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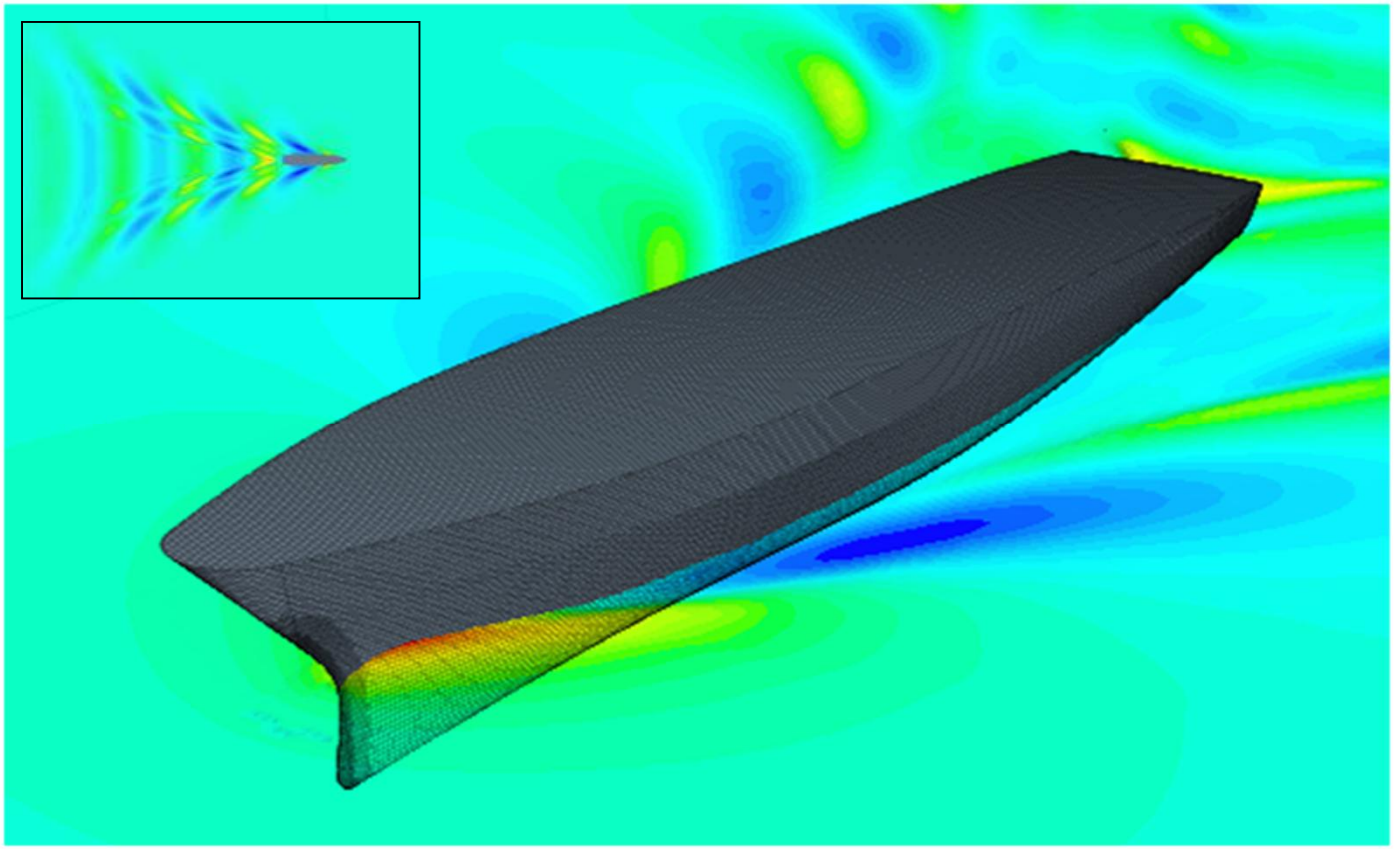

R & D Activities at Vard Marine

By Dan McGreer, Principal Naval Architect

July 5, 2016

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Agenda

- Vard Marine R&D Activities
- Examples of R&D at Vard Norway
- MARIN Cooperative Research Ships (CRS)
- Suggestions Regarding the iSMART Network

