



Department of Defense High Performance Computing Modernization Program



CREATE

Computational Research & Engineering Acquisition Tools & Environments



Rapid Design and Integration (RDI)

**Distribution Statement A: Approved for public
release, distribution is unlimited**



Product Description

The vision for the CREATE-SHIPS Rapid Design and Integration (RDI) effort is to create a high-end toolset that integrates ship design generation tools with physics-based analysis tools that enables the user to:

- DESIGN – hundreds of ships by running ship design generation tools to create a rich design space
- ANALYZE – hundreds of ship designs using physics based analysis tools, adding to the knowledge captured in the design space.
- OPTIMIZE – using the knowledge in design space, cost benefit trades are performed to find a low cost, low risk, robust design solution.

RDI will use high performance computing resources to reduce the time required to perform these activities, so that they can be completed within the decision cycle of early stage design or mid-life upgrade studies.

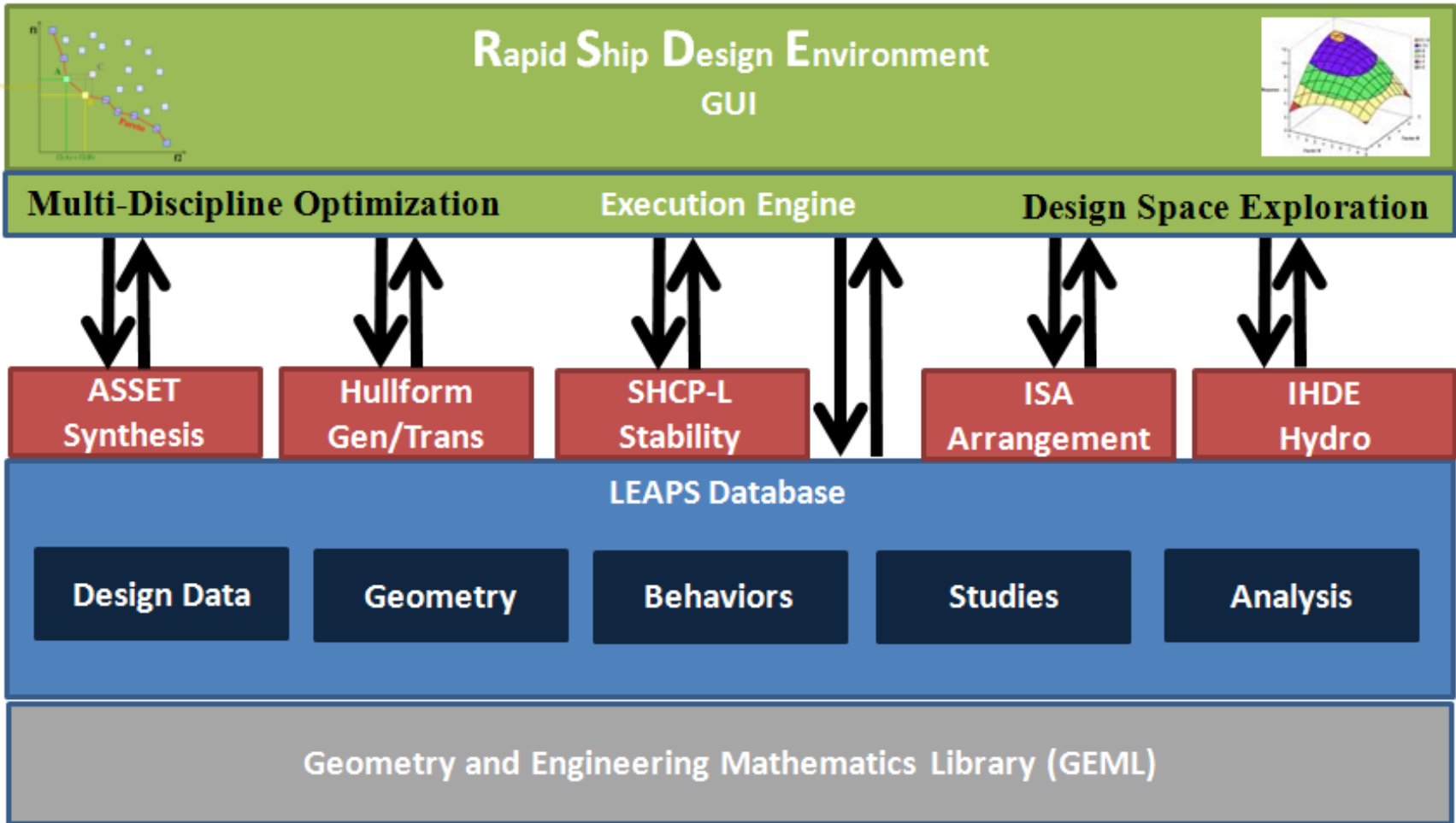


Product Architecture

- The CREATE-Ships RDI effort produces 1 Product:
 - **Rapid Ship Design Environment (RSDE)**
 - New Design Space Exploration capability
 - New Multi-Disciplinary Synthesis capability
- The use cases envisioned for RSDE require development of new capabilities in the existing tools:
 - **Advanced Ship and Submarine Evaluation Tool (ASSET)**
 - New Hull Transformation and Generation capability
 - New Structural Design Definition capability
 - **Leading Edge Architecture for Prototyping Systems (LEAPS)**
 - New Parallel Queries capability
- The use cases envisioned for RSDE require development of a new tool:
 - **Intelligent Ship Arrangements (ISA)**
 - New Ship Arrangement capability

