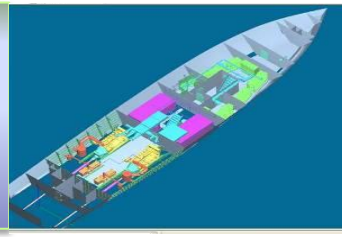
LEAPS

CREATE
Computational Research & Engineering Acquisition Tools & Environments

ASSET
NSWCCD

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.

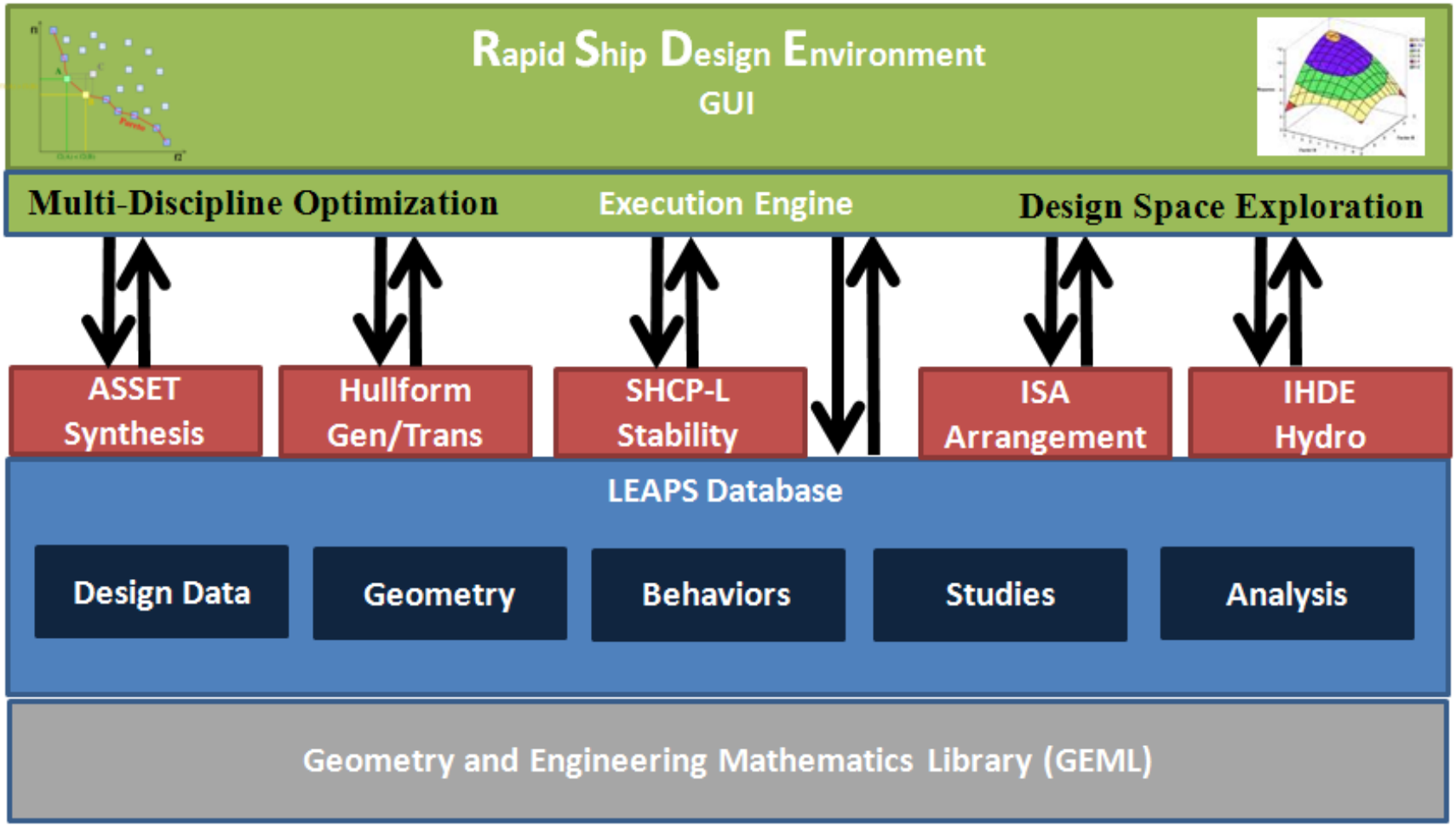
RDI will use high performance computing resources to reduce the time required to perform these activities, so that they can be completed within the decision cycle of early stage design or mid-life upgrade studies.

Product Architecture

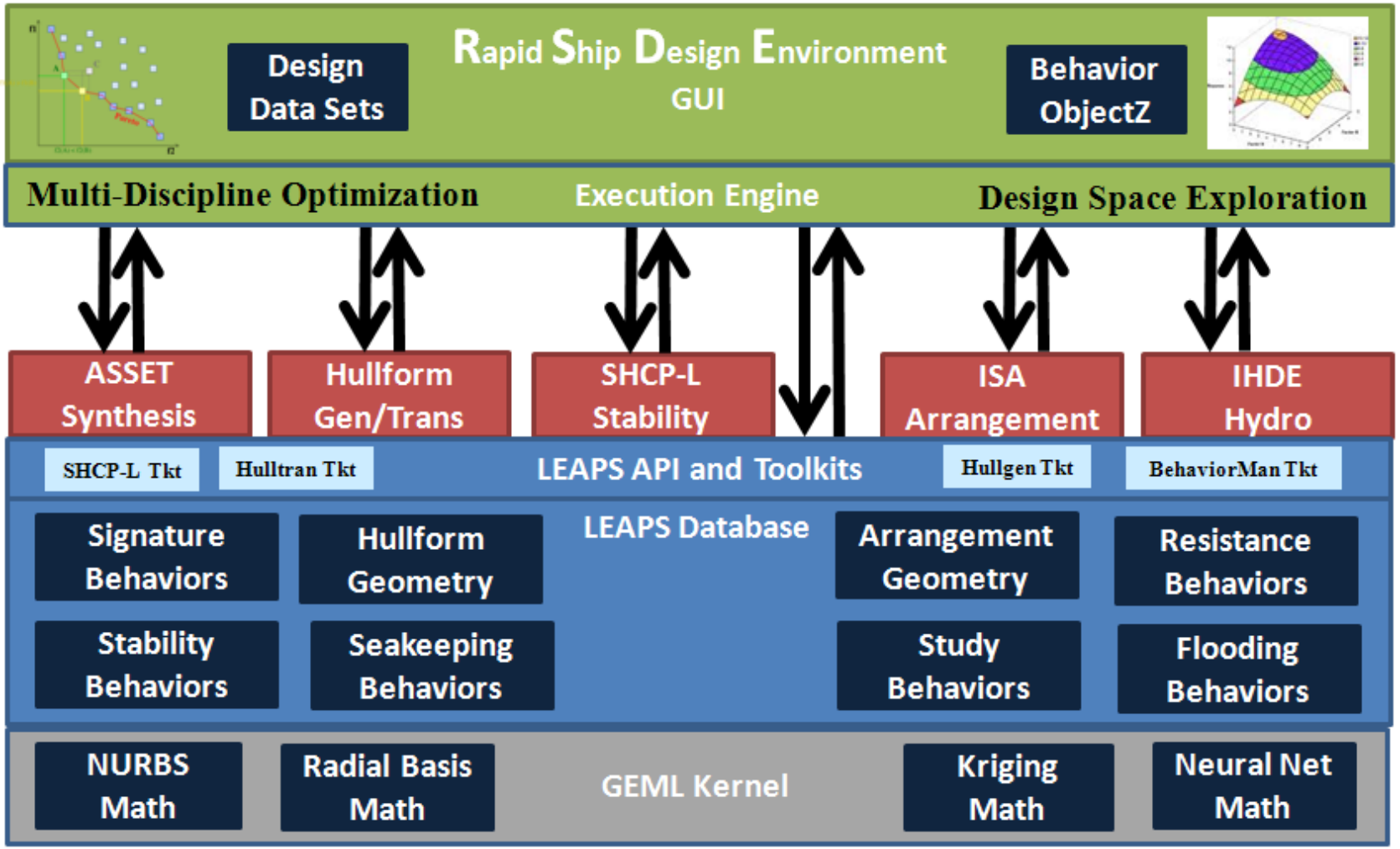
- The CREATE-Ships RDI effort produces 1 Product:
  - Rapid Ship Design Environment (RSDE)
    - New Design Space Exploration capability
    - New Multi-Disciplinary Synthesis capability