Vard Marine R&D Activities

There are three main areas of R&D at Vard Marine:

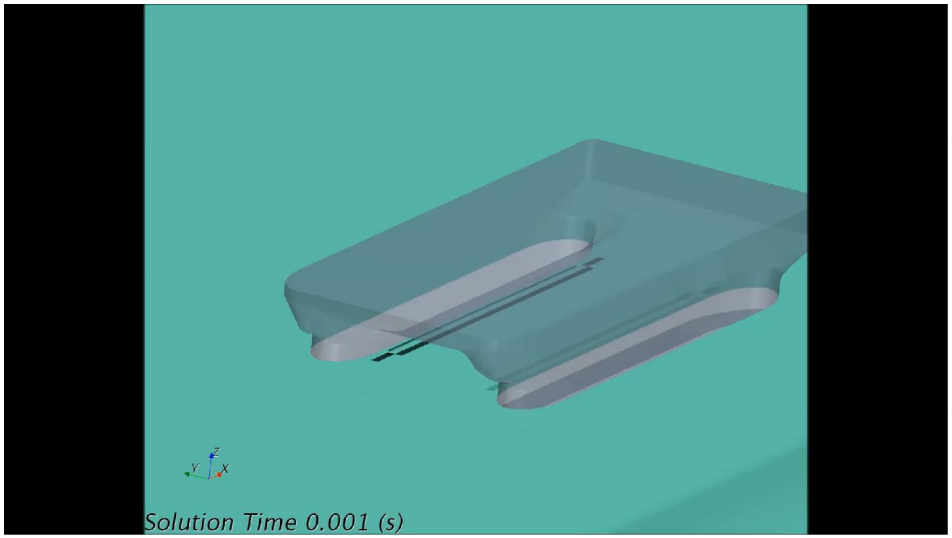
- Development of new ship design concepts for potential new projects and markets.
- Development of engineering techniques and advanced analysis tools for designing and assessing the performance of ships and mobile offshore units.
- Development of advanced analysis tools and expertise that can be marketed as engineering services.

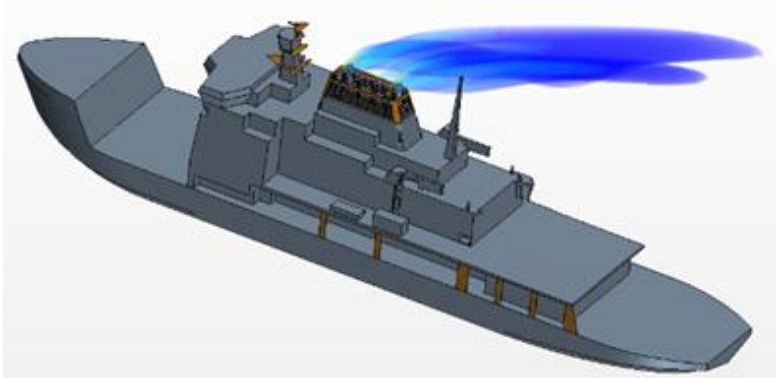
Vard Marine R&D Activities

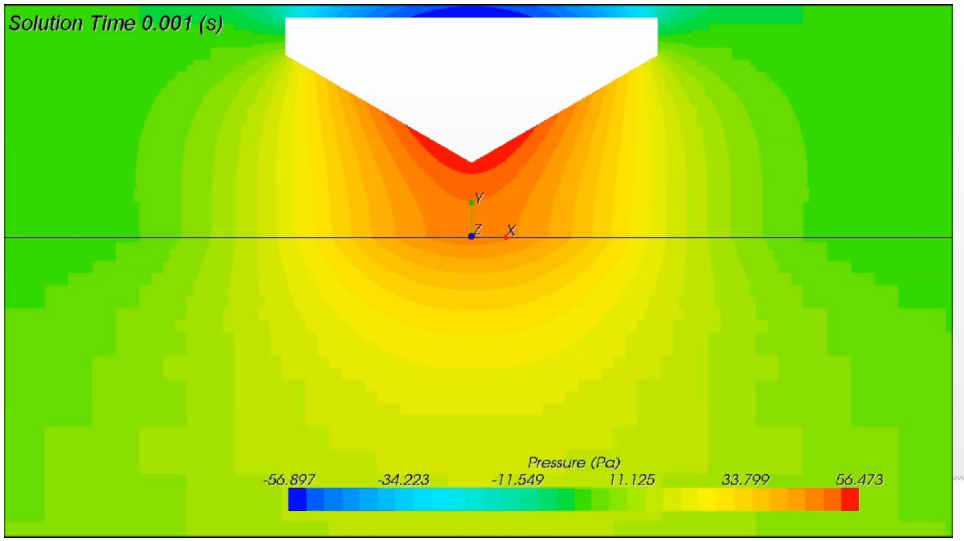
Computational Fluid Dynamics (CFD)