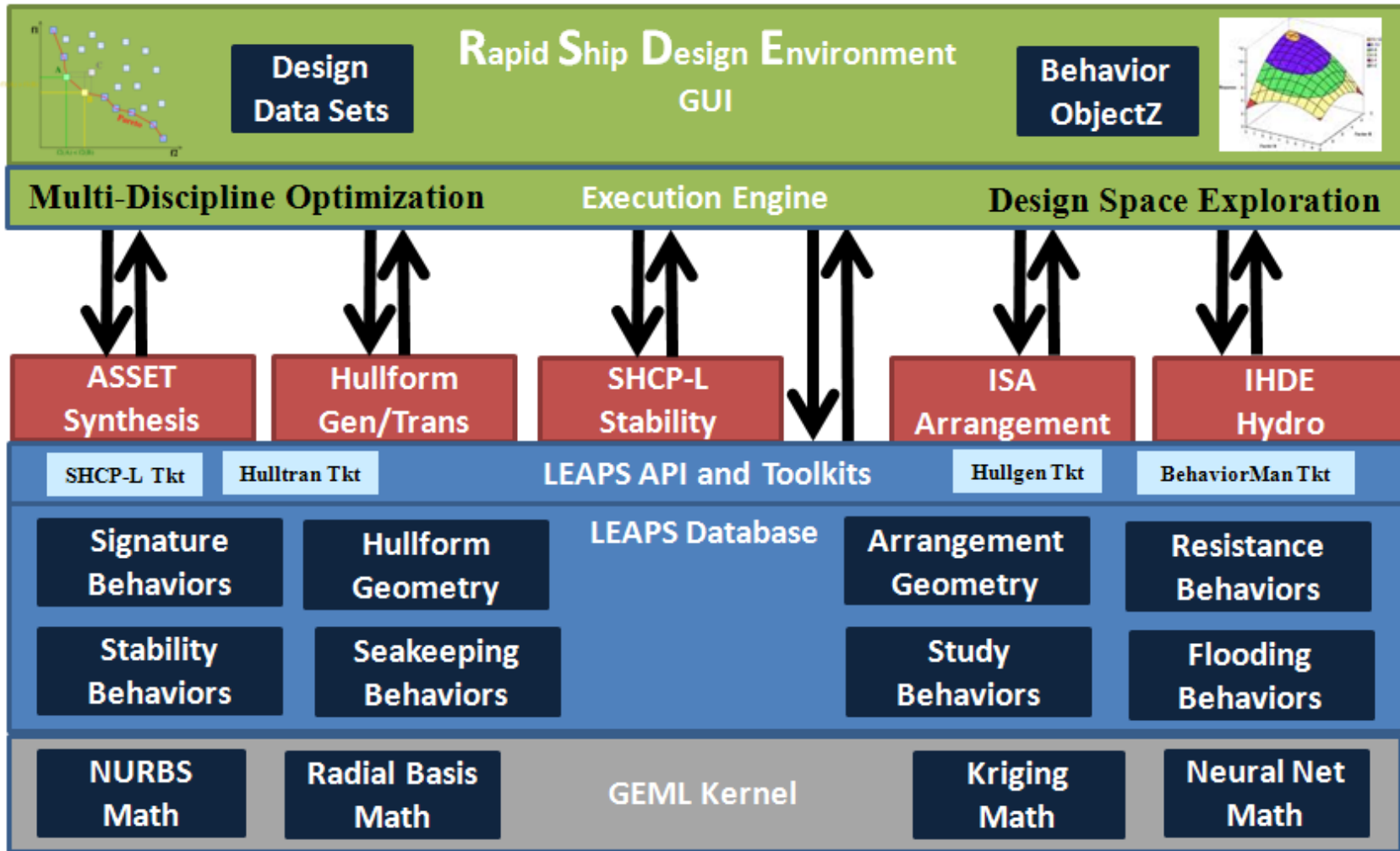


RSDE - Product Architecture





RSDE - Product Architecture





Description of the Rapid Ship Design Environment



1. RSDE will generate and interrogate design space data through....
 - 1.1 Generation of design space data through remote execution of tools.
 - 1.2 Aggregation of trade space data into larger sets.
 - 1.3 Evaluation and data extraction for downstream design and/or analysis tools.
2. RSDE will serve as a decision aid through visualization of trade space.
3. RSDE will be used by a naval architect needing higher fidelity design definition and physics based analysis during early stage design.
4. The output of this process will be a trade space. This trade space will be composed of discrete sets of design data and/or design data represented as interpolated behavior models.



Users



- Rapid Ship Design Environment- planned 1st release date: Early CY 2012.
- ASSET
 - Has been used in the early stages of design by most major ship acquisition programs in recent history: DDG-1000, LCS, CVN-78, LPD-17, CG(X), DDG-51 flight upgrade.
 - Currently has 86 org/users on distribution.
 - Currently there are an estimated 40 heavy users.
- LEAPS
 - Has been used by the following ship acquisition programs: DDG-1000, SSC (Ship to Shore Connector – LCAC replacement)
 - Used by all ASSET users as the database for ASSET models
 - *Has promise, but is currently underutilized – most users are computer programmers developing applications.*
 - Currently has 129 org/users on distribution.
 - Currently there are an estimated 30 heavy users.



Potential Ship Programs

- DDG-51 Flight III Destroyer (FY 16 award)
 - currently using ASSET/LEAPS toolset
- LHA-8 Amphibious ship (FY 16 award)
- T-AO(X) Tanker (FY 17 award)
 - currently using ASSET/LEAPS toolset
- LSD(X) Amphibious ship (FY 17 award)
 - currently using ASSET/LEAPS toolset
- Ohio Replacement (FY 19 award)
- Sub Tender replacement (FY 23 timeframe)
 - Good option for RSDE use
- DDG(X) Future Surface Combatant (FY 25 timeframe)
 - Good option for RSDE use
- LCS(X) replacement (FY 25 timeframe)
 - Good option for RSDE use
- Virginia class submarine replacement (???)



Product Use Cases



The Global RSDE use case is a process made of three steps, each of which has use cases associated.

A. Generate a large space of feasible ship designs, at the concept level of detail.

UC 1 – Synthesis

UC 2 – Hullform Transformation

UC 3 – Hullform Generation

UC 9 – Ship Arrangement/Functional Allocation

UC 10 – Ship Arrangement/Outside In Compartment Arrangement

UC 11 – Ship Arrangement/Constraint Management GUI

UC 12 – Ship Arrangement/Component Placement

UC 13 – Ship Arrangement/Routing Distributed Systems

UC 14 – Ship Arrangement/Inside Out Arrangement

UC 15 – Design Space Population



Product Use Cases

- B. Analyze the space of designs (and excursions from that space) for a large number of engineering and physics disciplines at a detailed level, with the results forming the basis of behavior objects that will be used in a multidisciplinary synthesis process.

UC 4 – Intact and Damaged Stability Analysis

UC 5 – Resistance Analysis

UC 6 – Seakeeping Analysis

UC 7 – Maneuvering Analysis

UC 8 – Structural Definition for Analysis

- C. Develop an optimized, balanced design, at the concept level. A balanced design is a ship design that meets the engineering requirements for sizing the hull and deckhouse, determining the subdivision/arrangement, and sizing ship systems/components.

