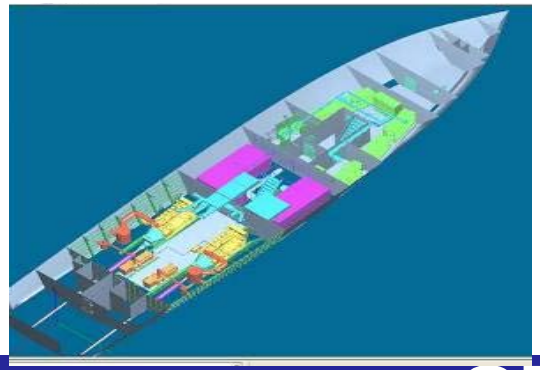


CREATE-Ships Project

Physics-based Modeling In Design & Development for U.S. Defense Conference 14-17 Nov 2011

Myles Hurwitz
DoD High Performance Computing Modernization Program Office

Typical Definition and Evaluation Processes Through Contract Design

Geometry Definition	Selection of Other Ship Design Analyses
Hullform Design	Airflow Analysis
Compartmentation and Arrangements	Combat Systems Engineering
Structural Definition	Communications Systems Analysis
Location of Key Components	Control Systems Engineering
Routing of Key Distribution Systems	Deck Systems Engineering
Hydrodynamics	Deckhouse Systems Engineering
Resistance and Powering Analysis	Electromagnetic Engineering
Seakeeping and Loads Analysis	Hull Girder Ultimate Strength Analysis
Maneuvering Analysis	Fluid Systems Engineering
Dynamic Stability Analysis	FEA Structural Analysis
Damage Stability Analysis	Manning Analysis
Propulsor Performance Analysis	Power Systems Analysis
Survivability	Propulsion Systems Analysis
Susceptibility	RM&A Analysis
Acoustic Signature Analysis	Steering and Maneuvering Controls
Infrared Signature Analysis	Structural Cost and Producibility Assessment
Magnetic Signature Analysis	Total Ship Cost Analysis
Radar Cross Section Analysis	Underway Replenishment Analysis
Vulnerability – UNDEX-Shock/Damage	Weapons Handling and Aircraft Support
Recoverability	Weight and Moment Analysis

- **From D. Billingsley – former NAVSEA lead for design tools, and**
- **From H. Fireman, former Director, Future Concepts and Surface Ship Design Group, presentation to CREATE, 6 Apr 2007**

The CREATE-Ships Project

- **Addresses three primary challenges**
  1. Shock/Damage response for a wide range of explosive events
     - Shock/Damage Product (NESM: Navy-Enhanced Sierra Mechanics)
       - Lead: Dr. E. Thomas Moyer (NSWC-Carderock) (Senior Research Scientist for Ship Survivability M&S)
  2. Hydrodynamics analysis of new, innovative ship designs and improvements to existing designs
     - Integrated Hydrodynamics Design Environment Product (IHDE)
     - Full-physics RANS Product (NavyFOAM)
       - Lead: Dr. Joseph Gorski (NSWC-Carderock) (Head, Computational Hydromechanics Division)
  3. Rapid Design and Integration : Comprehensive/Timely Concept Design Space Exploration
     - Rapid Ship Design Environment Product (RSDE)
       - Lead: Mr. Seth Cooper (NAVSEA) (Technology Group Tools Project Manager)
       - Lead: Mr. Adrian Mackenna (NSWC-Carderock) (Team Lead, Ship Design Tools Implementation)

CREATE-Ships Objectives for Shock/Damage

- **Develop robust capability to predict the response of surface ships & submarines to underwater explosion (UNDEX) loading for:**
  - **System/Component Environments**
  - **Structural Response & Damage**
  - **Scenarios (Use Cases)**
    - **Stand-Off UNDEX**
    - **Close-In UNDEX**
    - **SURFEX (e.g., USS Cole)**
    - **AIREX**
- **Interface w/ Ship State Modeling in earlier stages of design with tools such as:**
  - **ASAP/ARM (Advanced Survivability Assessment Program/Advanced Recoverability Module)**
  - **FASST (Fully Automated Ship Shock Tool – fast computational model preparation)**

NESM Development Approach

Enhanced GEMINI

Euler solver

Shock and Fluid Dynamics

Navy Enhanced Sierra Mechanics (NESM)