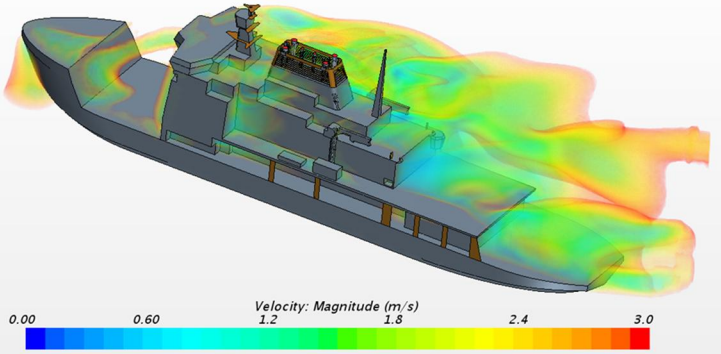
- Vard Marine has used CD Adapco CCM+ for over 12 years.
- Our focus has been on hydrodynamics and marine related fluid dynamics problems.
- Development of appropriate analysis strategies for:
  - Meshing and analyzing calm water resistance, streamlines and propeller wake.
  - Determining manouevring coefficients and performance.
  - Analysis of air wakes (Applicable to heli-decks and superstructure aerodynamics).
  - Determining wind and current force coefficients for offshore platforms and vessels.
  - Slamming and moon pool sloshing.
  - Analysis of contaminant dispersion (Applicable to exhaust gas and natural gas).
  - Heat transfer (Applicable to heat exchangers and solar radiation).
  - Hydrodynamics in highly restricted channels.
  - Analysis of semi-planing hull forms.
  - Bubble sweep-down analysis for research vessels.
  - Air mixing and ventilation of compartments (Applicable to ventilation of machinery, and electrical equipment spaces).