UC 16 – Design Optimization

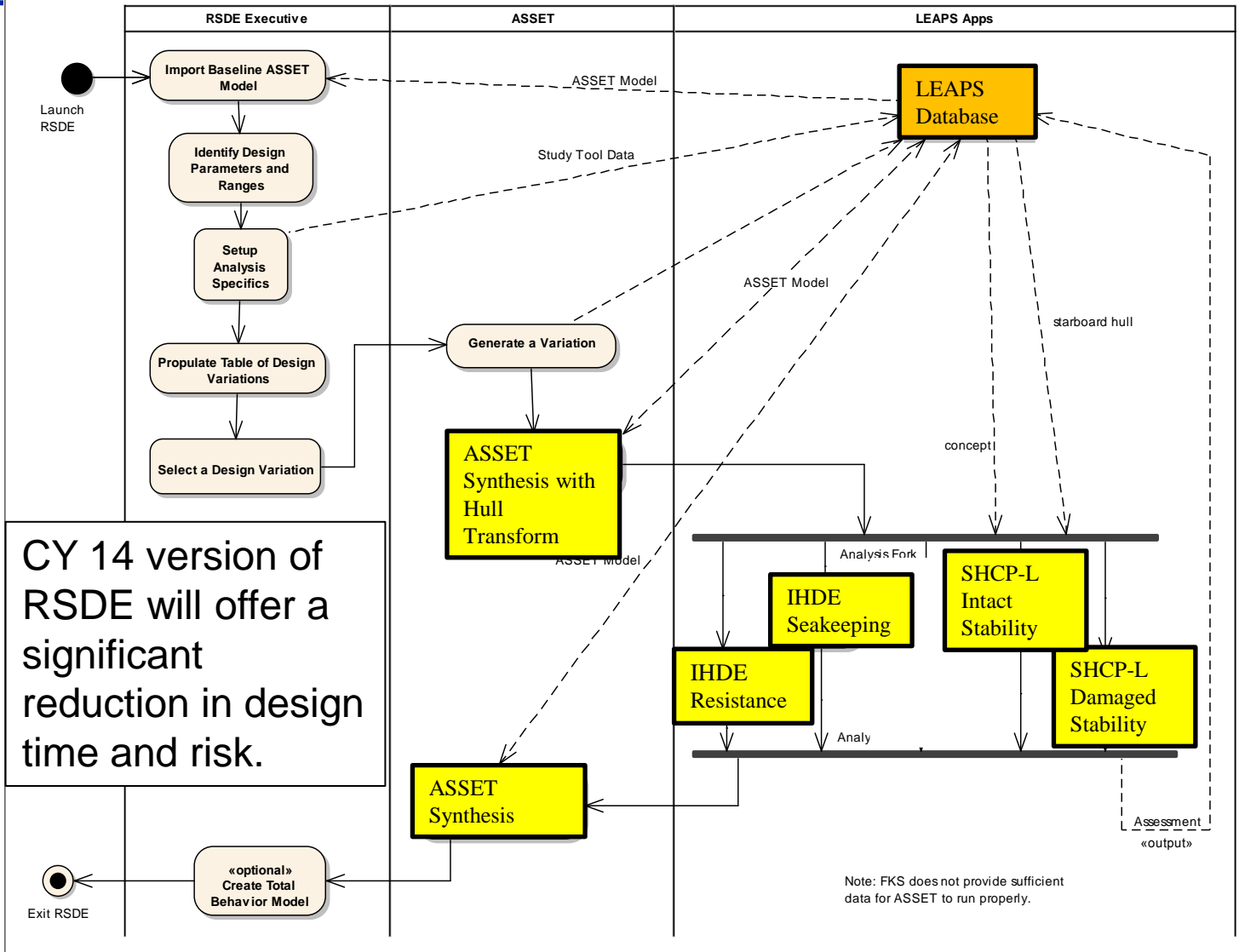


RSDE CY 14 Use Case



act UC15 Activity Diagram

Use Case 15: Design Space Population - Activity Diagram



CY 14 version of RSDE will offer a significant reduction in design time and risk.

Note: FKS does not provide sufficient data for ASSET to run properly.



Ship Synthesis (using ASSET)



LEAPS Editor - [DDGX_Baseline]

File Edit View Display Tools Window Help

Editor Log

Messages

PM LDB

- Views Of Bulkhead 00
- Views Of Bulkhead 00
- Views Of Bulkhead 00
- Watertight Bulkheads
- Views Of Deckhouses
- Deckhouses
 - Deckhouse 000000
 - Deckhouses Char
- Views Of Deckhouse 1
- Deckhouse 000000
- Views Of Decks
- Views Of Hulls
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 - Hull 0000001
 - Port Hull 0000001
 - Starboard Hull 00
 - Transom Of Hull 1

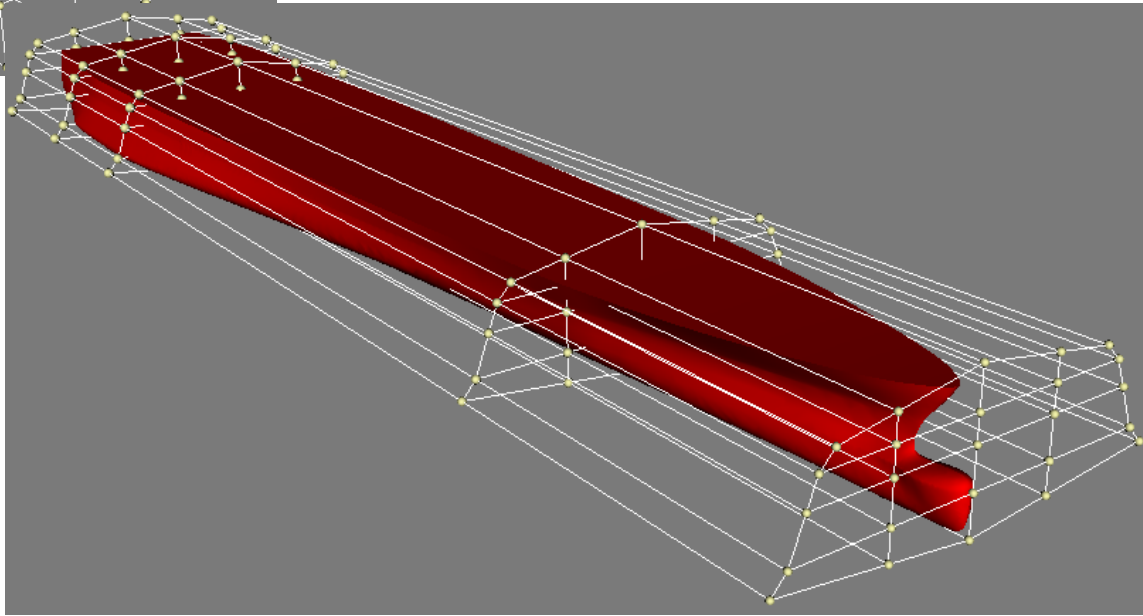
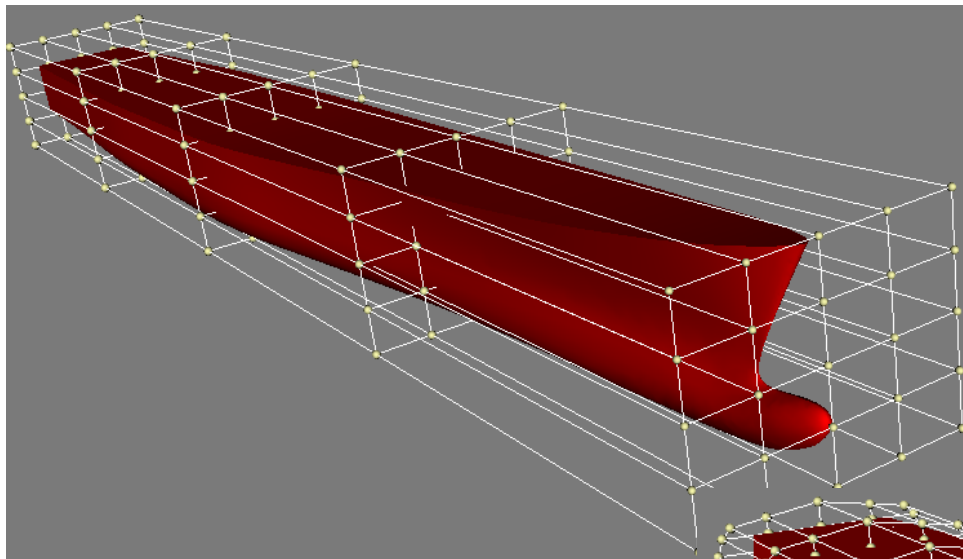
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Hull Transformation Approach