  - 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

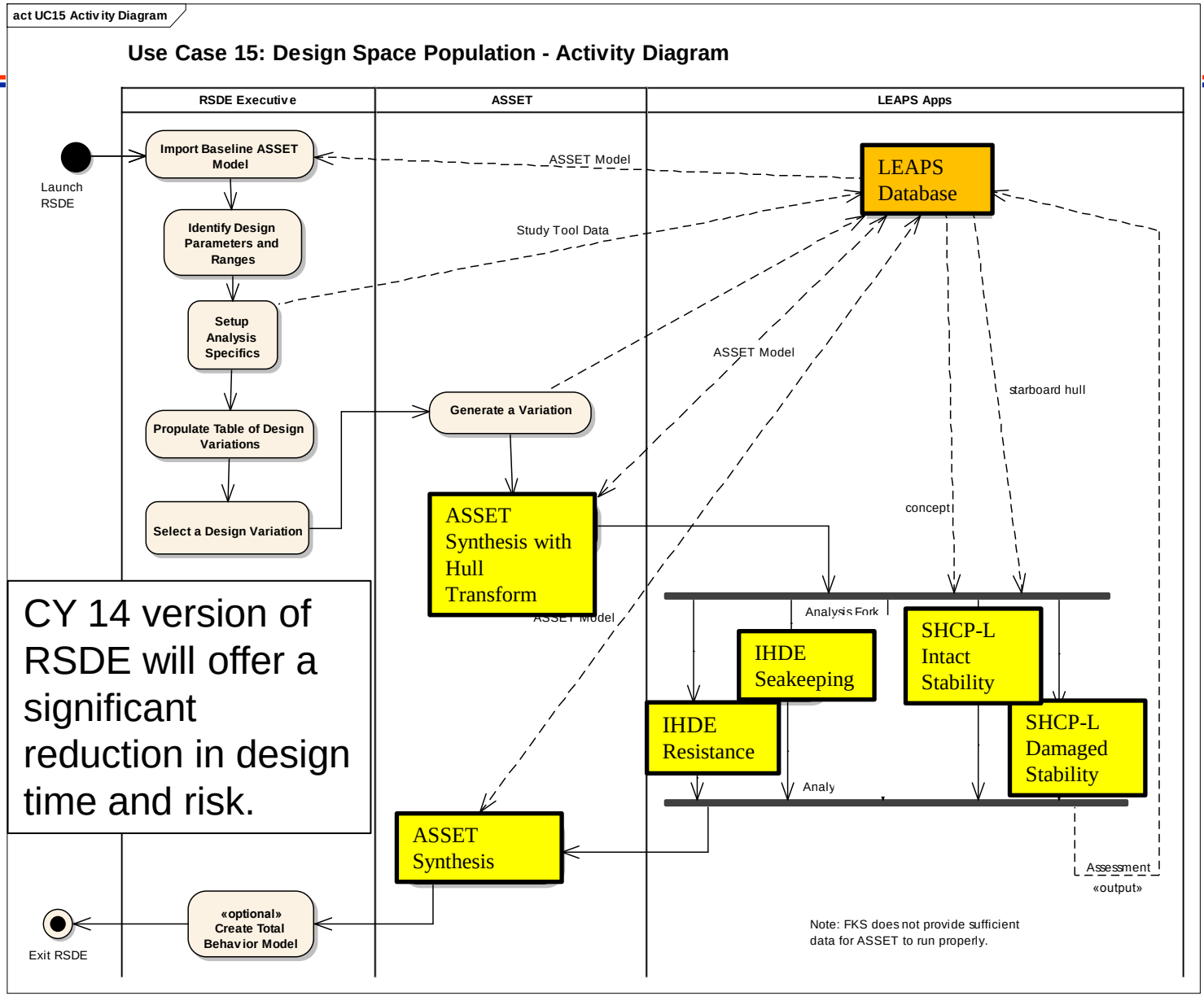
B. Analyze the space of designs (and excursions from that space) for a large number of engineering and physics disciplines at a detailed level, with the results forming the basis of behavior objects that will be used in a multidisciplinary synthesis process.

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

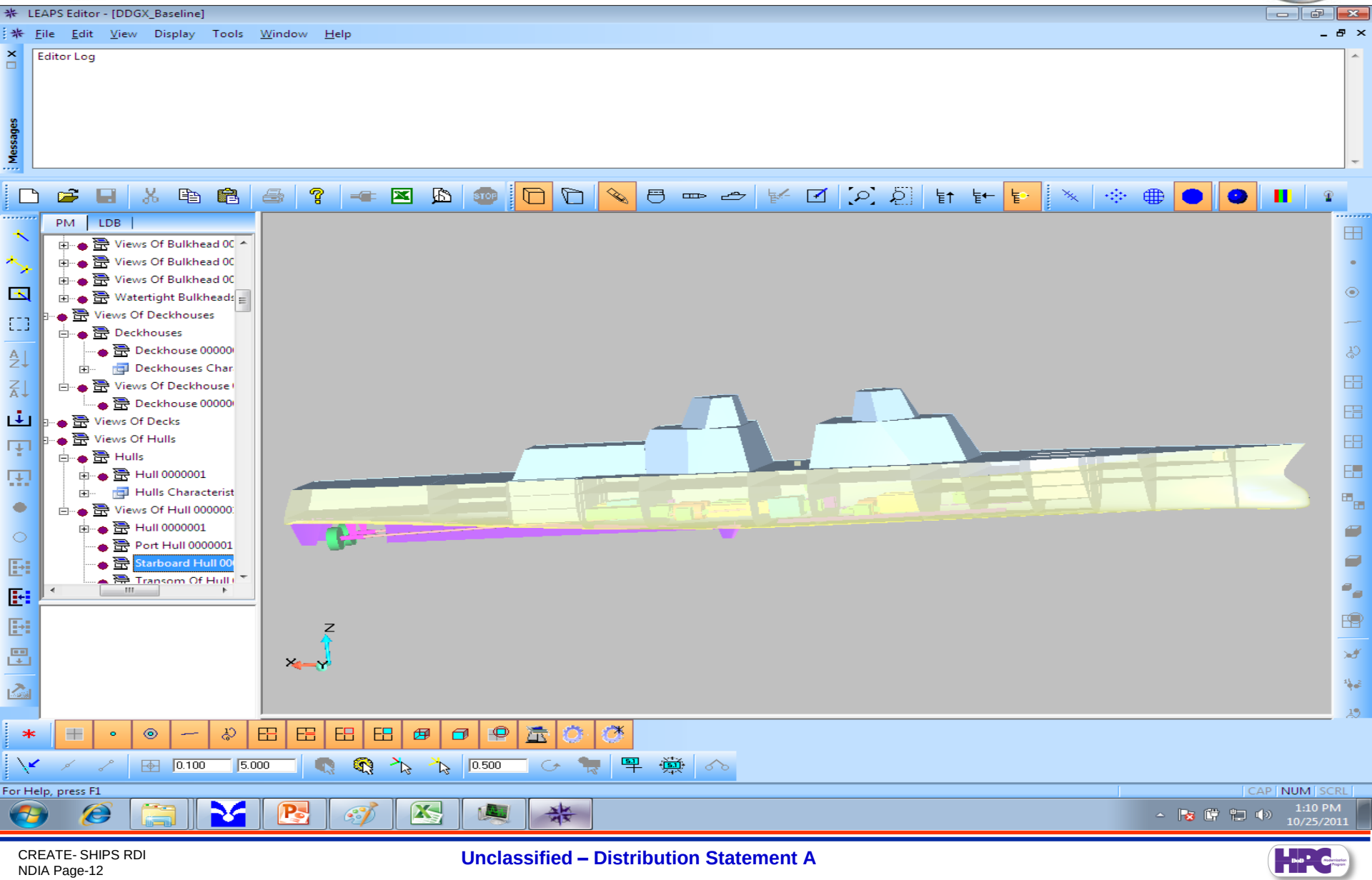
C. Develop an optimized, balanced design, at the concept level. A balanced design is a ship design that meets the engineering requirements for sizing the hull and deckhouse, determining the subdivision/arrangement, and sizing ship systems/components.