Examples of CFD









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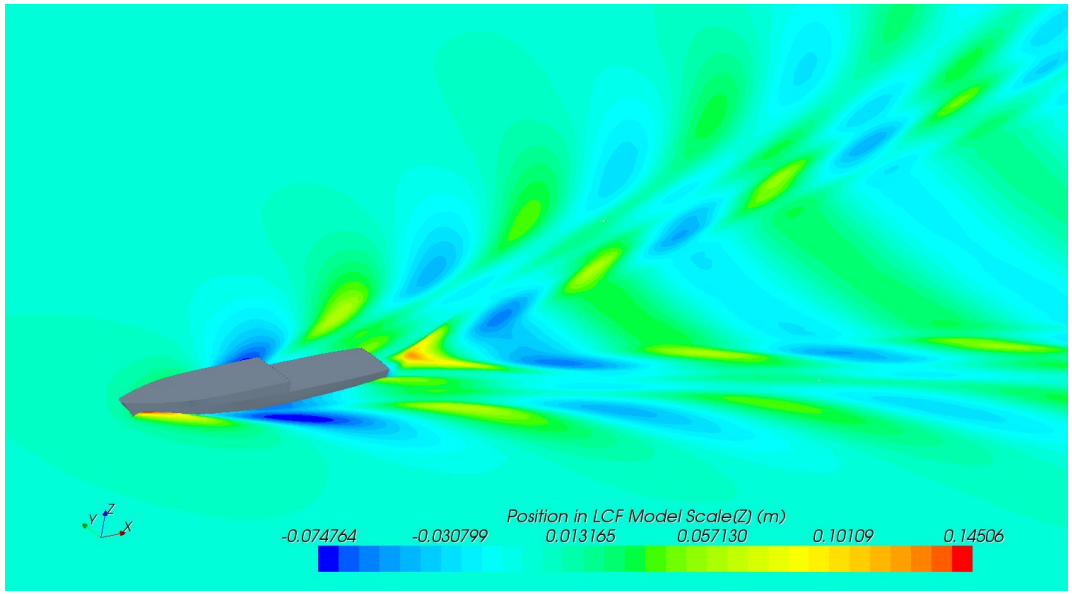
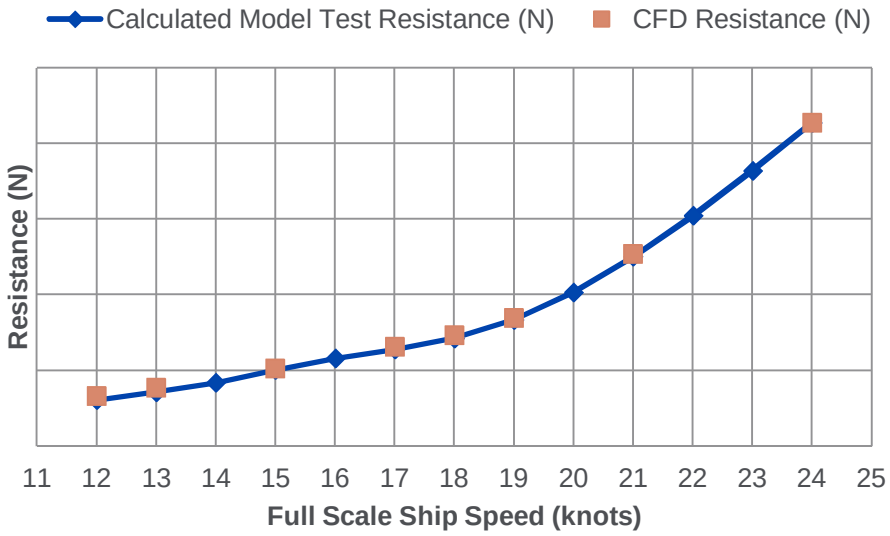
Validation of CFD Resistance Prediction



Ship Speed (knots)	Error
12	+7.8%
13	+6.7%
15	+1.6%
17	+2.4%
18	+2.4%
19	+1.0%
21	+1.1%
24	-0.0%



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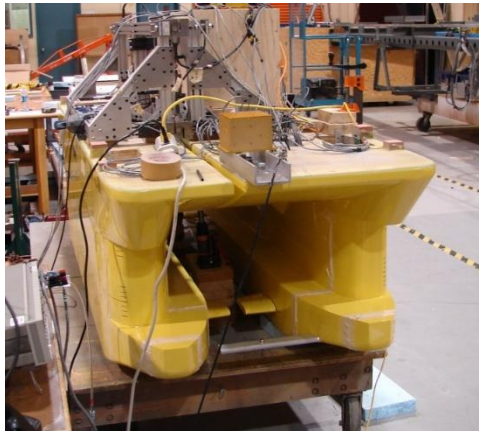
Vard Marine R&D Activities