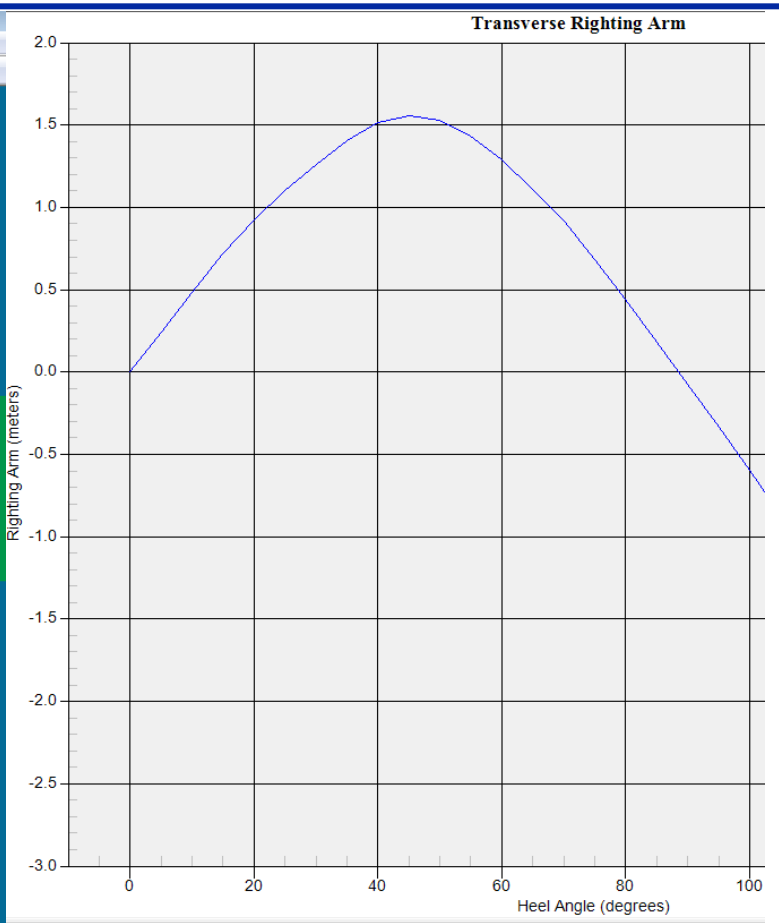
Intact Stability using SHCP-L



LeapsSHCP - [DDGXBaseline[ship_0000001-1]]

File Edit View Window Help

- Input Data
- Report
- Watertight Envelope Analyses
 - Hydrostatics
 - Hydrostatics Analysis #1
 - Input Data
 - Results
 - Plots
 - Report
 - Trim Lines
 - Limiting Drafts
 - Floodable Length
 - Floodable Length Analysis
 - Input Data
 - Results
 - Plots
 - Report
 - Damageable Length
 - Longitudinal Strength
 - Watertight Zone Analyses
 - Intact Cross Curves
 - Intact Transverse Stability
 - Intact Stability Analysis #1
 - Input Data
 - Results
 - Equilibrium Condition
 - Waterplane
 - Flooding
 - Liquid Loads
 - Plots
 - Report
 - Intact Transverse Stability on
 - Damage Cross Curves
 - Damage Transverse Stability
 - Damage Transverse Stabi
 - Input Data
 - Results
 - Equilibrium Condition
 - Waterplane
 - Flooding
 - Liquid Loads
 - Plots
 - Report



INTACTTS: Calculations Complete
INTACTTS: Saving Results
INTACTTS: Calculations Complete
Found Hull Length Between Perpendiculars = 159.997





Damage Stability using SHCP-L



LeapsSHCP - [DDGXBaseline[ship_0000001-1]]

File Edit View Window Help

SHCP

- Ship Geometry
 - Ship Particulars
 - Hull & Solid Appendages
 - Watertight Envelope 0000
 - Propulsion Shaft Section
 - Propulsion Shaft Section
 - Propulsion Shaft Section
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Iteration 8, Volume Difference = 0.003, LCG Difference = 0.000
 DAMTS: Balance Achieved
 DAMTS: Equilibrium Calculations Complete
 DAMTS: Total Iteration 26, Total No Balances 0

For Help, press F1

SHCP

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 Design Condition
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 File Menu
 Floodable Length
 Flooding Scenario
 Getting Started
 Heeling Arm
 Transverse Stability Evaluation

Damage Transverse Stability

Description

The Damage Transverse Stability module computes transverse righting arms over a range of heel angles. These calculations include the effects of flooding and liquid load movement. The vessel is balanced in displacement and LCG during the

- Damage Transverse Stability
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 - High Speed Turn An
 - Results
 - Equilibrium Condition
 - Waterplane
 - Flooding
 - Liquid Loads