UC 16 – Design Optimization

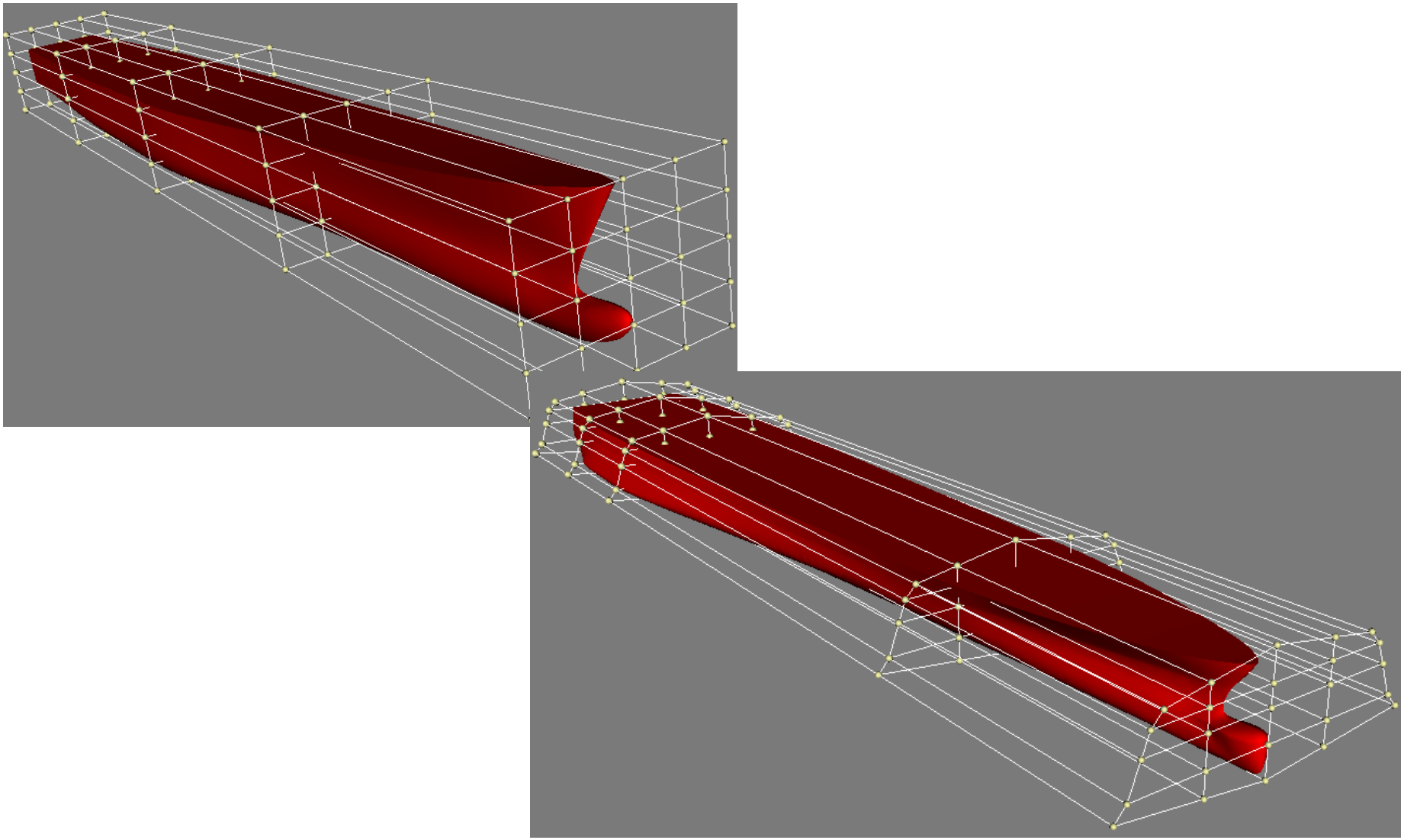
RSDE CY 14 Use Case



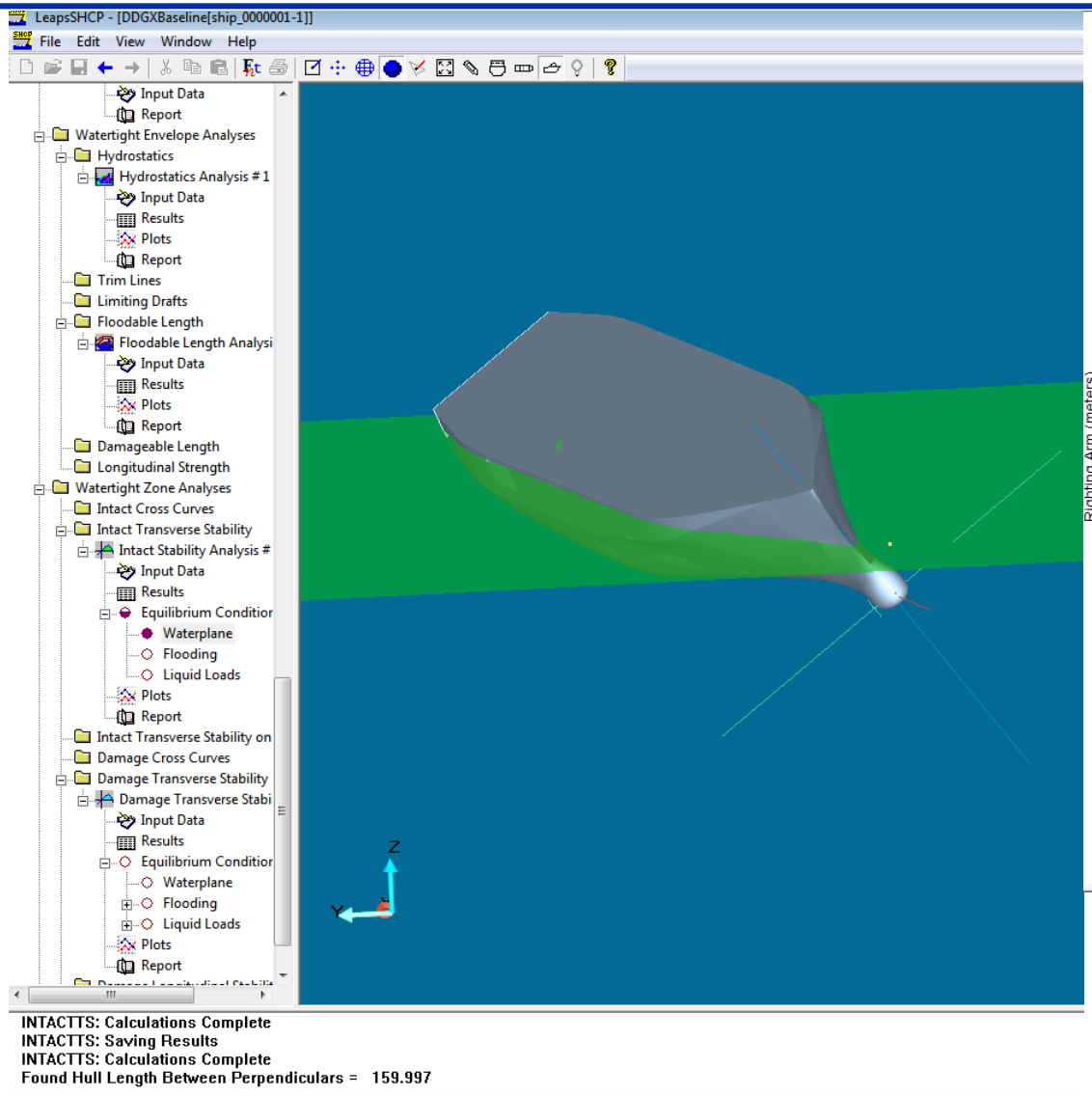
Ship Synthesis (using ASSET)