Seakeeping Analysis

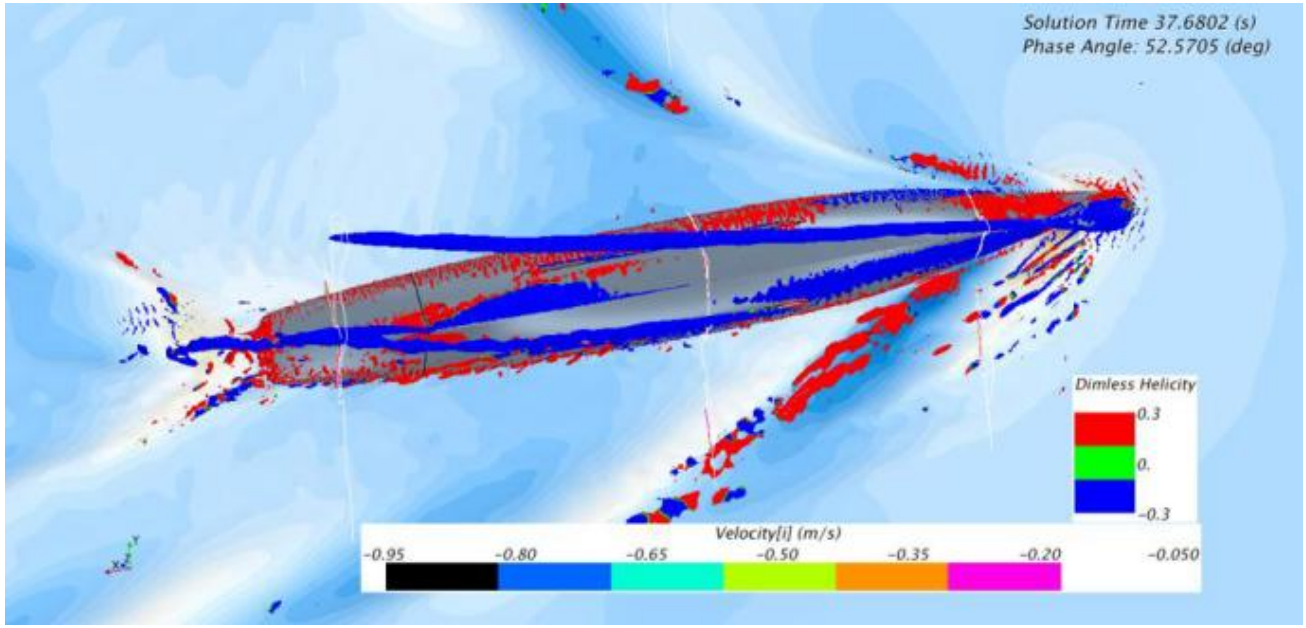
- Developed macros for analysis of a wide variety of marine dynamics problems including:
  - Operablity calculations
  - Effectiveness of alternative roll stabilizing systems such as gyros
  - Slamming analysis
  - Non-linear U-tube tank analysis
  - Analysis of adaptive roll control systems
  - Validation with model tests
- Analysis and model testing of our twin hull CSS designs including:
  - Use of PRECAL seakeeping code from MARIN to determine motions and wave loads.
  - Correlation of motions and loads with model tests
  - Determinate of slamming loads



Vard Marine R&D Activities

Manoeuvring Analysis

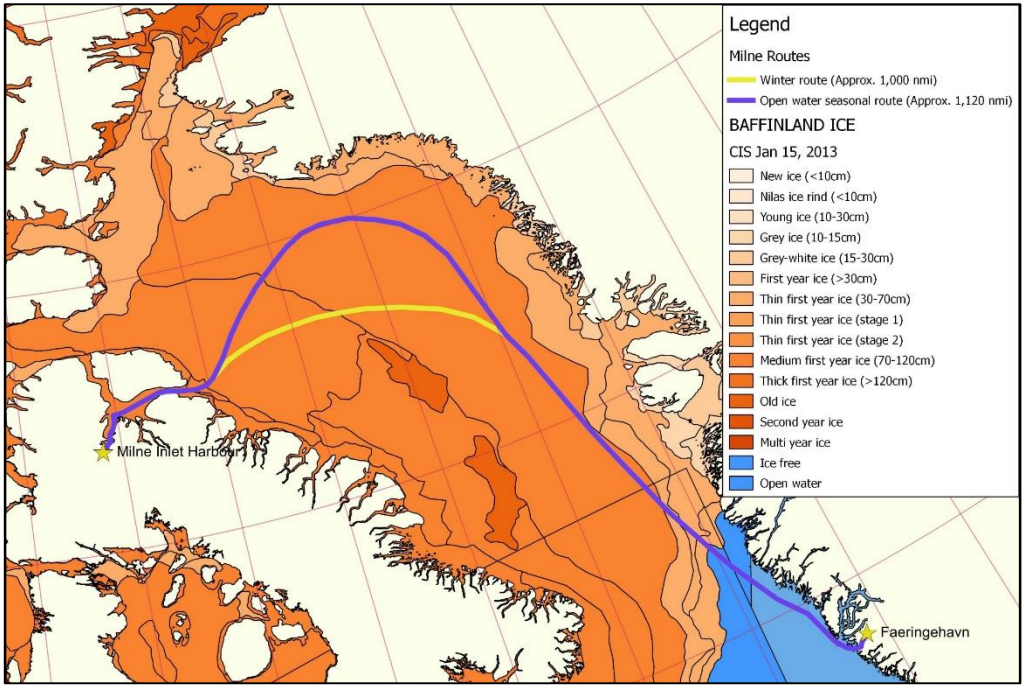
- Low speed manoeuvring simulations with environmental forces
- Manoeuvring analysis of ships using MARIN MPP
  - Validation with model tests
- Determination of manoeuvring coefficents with CFD
  - Validation with model tests



