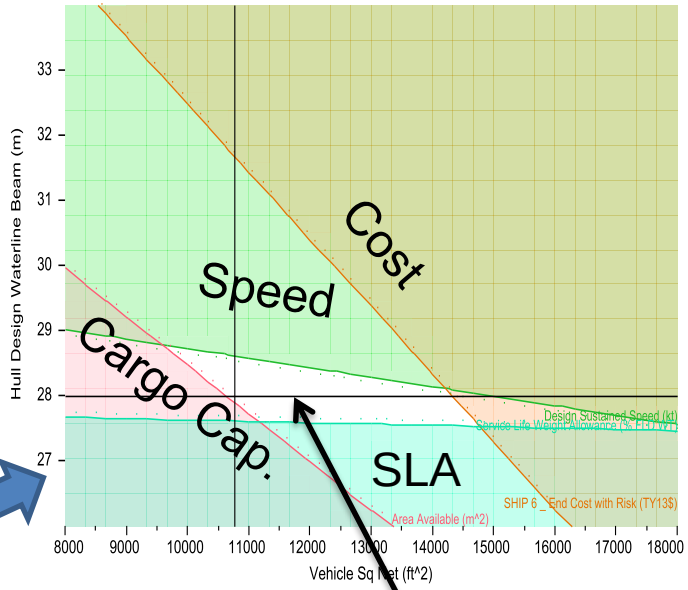
The Future of RSDE: Near Term

RSDE v3.1 - Release Dec. 2017

- ***Improved*, High Magnitude DSE (monohull)**
  - Rapidly generate 1000's of ship concepts
  - Now with *SHCP & IHDE* integrated
- **Multi-hull hullform study DSE**
  - Rapidly generate and analyze resistance & seakeeping of multi-hull hullforms (catamaran & trimaran)

High Magnitude





White space shows feasible region

RSDE: Long Term

- **Roadmap developed to 2025, planned development:**
  - Submarine Design Space Exploration
  - Systems Design (Machinery, Distribution, CPES)
  - Topside Design
  - Automated Costing
  - Arrangements (Manual & Automated)
  - Damage Stability Enhancements (Downflooding)
  - Predictive Structural Loads
  - Generative Structures
- **Constant emphasis on Decision Support, Visualization, and Data Analysis Capabilities and Tool Flexibility Improvements**

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