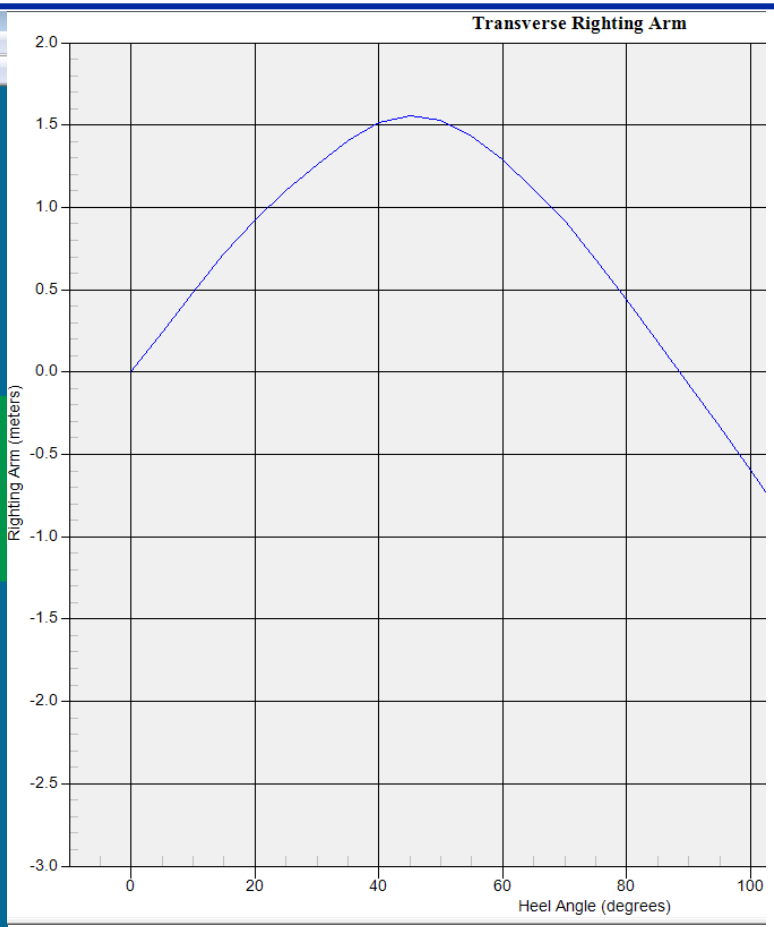


Hull Transformation Approach

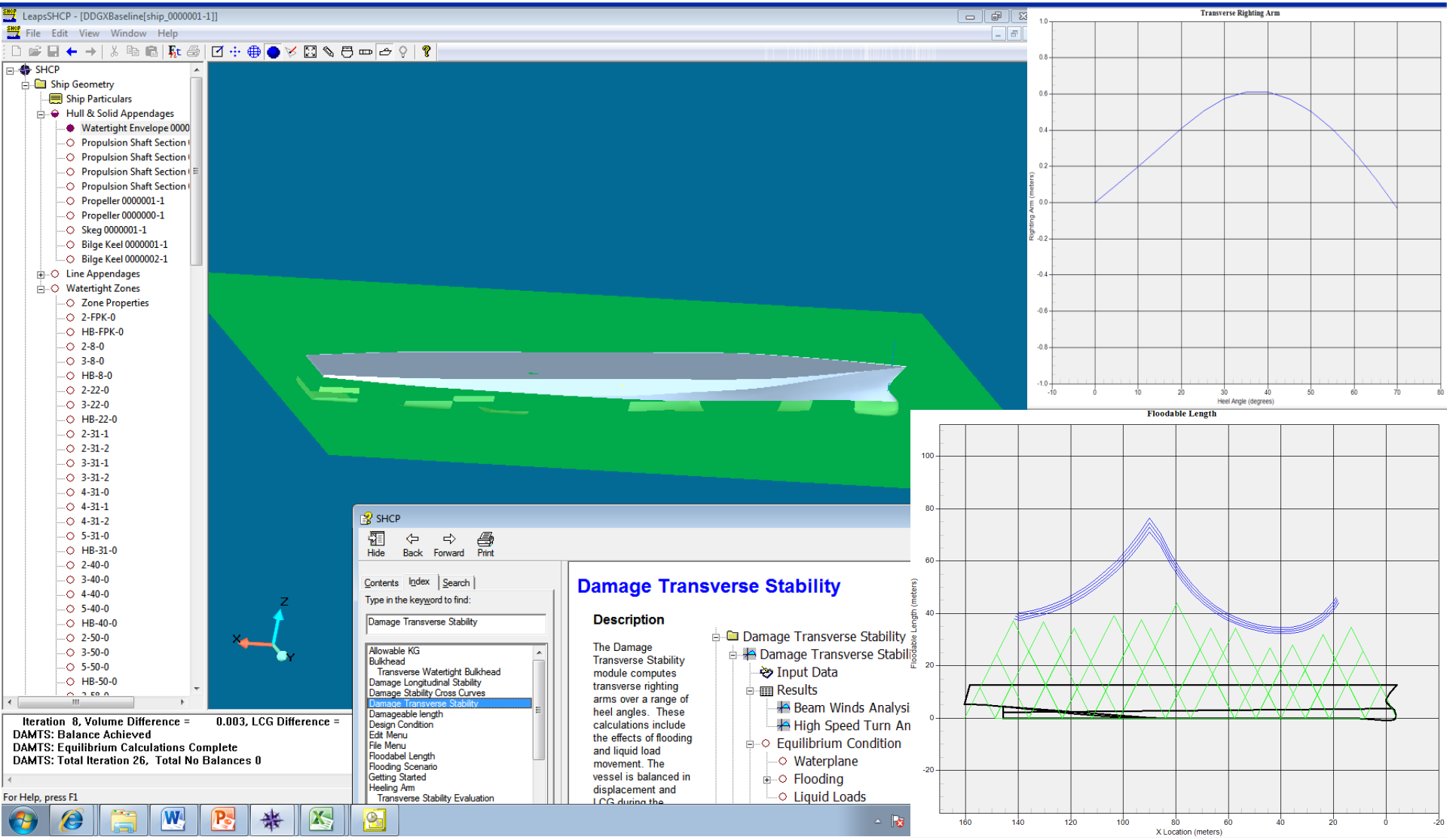


Intact Stability using SHCP-L

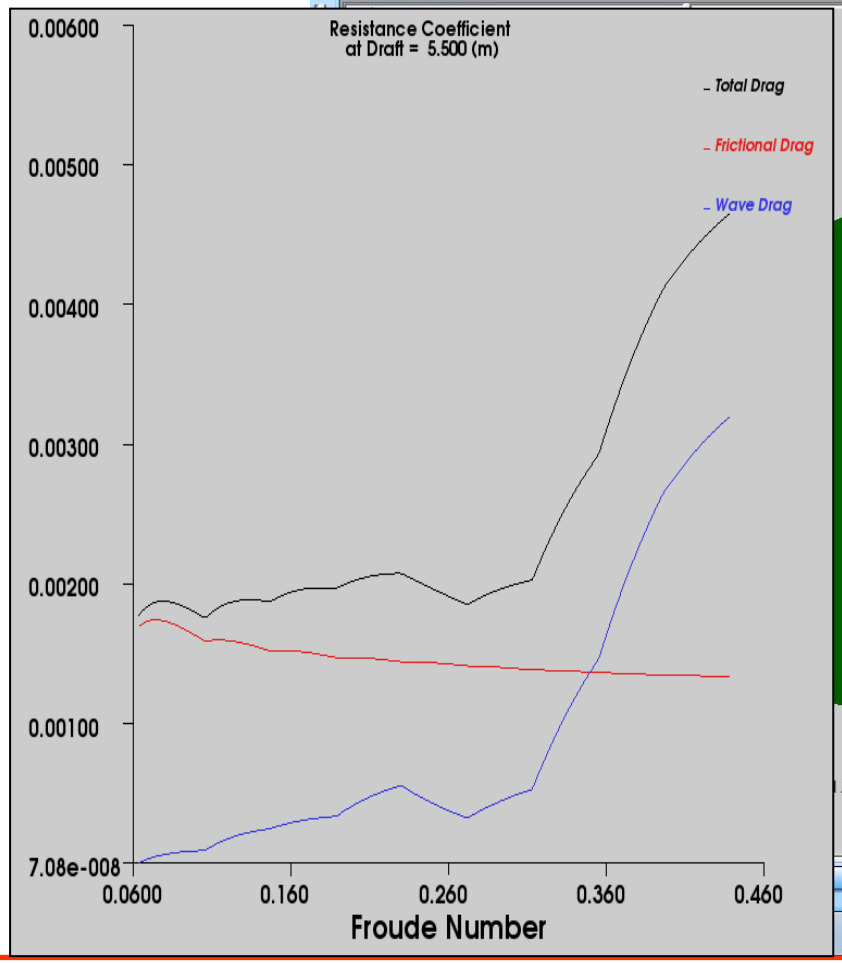


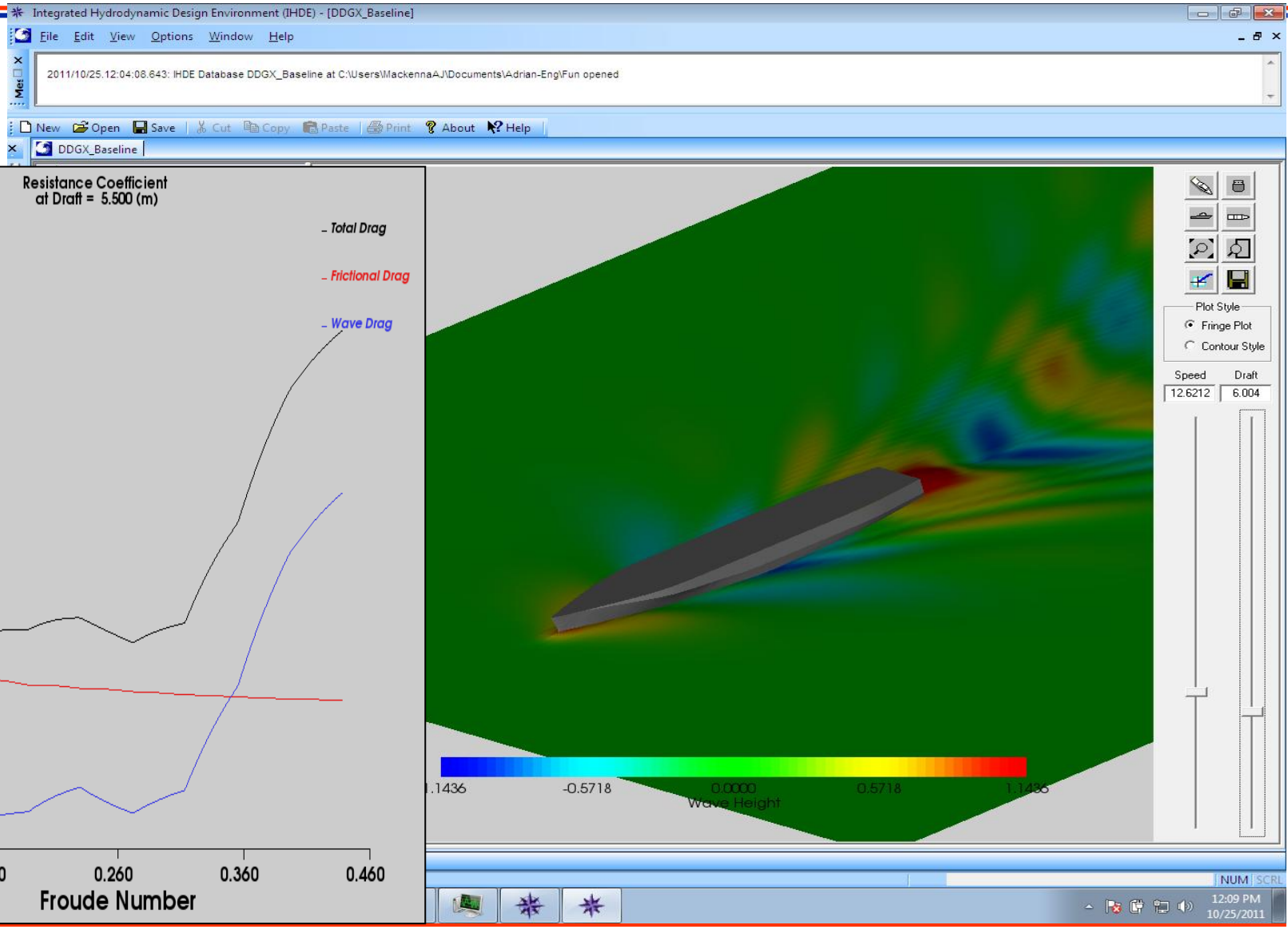


Damage Stability using SHCP-L