Vard Marine R&D Activities

Operational Simulation

- GIS Databases for assessment of voyage scenarios
- Ice trafficability analysis
- Safe speed in ice infested waters
- Fleet performance analysis
- Risk assessment



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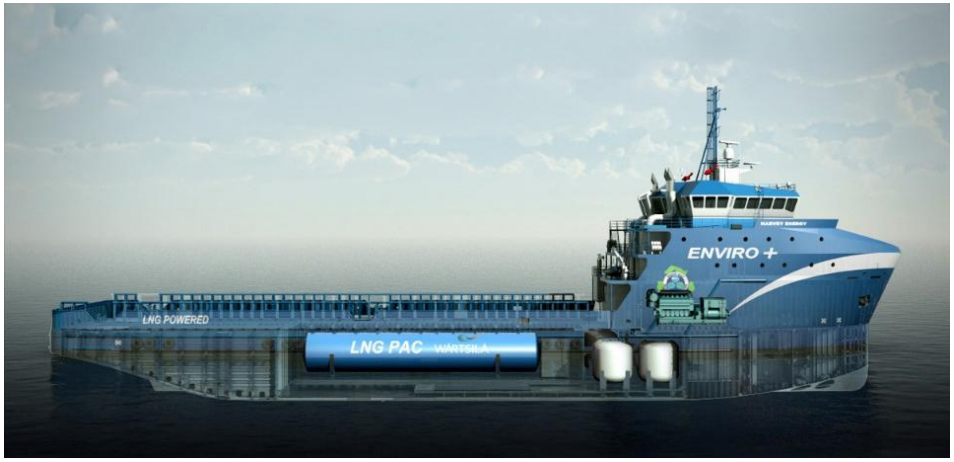
Vard Marine R&D Activities

Integration of Advanced Propulsion Systems into Ship Designs

- LNG/CNG
  - Developed designs for OSV and Ro-Ro Ferries
  - Carried out Hazard Analysis and Risk Assessments
- Hybrid/Battery Systems
- Electrical Distribution Options and AC/DC Converter Technology
- PTI/O Drives for OPV propulsion systems
- Infrastructure Assessments
  - Shore based and floating bunkering
  - Energy Transfer Systems



Vard Marine R&D Activities

Finite Element Analysis

- Extensive use of NX Nastran for over 15 years
- Development of macros for global analysis of ship strength and fatique.
- Import of wave load pressure distributions from PRECAL.
- Recent development of techniques for the nonlinear collapse analysis of structures using LS-DYNA (eg. icebreaker structures).
- Vibration analysis of local and global structures.

