ONR Initiatives
Arctic S&T and Naval Engineering

NAS TRB Marine Board
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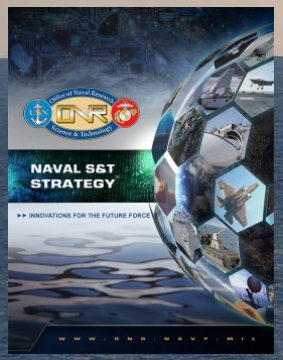
The Office of Naval Research

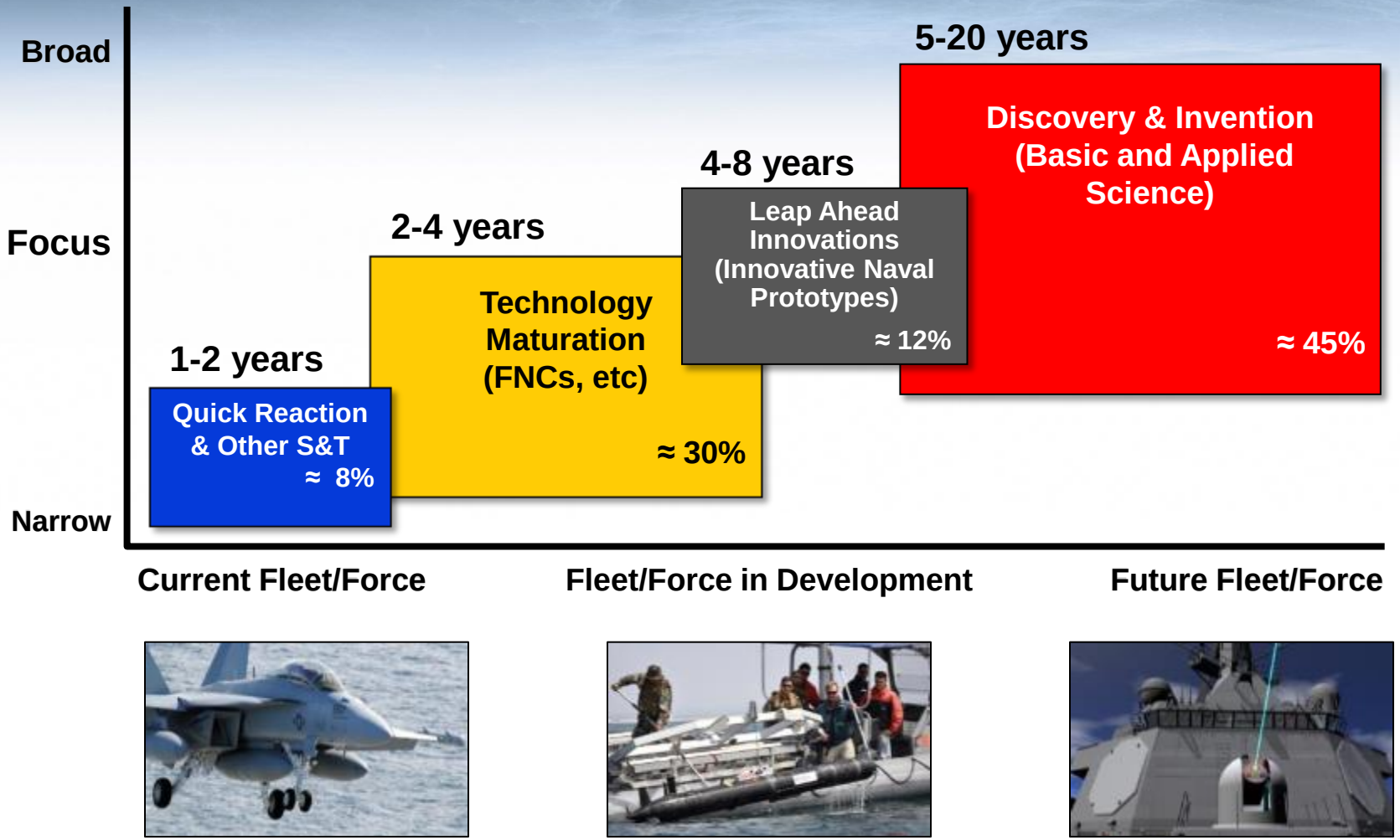
The S&T Provider for the Navy *and* Marine Corps