Transverse Righting Arm

Floodable Length





Resistance Analysis using IHDE



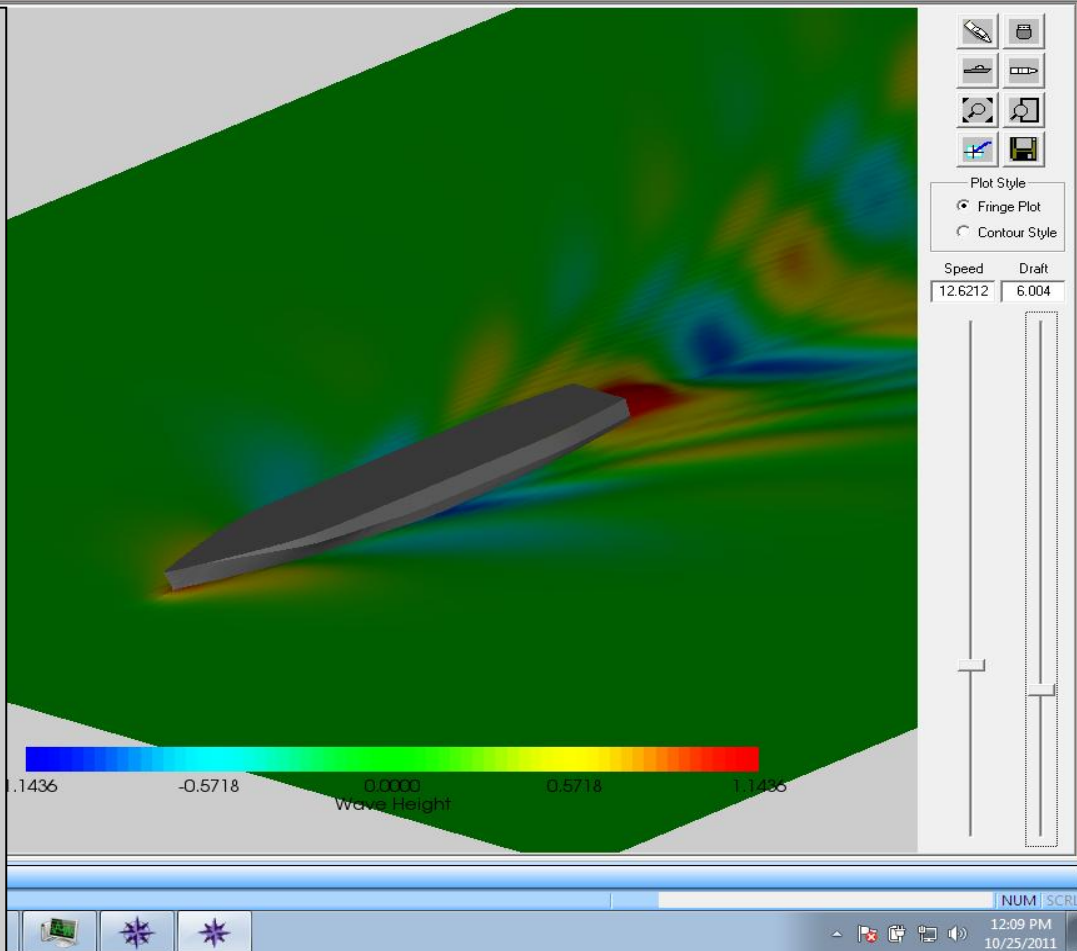
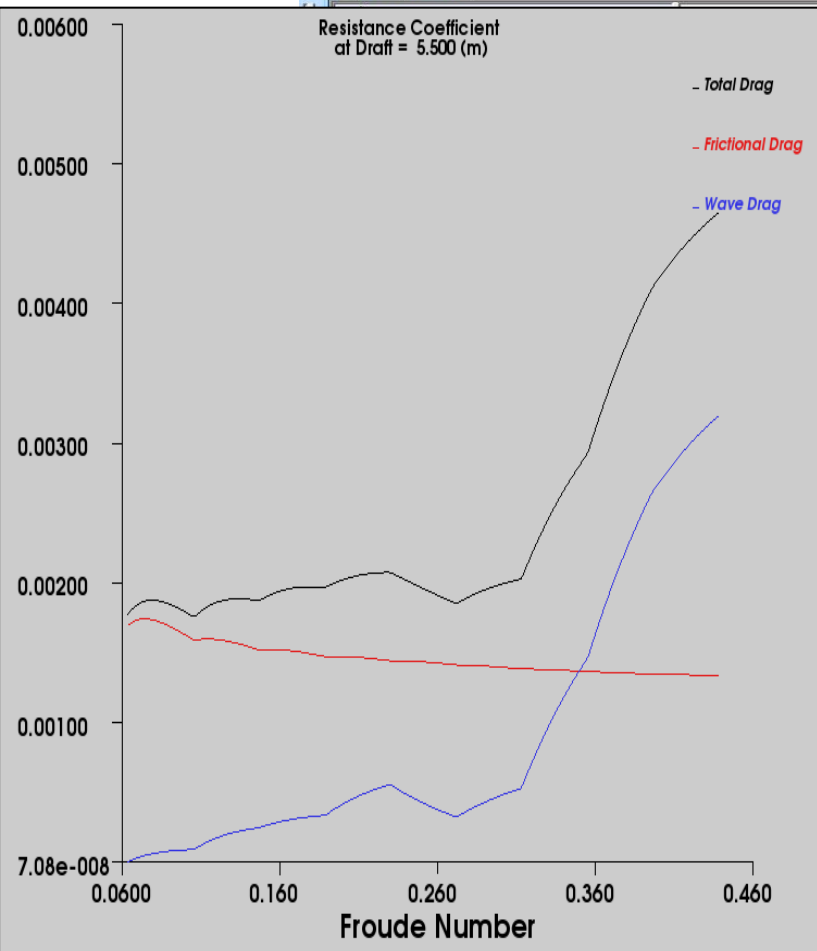
Integrated Hydrodynamic Design Environment (IHDE) - [DDGX_Baseline]

File Edit View Options Window Help

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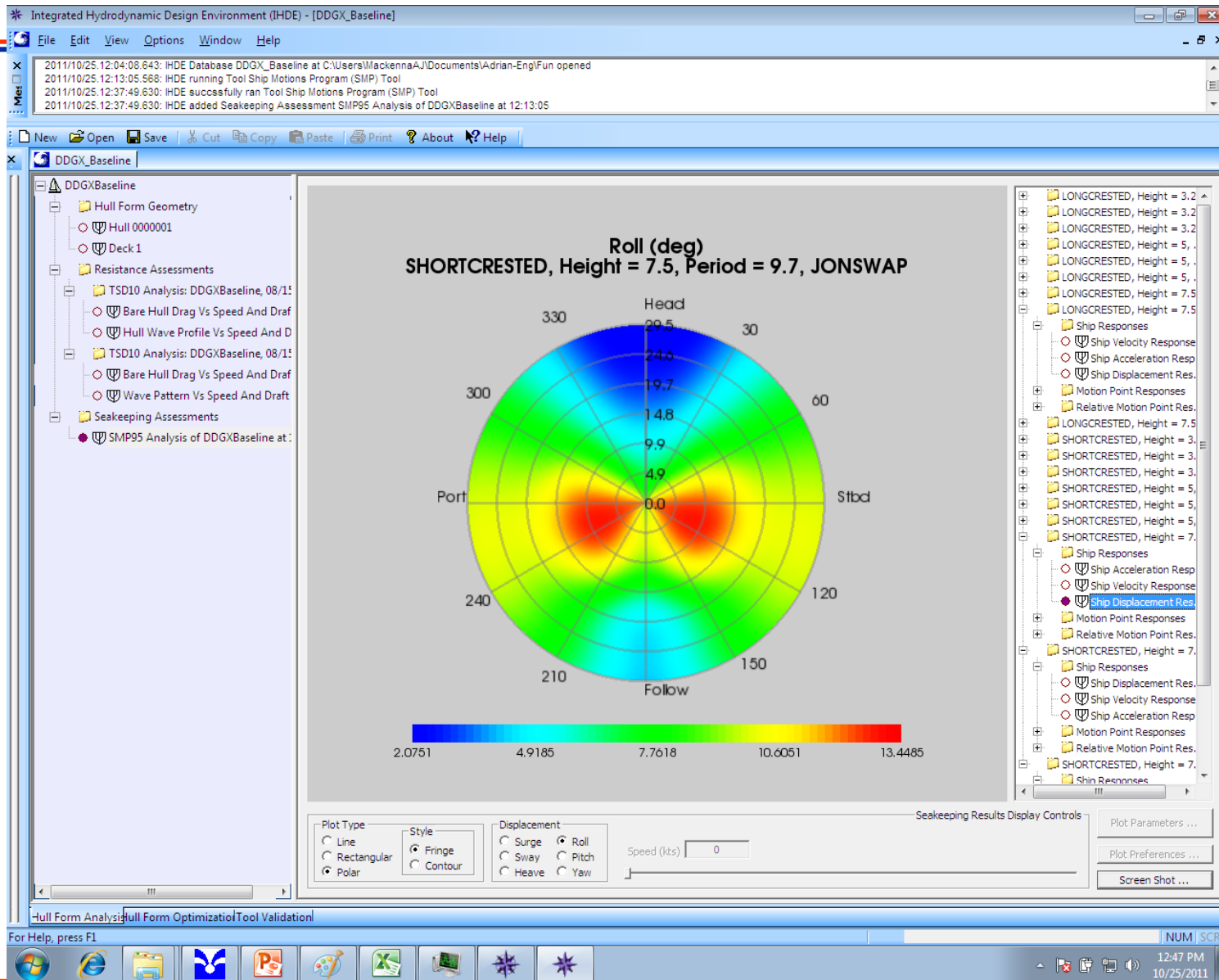
New Open Save Cut Copy Paste Print About Help