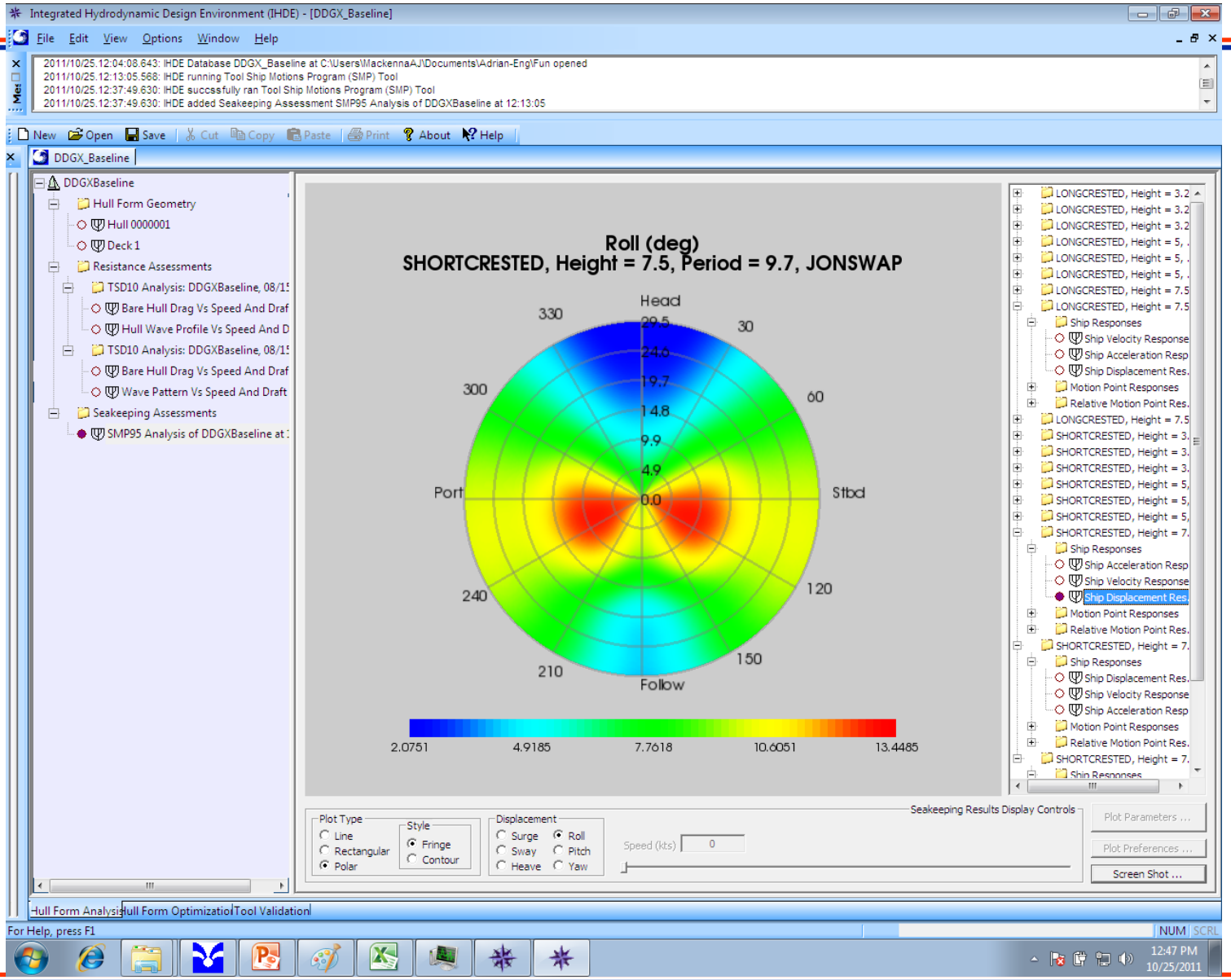


Resistance Analysis using IHDE



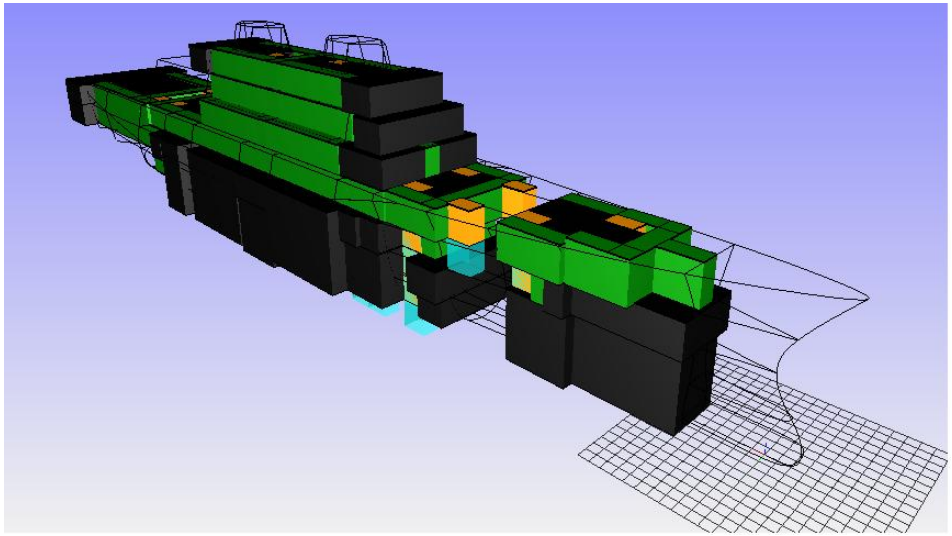


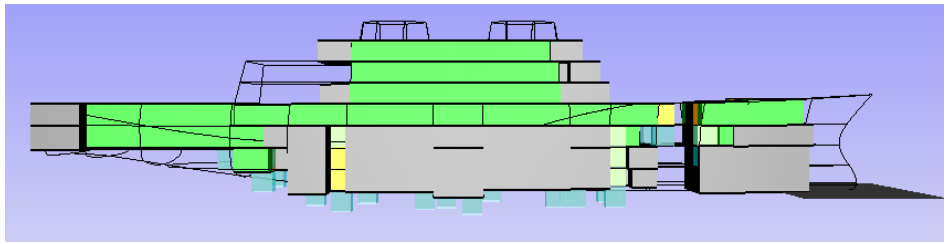
Seakeeping Analysis using IHDE

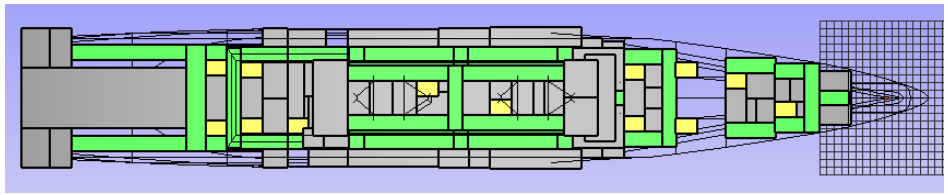