- 4,000+ People
- 23 Locations
- $2.1B / year
- >1,000 Partners



Discover → Develop → Deliver → Technological Advantage

Warfighting Capabilities Enabled by S&T Investments



Naval S&T Strategy Focus Areas

Autonomy & Unmanned Systems

Assure Access to Maritime Battlespace

Expeditionary & Irregular Warfare

EM Maneuver Warfare

Platform Design & Survivability

Info Dominance & Cyber

Power & Energy

Power Projection & Integrated Defense

Warfighter Performance

ONR Arctic Related Efforts and Interests

- High Latitude / Extreme Environment Surface Ship Operations
- Sea Ice Hull Interaction
- Ship Stability Risk from Topside Ice Accretion
- Assessment of Anti-Icing and De-icing Technologies for Air and Sea Vehicles
- High Latitude / Extreme Environment Surface Ship Operations
- Additional ONR Arctic Interest Areas

High Latitude / Extreme Environment Surface Ship Operations

US Objectives

- Assess limitations of current surface ship platforms to conduct Polar Operations safely and effectively
- Develop technologies appropriate for improved high-latitude operations in the Arctic and Antarctic.

Current Projects

- **Sea Ice Hull Interaction** (2014-2016)
  - Work conducted by Naval Surface Warfare Center Carderock Division, American Bureau of Shipping, US Army Cold Regions Lab (CRREL), Memorial University in Newfoundland, Canada
  - In partnership with US Coast Guard, Defense Research and Development Canada
- **Ship Stability Risk from Topside Ice Accretion** (2015-2018)
  - Work conducted by Naval Surface Warfare Center Carderock Division and Cornell University

Sea Ice Hull Interaction

Program Focus:

To improve ice-ship interaction modeling techniques to inform operational guidance for non-ice class ships deployed in Polar regions.

Ship Traveling Through Ice

Technology Objective:

- To develop a computational test-bed for estimating ice-ship interaction forces
- To improve experimental techniques and scaling laws used for numerical model validation and empirically based full scale prediction of ice-ship interaction forces

Technological Challenge/Risk:

- High-resolution, high-fidelity modeling of sea ice dynamics
- Accurate representation of ice – ship interaction in scaled physical experiments
- Translation of ice loading dynamics to operating procedures for ice and non-ice class naval ships

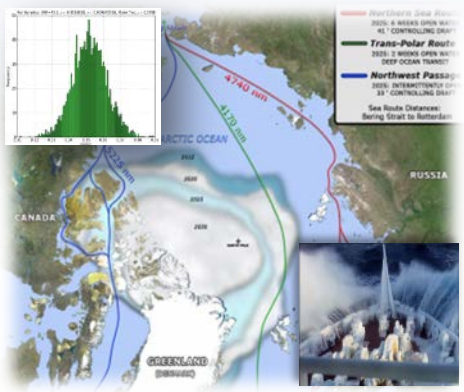
Benefit/Payoff:

Improved modeling techniques will aid ice class ship design and inform operational guidance for non-ice class ships deployed in Polar regions.

Ship Stability Risk from Topside Ice Accretion

Program Focus:

To enhance the Navy's ability to execute missions in Polar regions by providing an early warning system that quantifies the impact of topside icing on ship stability and provides an adjusted operational envelope that ensures the safety of the ship.



Technology Objective:

To develop approaches that synthesize meteorological data and own ship conditions to monitor and predict the impact of topside ice accretion on the ship's stability.

Technological Challenge/Risk:

- Existing topside icing models are crude, slow, and do not include essential parameters. Thus, a limited set of empirical data must be translated into a Bayesian context to support the envisioned stochastic inversion.
- Numerical and small-scale model results will need to be validated at full-scale.

Benefit/Payoff:

Enhances the Navy's ability to execute missions in Polar regions by augmenting the warfighter's awareness of the effect of ice accretion on the ship's safety (stability, operating envelope).