DDGX_Baseline





Seakeeping Analysis using IHDE



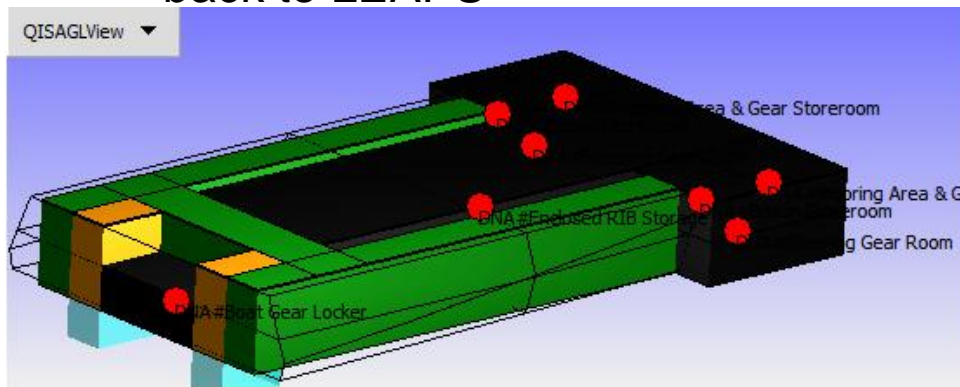
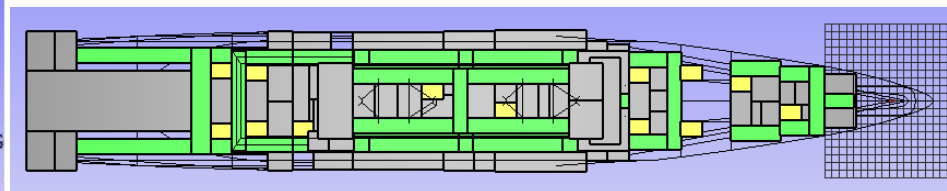
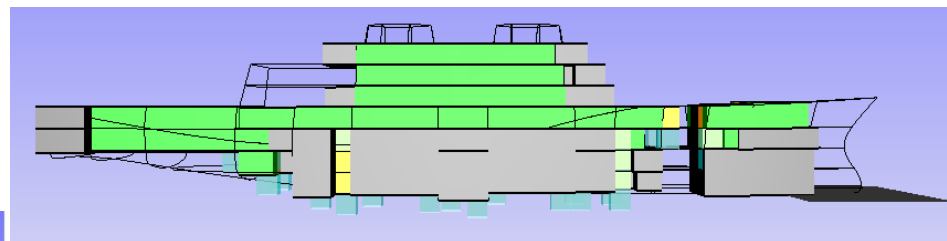
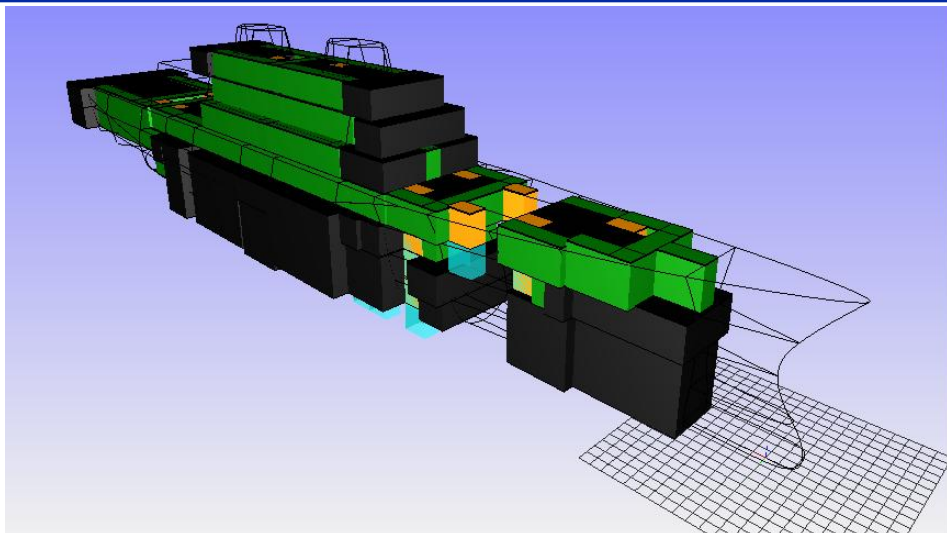


Intelligent Ship Arrangements (ISA)



- **Capabilities of ISA:**

- LEAPS database as input for ship geometry and requirements
- Arrangement requirements are input as a constraints database
- Passageways are laid out using an initial lattice network
- ISA performs allocation and arrangement of ship compartments
- Fuzzy logic is used to lay out and optimize arrangement
- 3D arrangements model is populated back to LEAPS

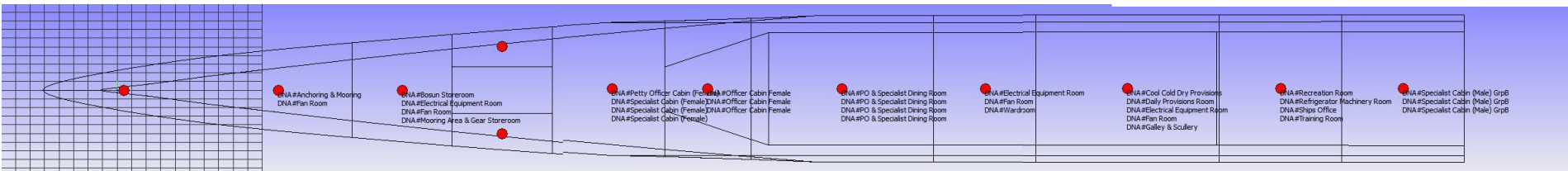




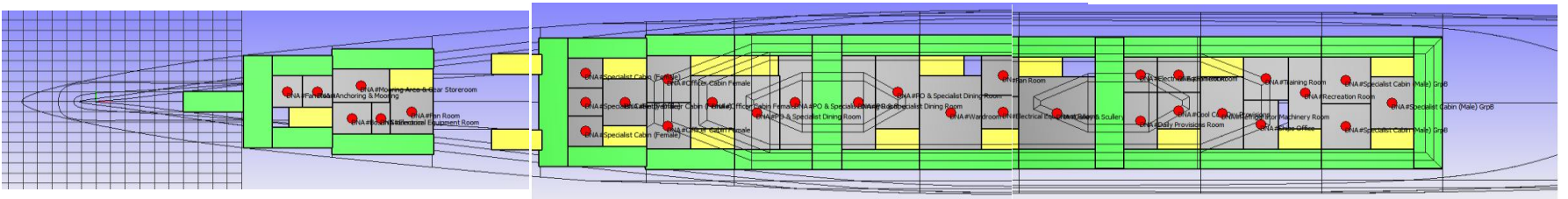
Intelligent Ship Arrangements (ISA)



Allocation Step



Arrangement Step





ISA Graphical User Interface



The screenshot displays the ISA FrmMain application window. The menu bar includes File, ISALibrary, Edit, ShipModel, View, Allocation, Arrangement, Debug, and Help. The interface is divided into several panes:

- LEAPS MODEL / ISA MODEL:** A tree view showing the object hierarchy. The selected object is "ISA Comba... ship_0000002".
- QISAGView (left):** A 3D wireframe view of a ship hull.
- QISAGView (right):** An inboard profile view of the ship.
- Structural Zone (SZ) Collection:** A list of compartments including: Compartment HB-FPK-0, Compartment 01-44-0, Compartment 03-44-0, Compartment 02-46-0, Compartment 3-68-0, Compartment 1-37-0, Compartment 5-92-0, Compartment HB-16-0, Compartment 4-106-0, Compartment 4-92-0, Compartment 1-75-0, Compartment 2-FPK-0, Compartment 02-41-0, Compartment 3-16-0, Compartment 3-23-2, Compartment 5-30-0, Compartment 2-56-0, Compartment 1-44-0, Compartment 03-52-0, Compartment 4-23-2, and Compartment 2-6-0.
- 3D Ship Viewer:** A panel with buttons for "Reload All Struct Zones", "Auto Set SZ Defaults", "Sort Zones", and "Reload All Geometry".
- SZ Passage/Variable Lattice Network:** A dialog box with tabs for "SZ Information", "SZ Characteristics", "SZ Geometry", "SZ Constraints", and "SZ Passage/Variable Lattice Network". The "SZ Passage/Variable Lattice Network" tab is active, showing "SZ PVLN Default Preferences" with options for "SZ Passages Required" (checked), "Max Number of Trans. Passages" (0), "Max Number of Long. Passages" (0), "Default Passage Template" (DOUBLEHLONG), "Default Passage Offset" (OFFSETHIRD), "Max Number of Stair Towers" (0), and "Default Stair Tower Template" (STBDFORE_PORTAFT). A "PVLN Sample View" shows a 3D model of the lattice network.

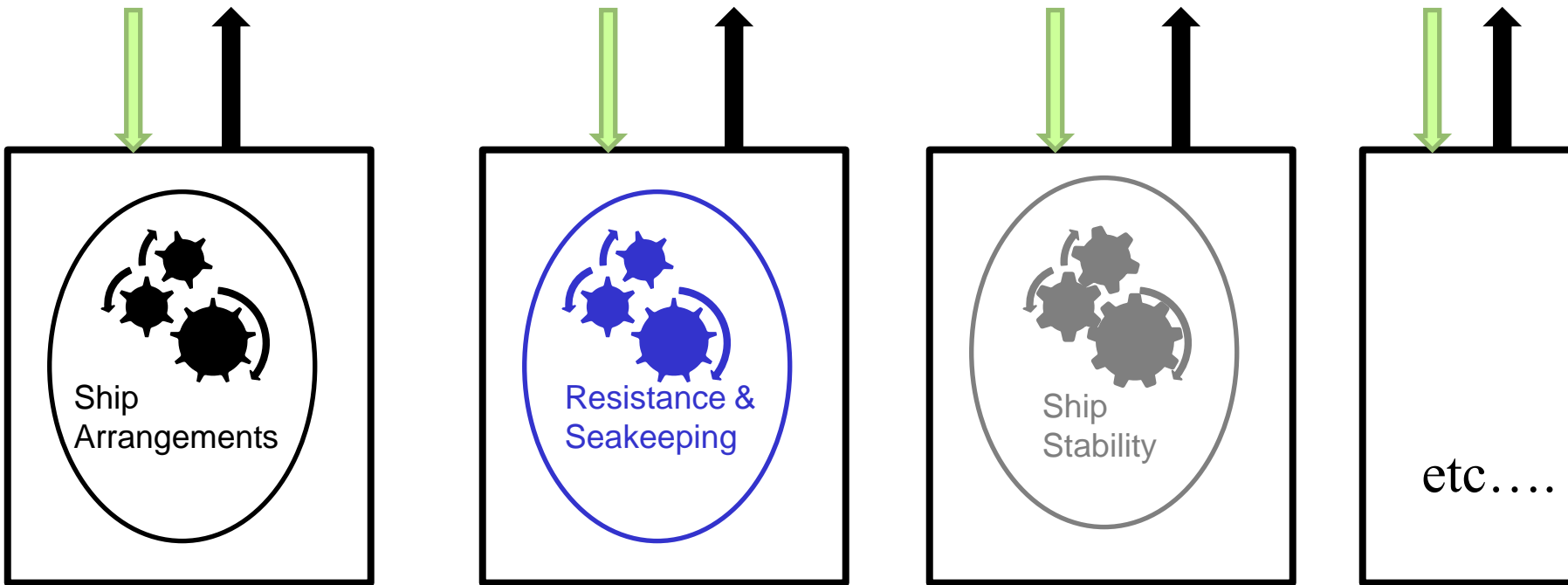
Buttons at the bottom include "Add SZ", "Delete SZ", "Delete All SZ", "Apply Changes", "OK", "Cancel", and "U A". A progress bar at the bottom left shows 0% completion.



Multi-Disciplinary Synthesis

MDS (Multi-Discipline hierarchical Systems engineering)

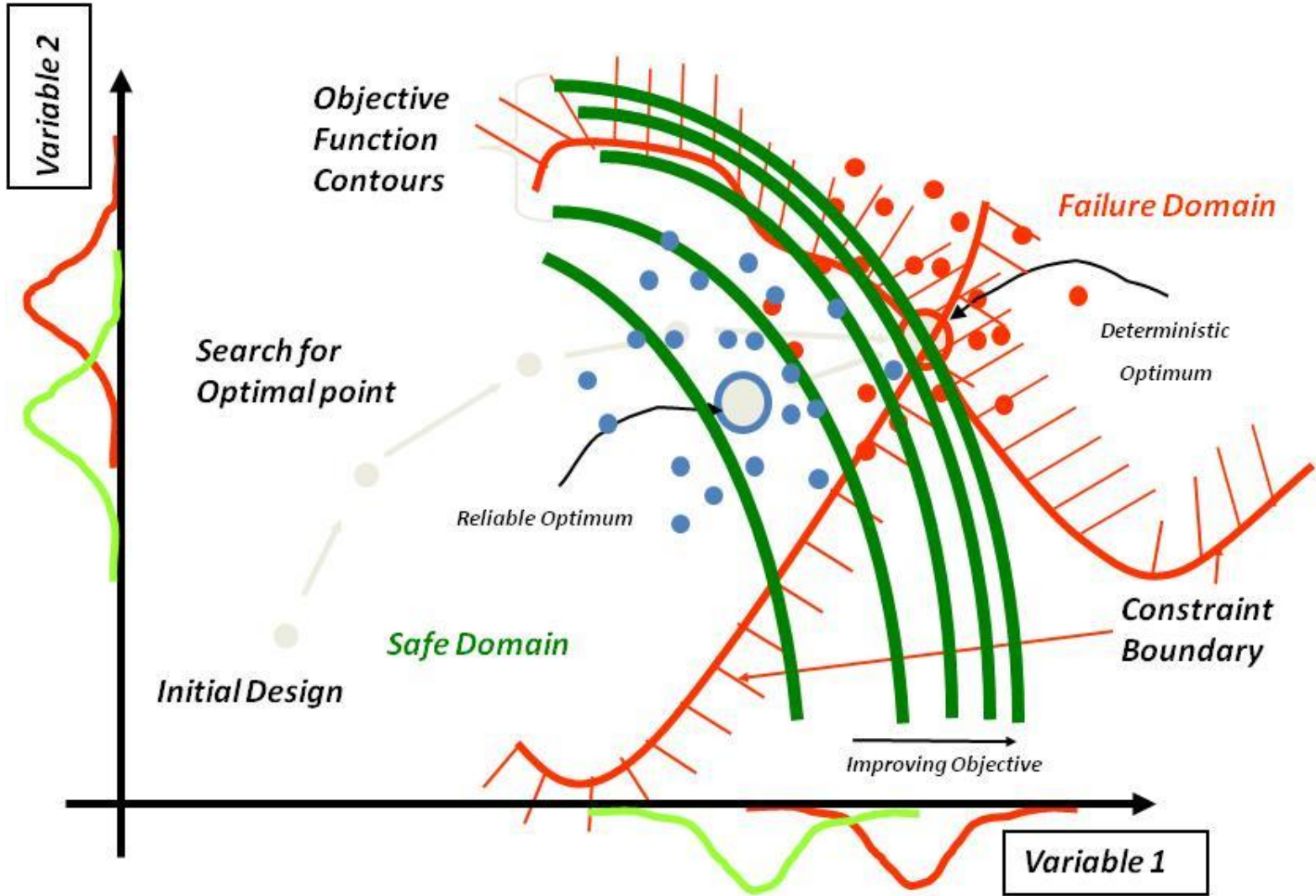
Coordinate decision making process among ship design generation tools and physics-based analysis tools