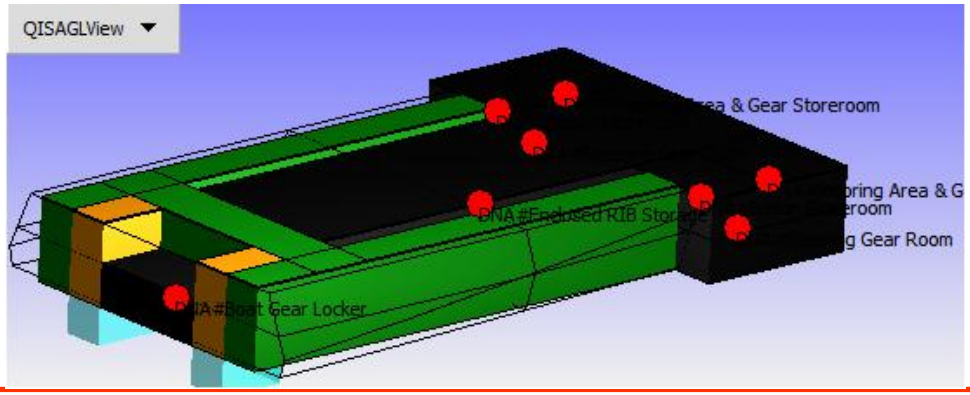
Intelligent Ship Arrangements (ISA)

- **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



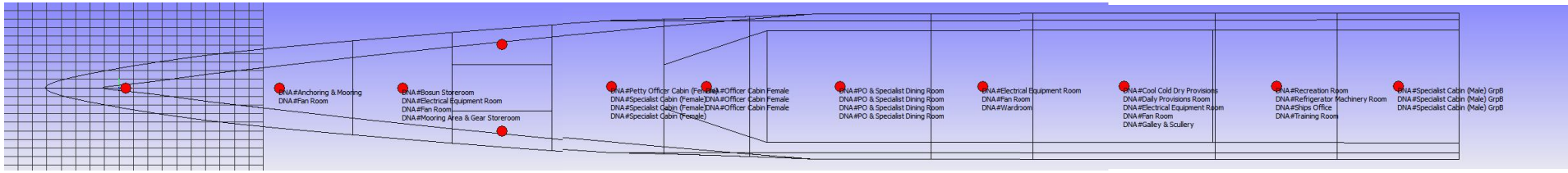




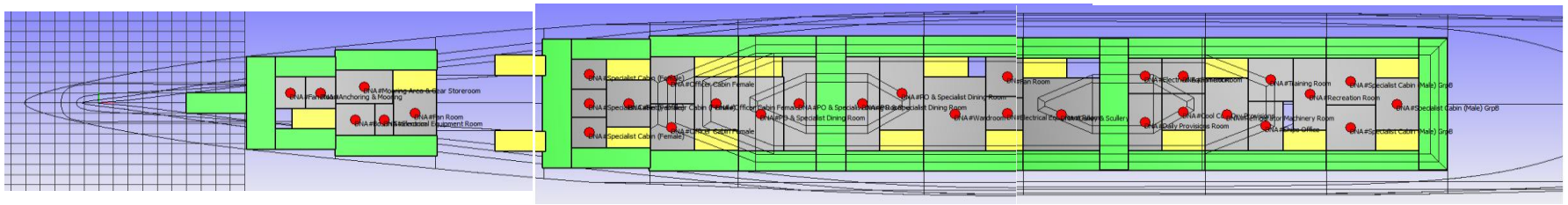


Intelligent Ship Arrangements (ISA)