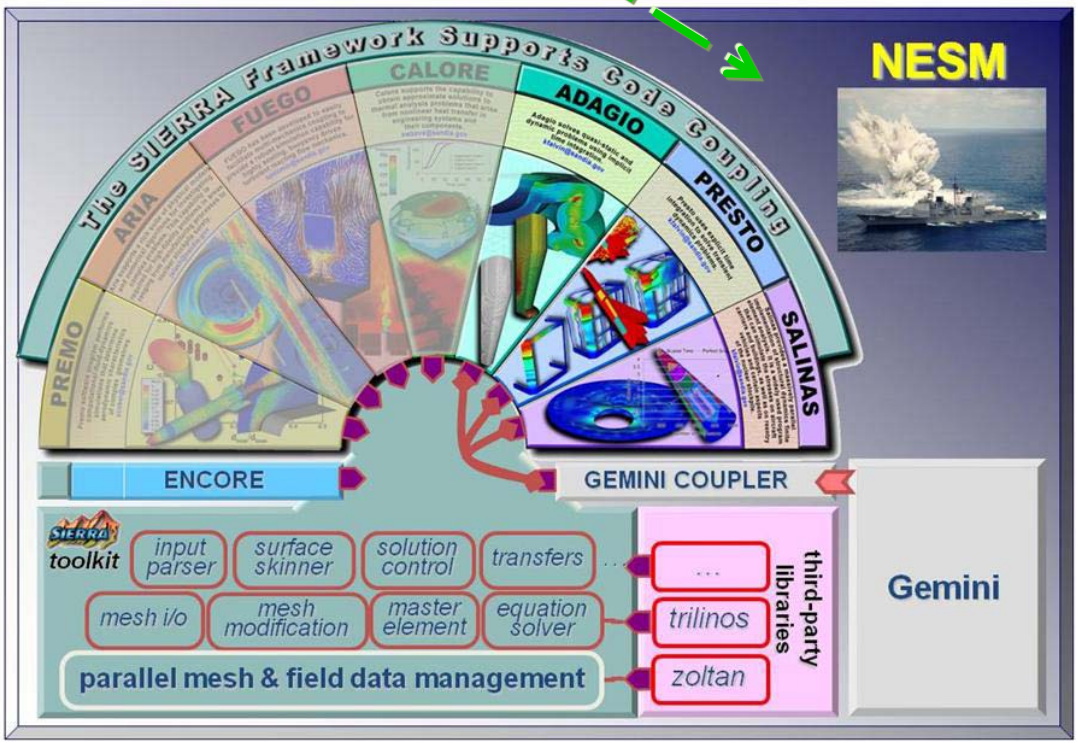
SOA Lagrange Solvers w/ Navy Enhancements