Assessment of Anti-Icing and De-icing Technologies for Air and Sea Vehicles

Program Focus:

Assess existing and emerging anti-icing and de-icing technologies and for testing methods of ice adhesion strength, and develop recommendations for standardized testing methods.

Ice crystals in the engine (Source: NASA)

Technology Objective:

Evaluate various technologies used for anti-icing and de-icing for military airplanes (including UAVs) operating in cold air and ships operating in cold regions. Evaluate existing testing methods of ice adhesion performance of the technologies. Recommend standardized testing method(s) of ice-adhesion strength.

Leading Edge of a Wing

Technological Challenge/Risk:

Ice buildup on vehicles in the arctic is a significant risk because it accumulates fast and is difficult/dangerous to remove.

Benefit/Payoff:

Minimize performance and safety issue from icing.

Participating Nations:

USA, CAN, GBR, NOR, DNK, NZL, FRA, NLD

High Latitude / Extreme Environment Surface Ship Operations

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Additional ONR Arctic Interest Areas

- **Hull Form Design Optimization for Arctic Operation**

  Issue: Current ship-to-shore transports were deigned to transition from sea, to surf zone to land. The transition from the sea to ice presents a more abrupt physical profile, with potentially larger/higher obstacles.

- **Seakeeping in Ice Environments / Ship Stability**

  Issue: Current fleet is comprised of “warm weather” ships; ice accumulation, its degradation to stability margin, and topside configurations for mitigating these effects were not considered in their design.

- **Ice Detection at Sea**

  Issue: Outside of visual detection, which may be limited during foul weather, the Navy does not have the ability to detect ice hazards at ranges to allow sufficient maneuvering for collision avoidance.

- **Exhaust Emissions**

  Issue: Carbon deposits on ice resulting in greater absorption of heat and increased ice melting.

- **Ballast Water/Black Water/Grey Water Effluents**

  Issue: Biological processes are slower in the arctic; marine life is therefore more fragile and our impact may be greater than in other seas.

- **Hull and Topside Coatings**

  Issue: Effectiveness and toxicity of antifouling and fouling release coatings are likely to be very different at Arctic temperatures.

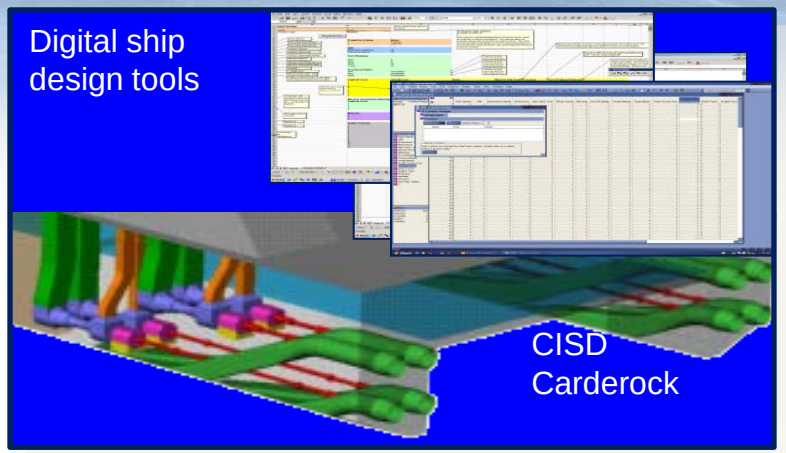
National Naval Responsibility Naval Engineering (NNR-NE)

- NNR-NE Focus
  - Conducts major field experiments that integrate various technologies into innovative ship concepts
  - Supports improved ship design tools and better analytics for platform affordability assessments.
- TRB Special Report 306: Naval Engineering in the 21st Century: The Science and Technology Foundation for Future Naval Fleets (2011)
  - Explores whether Office of Naval Research (ONR) activities, under its National Naval Responsibility for Naval Engineering (NNR-NE) initiative, have been effective in sustaining these fields.
- Recent ONR NNR-NE Efforts Since 2011
  - Centers for Innovative Naval Technology (CINTs)
  - RoboBoat and RobotX USV Competitions
  - SeaPerch
  - Electric Ship Research & Development Consortium (ESRDC)
  - Smart Ship System Design (S3D)

Centers for Innovative Naval Technology (CINT)

What is being developed?