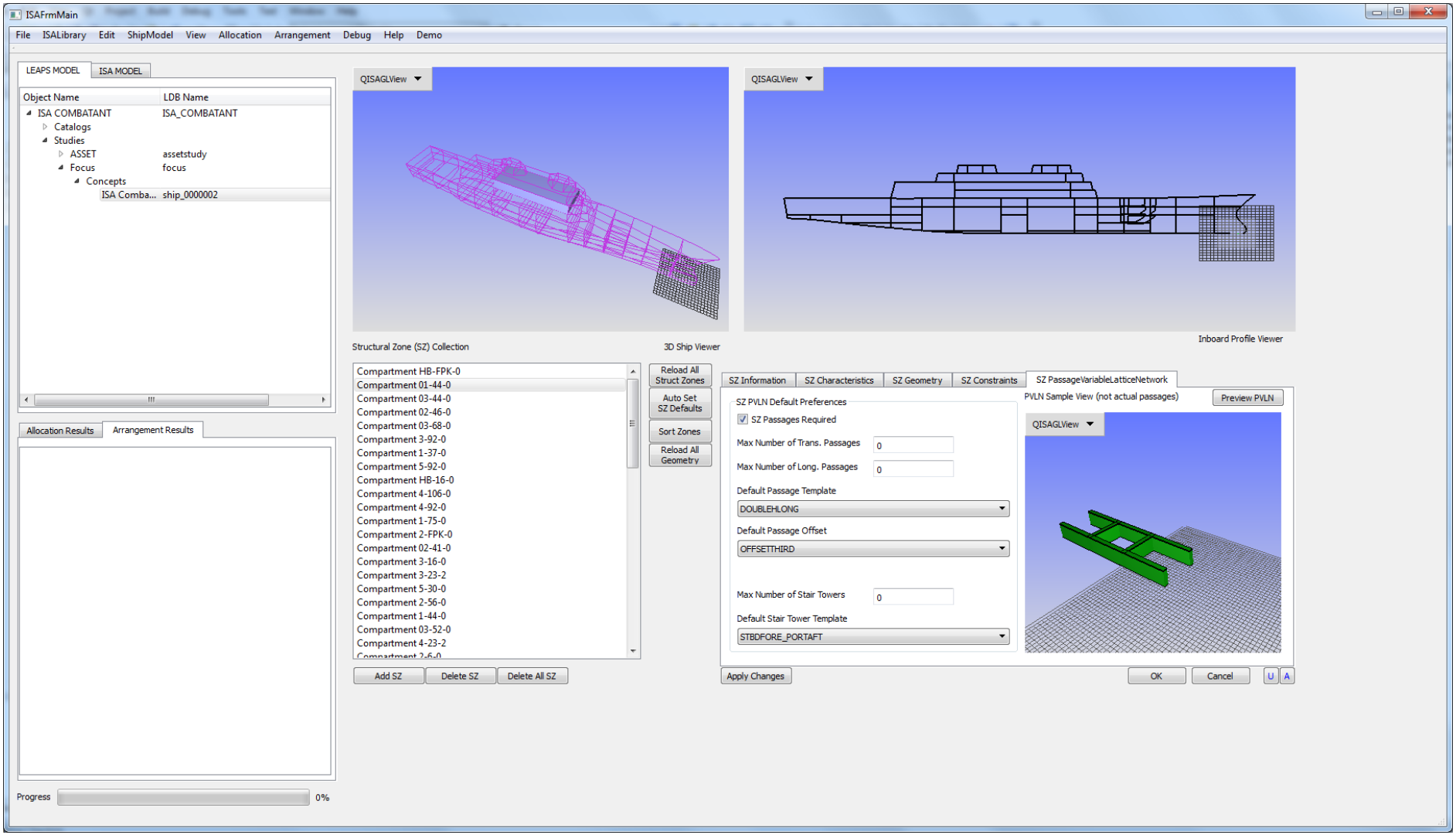
Allocation Step



Arrangement Step



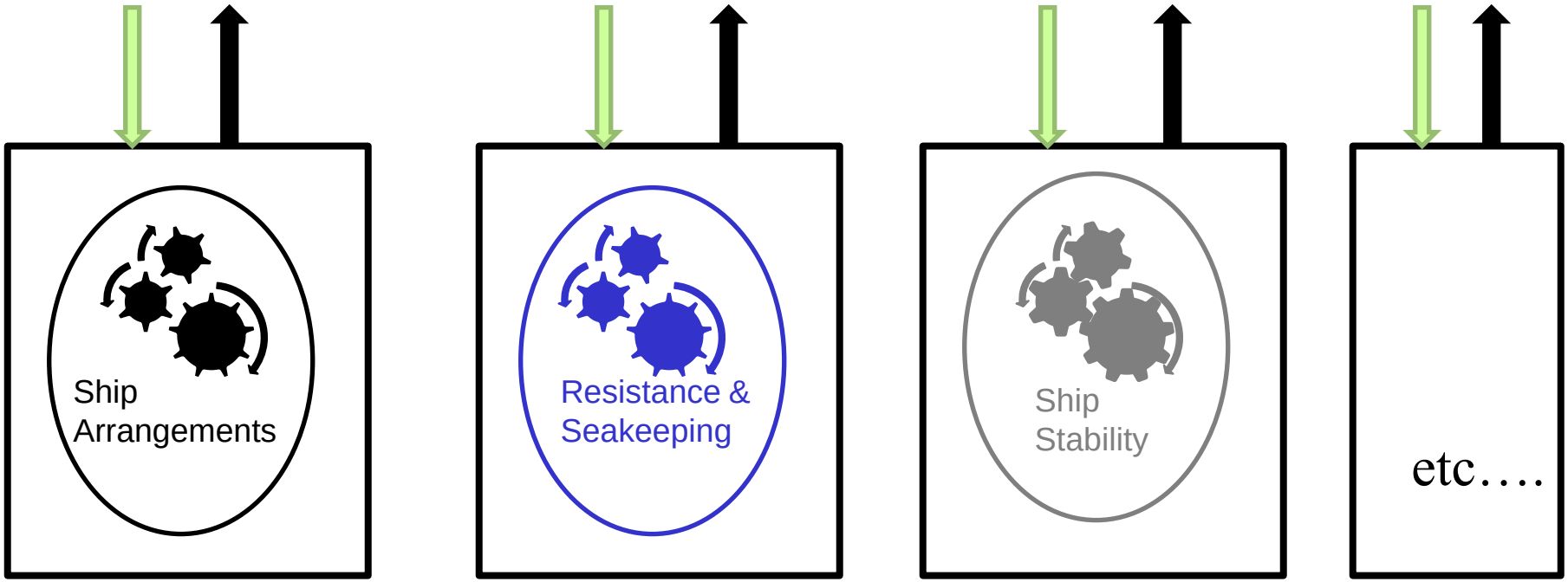
ISA Graphical User Interface



Multi-Disciplinary Synthesis

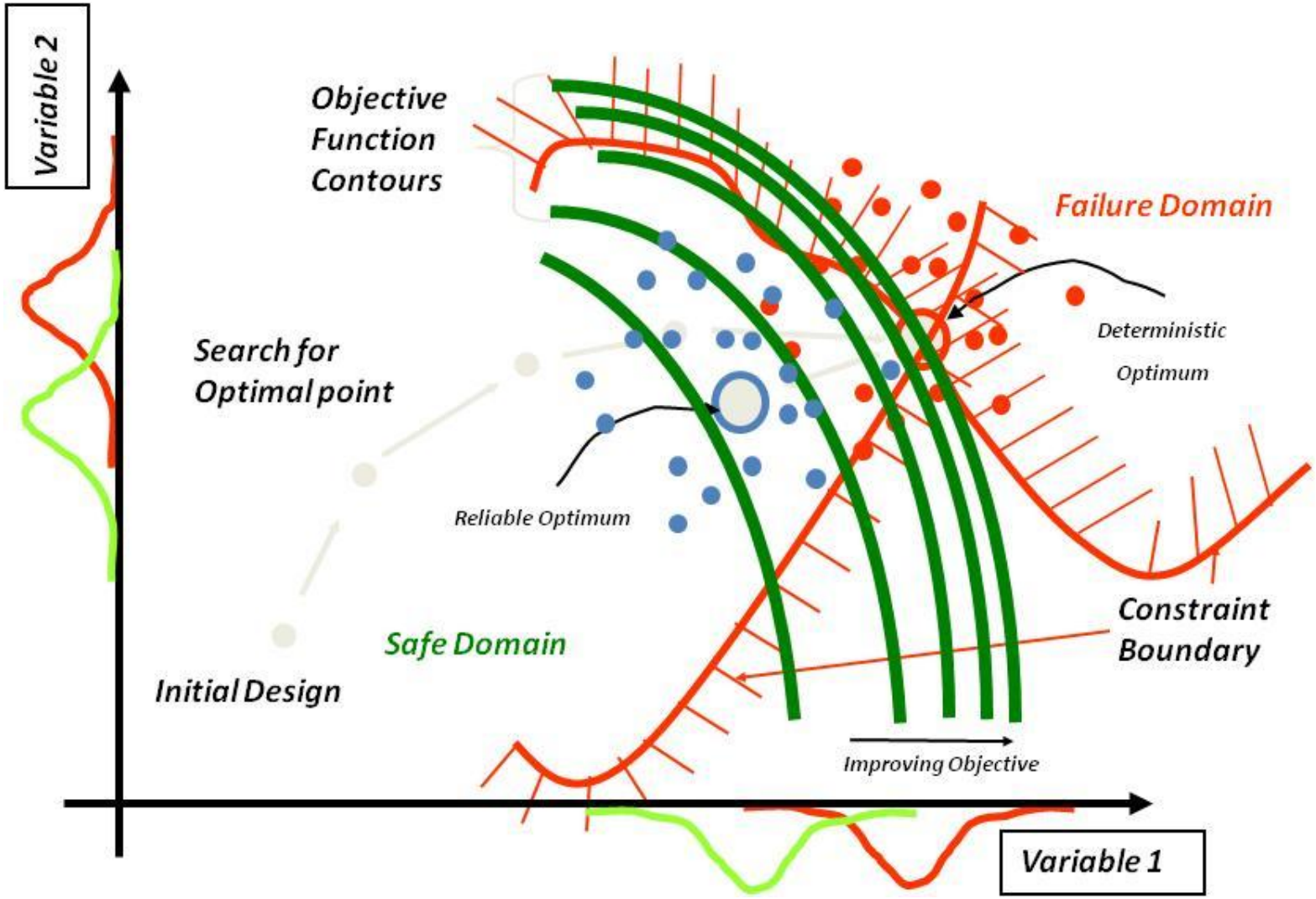
MDS (Multi-Discipline hierarchical Systems engineering)