Leveraging DOE (SIERRA) Investment

Evolving Coupler Interface

Optimized Fluid-Structure Interaction

Leveraging Navy (DYSMAS) Investment



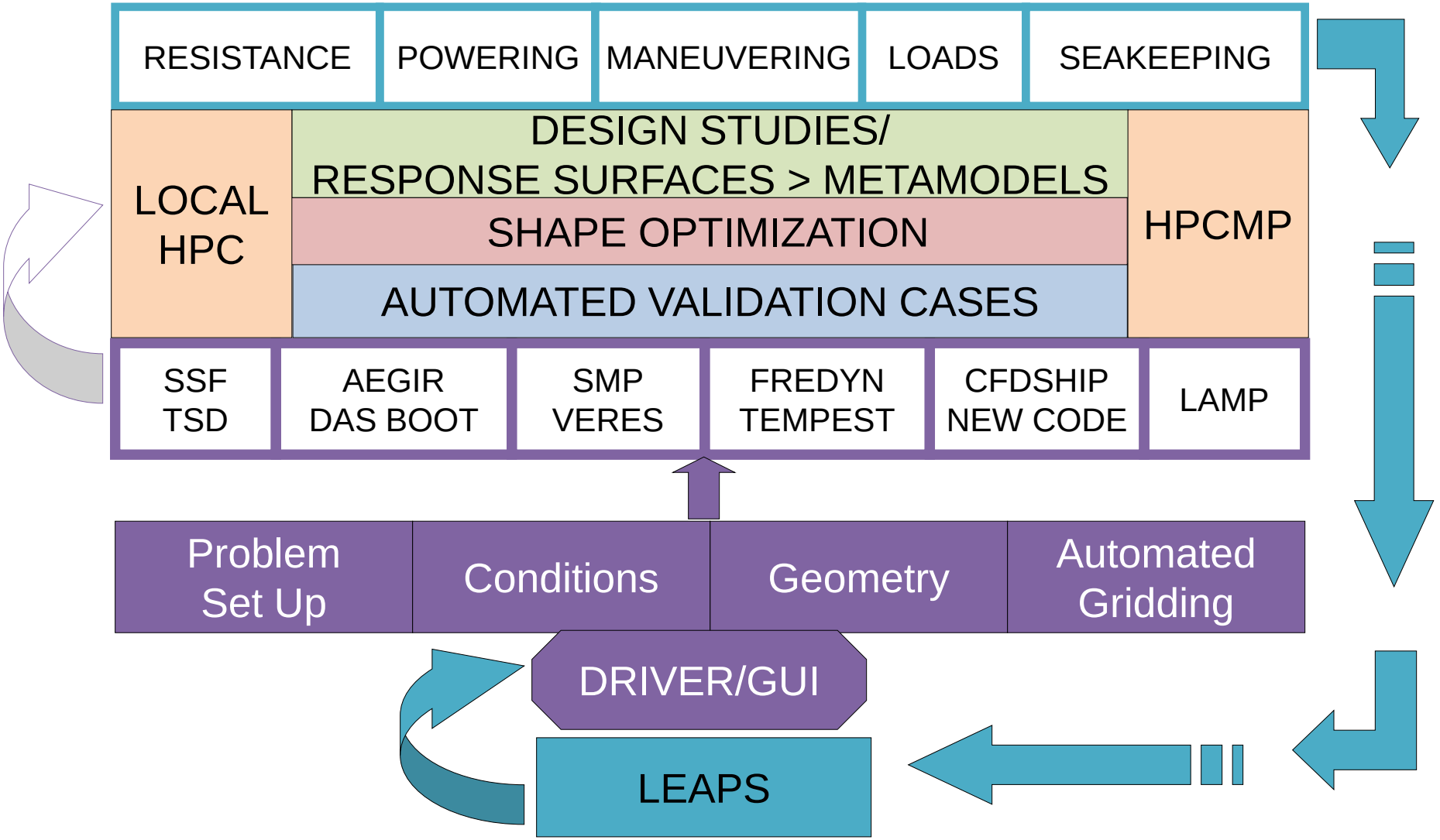
CREATE-Ships Objectives for Hydrodynamics

- **Provide the US Navy community with a suite of analysis methods that can be used to impact design and analysis**
  - **Existing and evolving semi-empirical methods for fast turnaround needs**
  - **Use of existing high-end methods where appropriate, within required timeframes**
  - **New CREATE-developed high-fidelity capability with a minimum of empiricism**
- **Provide an integrated user design environment for using these different levels of fidelity methods by users in both the design and analysis domains**
  - **Simultaneously optimize and evaluate different disciplines (e.g., resistance, powering, maneuvering, seakeeping)**