- CINTS: each associated with a Navy Warfare Center
- ✓ Center for Innovation in Ship Design – NSWC Carderock
- ✓ Center for Innovative Machinery Design and Integration – NSWC Philadelphia
- ✓ Warfare Innovation Cell Knowledge for Educational Development – NSWC Dahlgren
- ✓ Littoral Warfare Innovation Center – NSWC Panama City
- ✓ Information – SPAWAR San Diego
- Annually, each CINT selects topics from many sources; PEO Ships, OSD, NAVSEA, Warfare Centers. NREIP students, interns, summer faculty and new employees investigate, act, and report back.



Why is it being developed?

- To sustain the capability i.e., people, tools, and knowledge, to develop future innovative naval technologies
- To maintain a pipeline of people capable of substantive research contributions to the naval research enterprise
- To reinvigorate interest in Navy unique research and technology development through topical, short term innovation cell activities

Why is it important to the U.S. Navy/Marine Corps?

- Ensure the presence of a strong Naval Engineering discipline in the US to maintain the US Navy's maritime superiority
- Stimulate and educate the work force
- Expand the knowledge base for naval ship design and engineering
- Explore innovative solutions for future naval warfighting needs

RoboBoat and RobotX USV Competitions

Objective / Goal

- The purpose of the RoboBoat and Maritime RobotX Challenge competitions is to enhance the community of innovators capable of substantive contributions to the domain of autonomous unmanned surface vehicles (USVs). This enhancement is achieved by providing a venue and mechanism whereby the practitioners of the USV community may form new connections and collaborations, increase their proficiency and inventiveness, and foster their passion for robotics and the surface domain.

Technical Summary of Research

- Annual RoboBoat competitions attract an ever expanding number of college teams.
- Biennial international Maritime RobotX Challenge using a "one-design" approach to focus the competition on sensor selection, platform integration, and algorithm development. Future potential of multi-vehicle, multi-domain competition.

Major Participants

- AUVSI Foundation, US Universities, International Universities

Maritime RobotX Challenge

SINGAPORE 2014

Upcoming Events

- 9th annual RoboBoat competition at Founders Inn, Va Beach, VA 4-11 July 2016
- 2nd RobotX competition at Sand Island, Oahu, HI 11-18 Dec 2016

"We must nurture the next generation of innovators." – Zoz Brooks

NNR-NE / SeaPerch

Objective / Goal

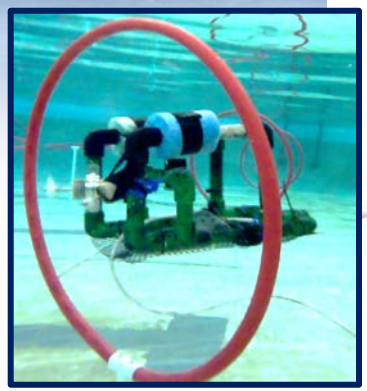
- Develop a hands on experiential learning project to attract K-12 students to Science, Technology, Engineering and Math (STEM)
  - Awareness
  - Interest
  - Pursuit

Technical Summary of Research

- Investigate effective SeaPerch program delivery methods
- Research new, scalable sensor technology for SeaPerch
- Deliver the SeaSense sensor suite to the SeaPerch community

Recent Accomplishments

- Trained more than 250,000 students
- Programs now in all 50 states
- Trained over 6,500 teachers
- Learning standards mapped to Common Core
- Design and implementation of curriculum and activity guide
- V-Perch and SimPerch



Student-built SeaPerch RoV passing through underwater obstacle in regional competition

SeaPerch Kit

Major Participants

- 29 Navy Systems Commands and Warfare Center Partners
- Five Navy Diversity Offices
- 99 NJROTC Programs
- 517 Programs/ Partners total
- 35 DoD partners