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 Number of Ship Designs	CY 11 Number of Ship Designs	CY 12 Number of Ship Designs	CY 13 Number of Ship Designs	CY 14 Number of Ship Designs	CY 15 Number of Ship Designs	CY16 Number of Ship Designs	CY 17 Number of Ship Designs	CY 18 Number of Ship Designs	CY 19 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	Capabilities		LEAPS - Hullran Toolkit	ASSET - Hullform Utility (w Hullran)	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 Module	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	CY14	CY 14
UC 1	ASSET Synthesis	1						X							
		100+						X							
UC 2	Hullform Transformation	1	X	X				X							
		100+	X			X		X		X				X	X
UC 3	Hullform Generation	1										X		X	X
		100+				X		X		X		X		X	X
UC 4	Hullform - Intact and Damaged Stability	1												X	X
		100+				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	
UC 9	Ship Arrangement - functional complex allocation	1			X									X	
		100+			X	X		X	X	X				X	
UC 10	Arrangement - Internal Compartments (Outside in)	1			X									X	
		100+			X	X		X	X	X				X	
UC 11	Ship Arrangement - compartment constraint management	1			X										
		100+			X	X		X	X	X					
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 .

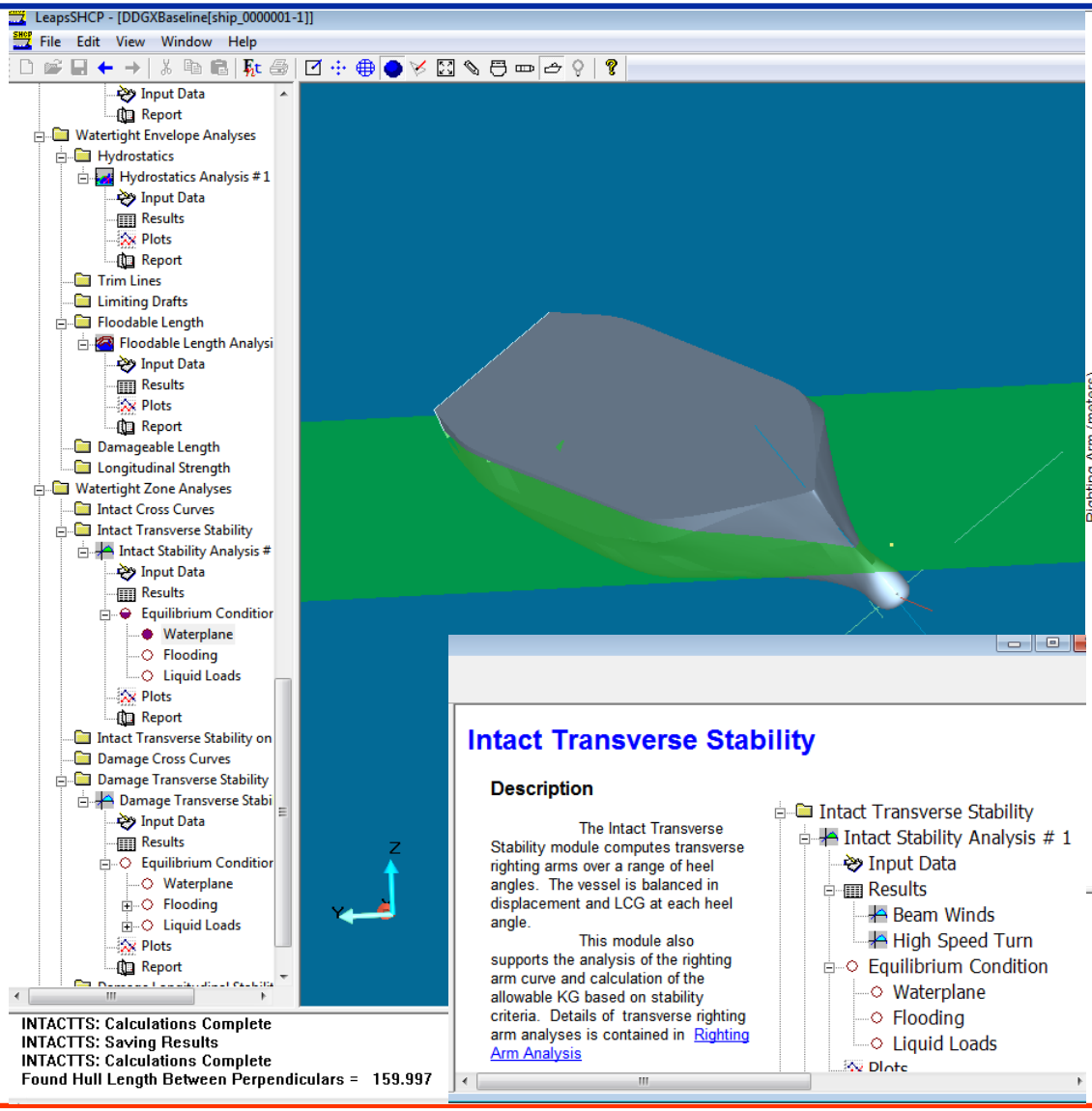
•Complete LEAPS Structural Definition in LEAPS Focus model.

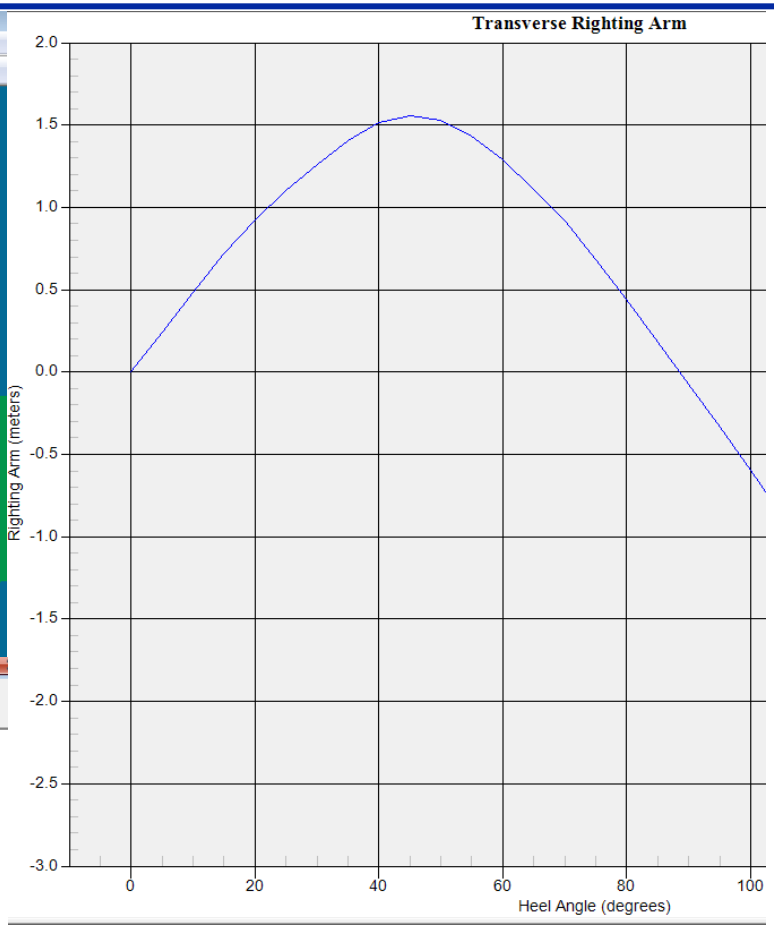
•Complete Rapid Ship Design Environment 1.0:
- •ASSET Synthesis
- •Hull Transformation capability.

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

Intact Stability





Damage Stability