CREATE-Ships Hydrodynamics Products

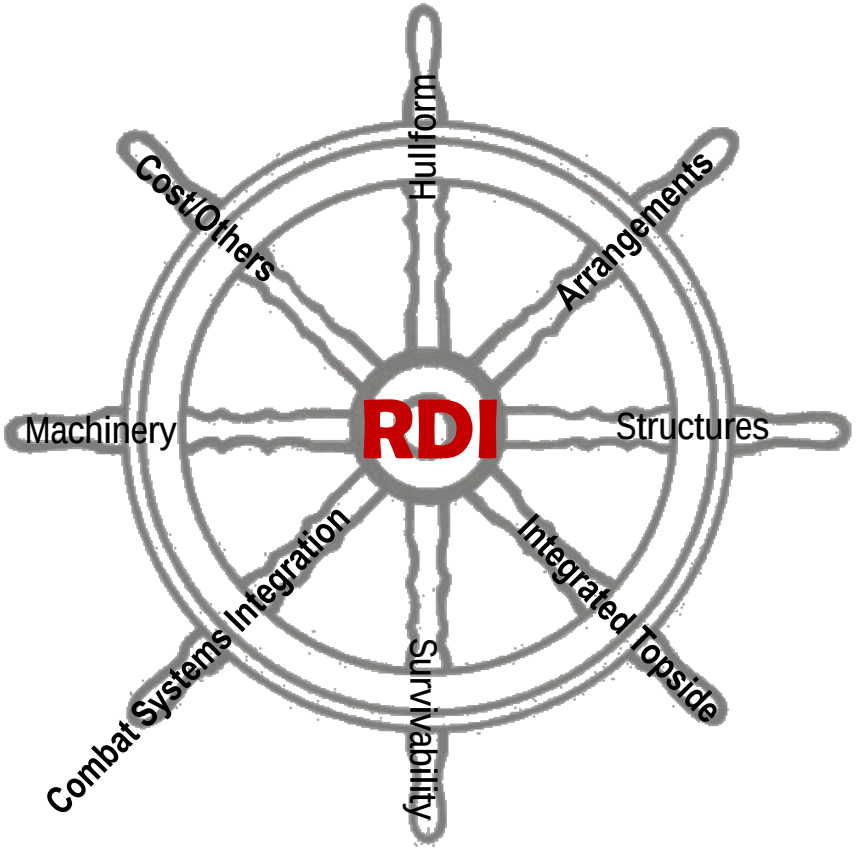
- **NavyFOAM**
  - High-end (full physics) code, Reynolds Averaged Navier-Stokes (RANS) as well as large eddy simulation (LES) capabilities
  - Based on open source code OpenFOAM (significant international user base)
  - Applicable to ships, submarines, propulsors.
  - Currently geared towards typical RANS experts
- **Integrated Hydrodynamics Design Environment (IHDE)**
  - Automated work flow process of using existing hydrodynamic analysis tools
  - Interoperability with LEAPS (Leading Edge Architecture for Prototyping Systems)
  - Focus on surface ships and earlier stages of design process
  - Geared toward designers (also improved process for current users of candidate codes)
- **Use Cases associated with Resistance, Powering, Maneuvering, and Seakeeping**