Upcoming Events

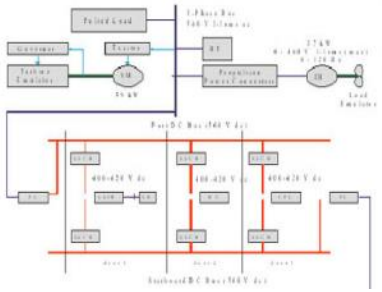
- 2016 National SeaPerch Challenge Louisiana State University 20-22 May 2016 with 200+ top teams from regional competitions

Electric Ship Research & Development Consortium (ESRDC)

ESRDC
ELECTRIC SHIP RESEARCH AND DEVELOPMENT CONSORTIUM

Bringing together leading research institutions to advance electric ship concepts.

- The Florida State University Center for Advanced Power Systems (CAPS) Research Facilities
- Real-Time Hardware-in-the-Loop Modeling and Simulation.
- Purdue's Energy Conversion Research Laboratory
- The Genetic Optimization System Engineering Tool
- The Genetic Optimization Processing Array
- The Naval Combat Survivability Testbed
- Balcones Homopolar Generator Power Supply
- Realtime Electromechanics Laboratory



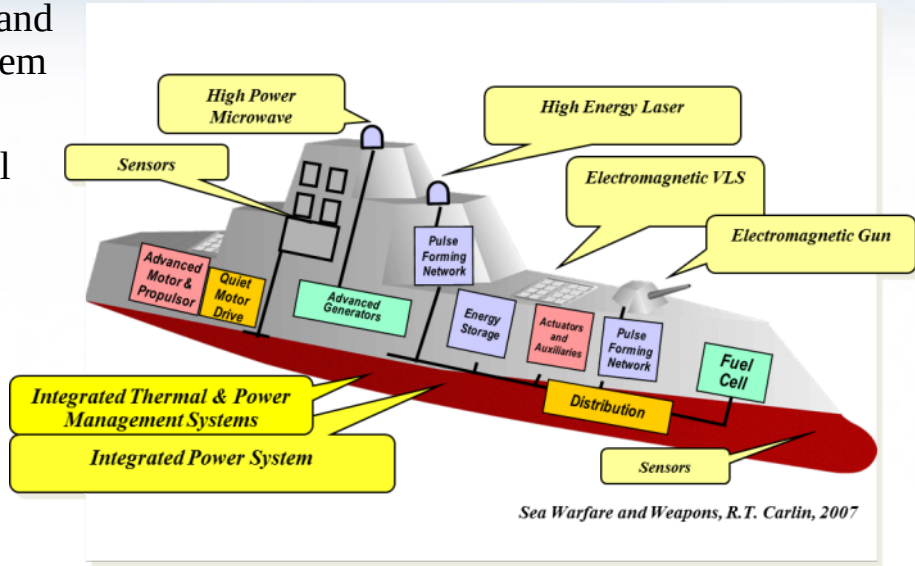
Accomplishments

- Modeling and simulation capability that has been used by industry and the Navy in the design of new equipment and systems.
- Prototype development and testing capability that have contributed to the Navy's decision to fund at least three major development programs with industry.
- Technology and Software that is being adopted by industry for integration into the fleet.
- Workshops on modeling and simulation, reconfiguration, and power train technology that brought leaders of industry, government, and academe to discuss and stimulate technical advances in this area
- More than 300 papers were presented to the technical community helping to establish U.S. leadership in this area
- More than 50 students have received advanced degrees for research conducted in support of future electric ships

Smart Ship System Design (S3D)

Early-stage tool for the design, simulation and analysis of ship systems.

- Each discipline (electrical, mechanical, piping, and HVAC) has its own view/abstraction of the system
- 3D visualization and arrangements.
- Equipment catalog populated with mathematical models and equipment properties.