Exchange of information and interaction among disciplines; effects of uncertainty; sharing of design variables; coordination of mutually competing objectives and constraints.



Multi-Disciplinary Synthesis





Long Term Roadmap

Use Cases	CY 10	CY 11	CY 12	CY 13	CY 14	CY 15	CY16	CY 17	CY 18	CY 19
	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs
UC 1 ASSET Synthesis	Working	Working	100+	100+	100+	100+	100+	100+	100+	100+
UC 2 Hullform Transformation	Working	Working	1	1	100+	100+	100+	100+	100+	100+
UC 3 Hullform Generation	Start	Working	Working	Working	100+	100+	100+	100+	100+	100+
UC 4 Hullform - Intact and Damaged Stability		Start	Working	Working	1	1	100+	100+	100+	100+
UC 5 Hullform - Resistance Analysis			Start	100+	100+	100+	100+	100+	100+	100+
UC 6 Hullform - Maneuvering Analysis										
UC 7 Hullform - Seakeeping Analysis			Start	100+	100+	100+	100+	100+	100+	100+
UC 8 Hullform - Structural Analysis		Start ?	Working	Working	Working	1	1	1	1	1
UC 9 Ship Arrangement - functional complex allocation	Working	Working	Working	Working	Working	Working	1	1	100+	100+
UC 10 Arrangement - Internal Compartments (Outside in)	Working	Working	Working	Working	Working	Working	1	1	1	100+
UC 11 Ship Arrangement - compartment constraint management			Start	Working	Working	Working	1	1	1	1
UC 12 Arrangement - Component Placement						Start	Working	Working	1	1
UC 13 Arrangement - Routing of Distributed Systems								Start	Working	Working
UC 14 Arrangement - Internal Compartments (Inside out)									Start	Working
ASSET Version	ASSET 6.2	ASSET 6.3	ASSET 6.4	ASSET 6.5	ASSET 7.0	ASSET 7.1	ASSET 7.2	ASSET 7.3	ASSET 8.0	ASSET 8.1
ISA Version							ISA 1.0	ISA 1.1	ISA 2.0	ISA 3.0
LEAPS Version	LEAPS 4.2	LEAPS 4.3	LEAPS 4.4	LEAPS 5.0	LEAPS 5.1	LEAPS 5.2	LEAPS 5.3	LEAPS 5.4	LEAPS 5.5	LEAPS 6.0
RSDE Version		RSDE 1.Beta	RSDE 1.0	RSDE 2.0	RSDE 3.0	RSDE 4.0	RSDE 5.0	RSDE 5.1	RSDE 6.0	RSDE 4.0

1 Capability of performing one point Design using the RDI suite of tools

100+ Capability of generating a design space using the RDI suite of tools



Software Development Activities to CY 14



Use Cases		LEAPS - Hulltran Toolkit		ASSET - Hullform Utility (w Hulltran)		ISA - Arrangement Population to LEAPS		LEAPS - MDO Toolkit		LEAPS - Structure Definition in Focus		RSDE - Design Space Execution		LEAPS - Parallel Queries		LEAPS - 64 bit		LEAPS - Behavior Objects		LEAPS - Hullgen Toolkit		RSDE - With Resistance and Seakeeping Execution		ASSET NURBS Geometry and Arrangement		RSDE - With Hull Transformation and Generation	
		CY 11	CY 11	CY 11	CY 12	CY 12	CY 12	CY 13	CY 13	CY 13	CY 13	CY 13	CY 13	CY 13	CY 14	CY 14											
UC 1	ASSET Synthesis	1																									
		100+																									
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		100+	X			X						X											X			X	
UC 3	Hullform Generation	1																									
		100+				X						X											X			X	
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		100+				X					X	X	X	X									X			X	
UC 5	Hullform - Resistance Analysis	1																					X				
		100+				X					X	X	X	X									X				
UC 7	Hullform - Seakeeping Analysis	1																					X				
		100+				X					X	X	X	X									X				
UC 8	Hullform - Structural Analysis	1																									
							X																	X			
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		100+				X	X				X	X	X											X			
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		100+				X	X				X	X	X											X			
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UC 12	Arrangement - Component Placement	1				X																			X		
		100+				X	X				X	X	X											X			
UC 13	Arrangement - Routing of Distributed Systems	1				X																			X		
		100+				X	X				X	X	X											X			
UC 14	Arrangement - Internal Compartments (Inside out)	1				X																			X		
		100+				X	X				X	X	X											X			





QUESTIONS ?



Backup



Short Term Development Activities



CY 11

- Hullform Transformation capability added to ASSET hullform utility (CY 11 Delivery with ASSET 6.3).
- Start changing Hull definition in ASSET to NURBS for full integration with Hulltran (CY 14 delivery with ASSET 7.0).
- Intelligent Ship Arrangements population to LEAPS database

CY 12

- Start Hull Subdivision and Deckhouse in ASSET changed to NURBS for integration with Hulltran for parametric ship geometry manipulation (CY 14 delivery with ASSET 7.0).
- Start 64 bit version of LEAPS to handle large models and large datasets (CY 13 delivery with LEAPS 5.0).
- Complete Multidisciplinary Optimization LEAPS Toolkit .
- Complete LEAPS Structural Definition in LEAPS Focus model.
- Complete Rapid Ship Design Environment 1.0:
 - ASSET Synthesis
 - Hull Transformation capability.



CY11 Deliverables

- **Rapid Ship Design Environment:**
 - Beta testing of Rapid Ship Design Environment with design space exploration.
 - Detailed use case execution plan for all elements.
 - Detailed roadmap for Multidisciplinary Design Synthesis MDS solver and Rapid Ship Design Environment.
- **ASSET:**
 - Hullform transformation toolkit integration with the ASSET hullform utility.
- **LEAPS:**
 - Behavior object software development plan and requirements specification.
- **ISA:**
 - Arrangements population to LEAPS database



Damage Stability

LeapsSHCP - [DDGXBaseline[ship_0000001-1]]

File Edit View Window Help

SHCP

- Ship Geometry
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 - 3-50-0
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 - 2-50-0

Iteration 8, Volume Difference = 0.003, LCG Difference = 0.003
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For Help, press F1

SHCP

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Transverse Righting Arm

Floodable Length