Integrated Hydrodynamics Design Environment

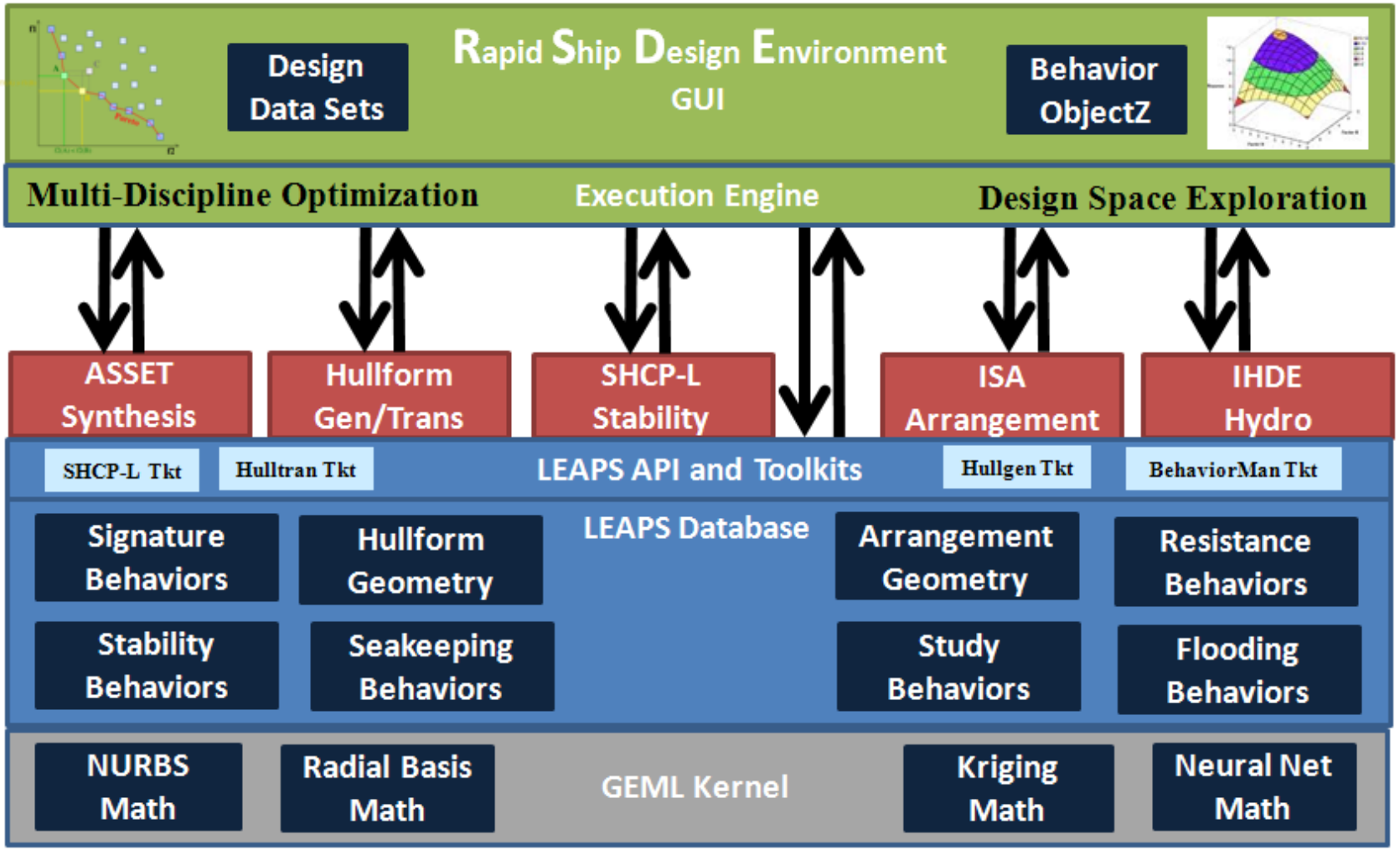


Rapid Design and Integration (RDI) Enabling Concepts

- **Design Space Exploration, Optimization and Visualization**
  - Hullform Transformation
  - Hullform Generation
  - Arrangements (Interior and Topside)
  - Behavior Models/Response Surfaces/Neural Nets/Kriging
  - Multidisciplinary Optimization
- **Generate, Explore, Evaluate**
- **Standard Product Model Data Structure**
  - Analysis Activity Integration



RSDE - Product Architecture



From: RADM T. Eccles, Chief Engineer and Deputy Commander, NAVSEA 8/23/11

- This memorandum reaffirms a NAVSEA commitment to the High Performance Computing Modernization Program's (HPCMP) Computational Research and Engineering Acquisition Tools and Environments ship design and analysis tools program (CREATE-Ships). NAVSEA 05 will continue to take an active part in setting software requirements and ensuring the continued use and an adequate level of support for the tools, including those developed for Hydrodynamics, Shock Analysis, and Rapid Design and Integration.
- CREATE-Ships represents an integral part of NAVSEA's strategy to remain world leaders in ship design. Analysis tools developed through CREATE are currently being used on the DDG-1000 Surface combatant, the CVN 78 and 79 Aircraft Carriers, and the Ohio Replacement Submarine program, and are planned for use in many upcoming ship programs …

CREATE-SHIPS Presentations

- Dr. Tom Moyer: 11/16: 8:00 a.m., Track 5 (U.S. Only) – "Computational Approach to the Design and Assessment of Military Equipment to Survive Severe Dynamic Loading" (NESM)
- Dr. Sung-Eun Kim: 11/16: 1:30 p.m. Track 1 – "Toward High-Fidelity Prediction of Turbulent Shear Flow Around Self-Propelled Submarines in a Maneuver" (NavyFOAM)
- Dr. Bong Rhee: 11/16: 2:25 p.m. Track 1 – "A Physics-Based Modeling of Surface Ship Fixed at Sinkage and Trim (NavyFOAM)
- Bob Ames: 11/16: 3:30 p.m. Track 4 – "Development of the CREATE Integrated Hydrodynamic Design Environment" (IHDE)
- Bob Keane: 11/16: 4:25 p.m. Track 4 – (moved from Track 10, 11/17 at 8:00) "Controlling the Risks of a New Naval Ship Design: Using More Physics-based Design Tools in Early Concept Design"
- Adrian Mackenna: 11/17: 8:55 a.m. Track 10 – "Rapid Ship Design Environment" (RSDE/IHDE/ISDE)