Allows sharing of ship model across the design disciplines

- Users create and edit designs using discipline-specific schematic views
- Pertinent information is conveyed to other disciplines

Analyses flows of power and energy across disciplines

- Balances power generation with demand and losses
- Computes heat flows through thermal management systems
- Checks validity of connections

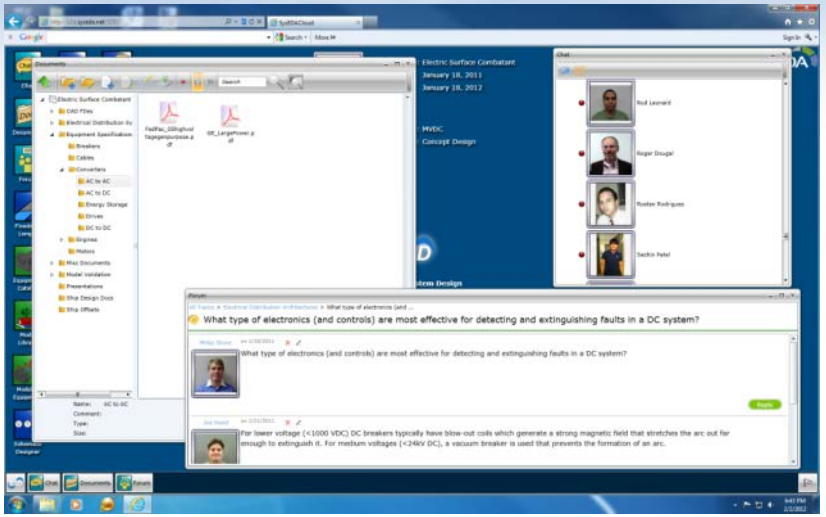
Co-simulate across all disciplines permits convergence of the design

- Reduces the time and costs associated with the design process
- Simplifies the exchange of information between team members
- Increases understanding of complex interactions between systems

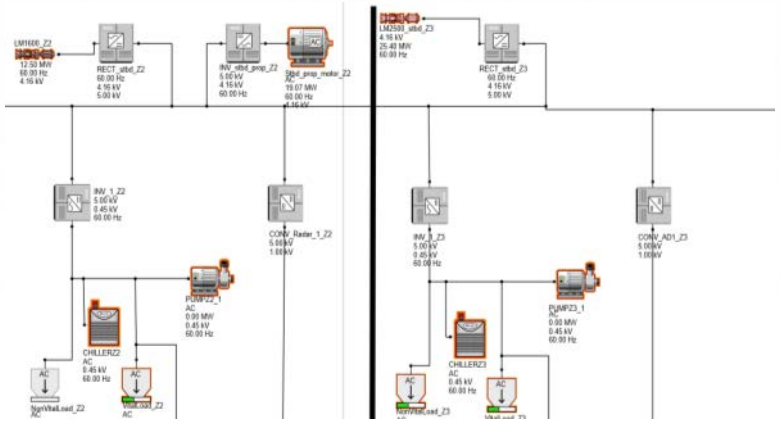
S3D

Cloud based / web accessible

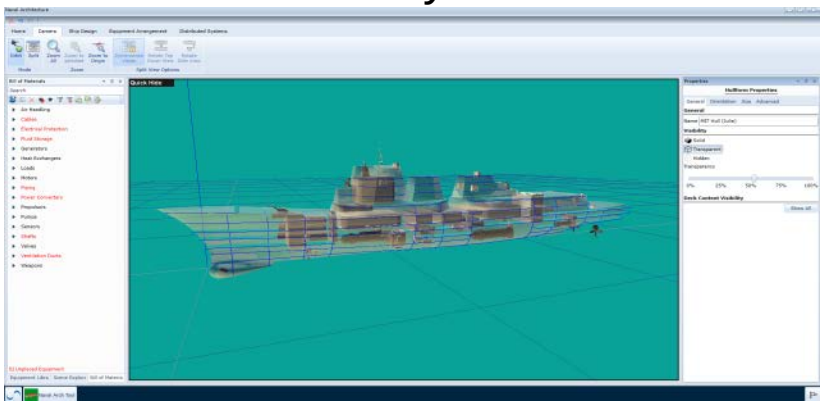
Social collaboration features



Discipline specific views of system



Shared system model



Immediate propagation and exchange of ideas

Concurrent engineering

Design and simulation