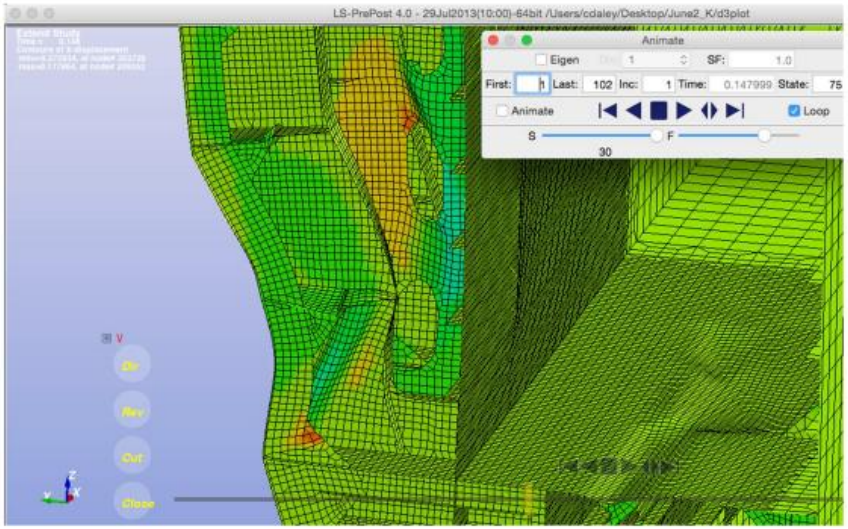


Figure 22: Longitudinal displacements (1)

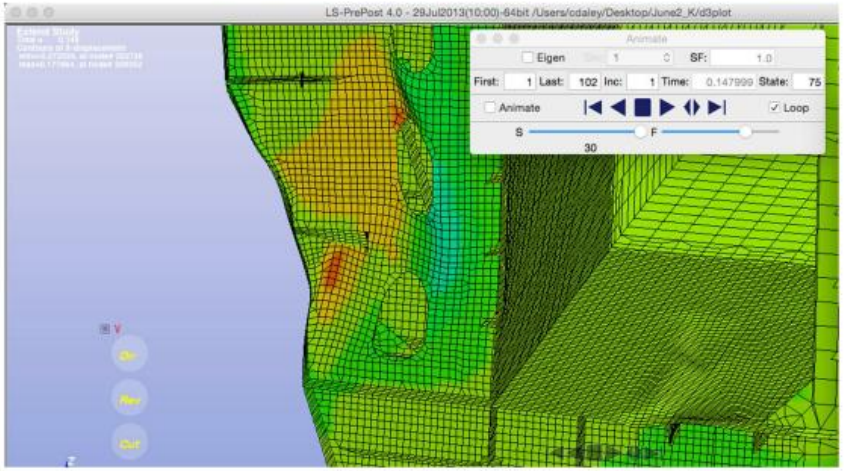


Figure 23: Longitudinal displacements (2)

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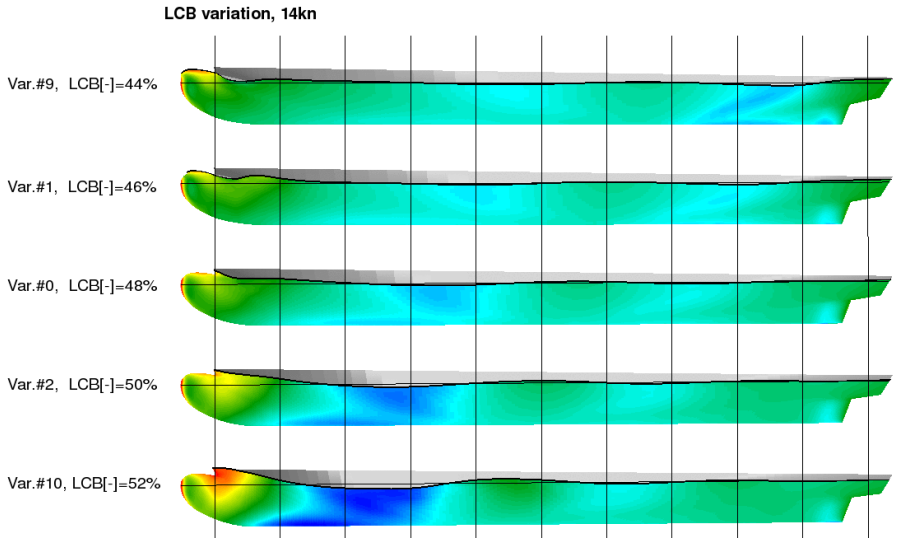
Vard Norway – Examples of R&D

Calm water optimization of Offshore Support Vessels

- Systematic main parameter study of 15 hulls.
- Variation of L/B, B/T, LCB & Cb. Except for Cb variation, all hulls have equal displacement.
- Seakeeping evaluation of all variations
- CFD calculations calibrated against model tests. 9 hulls are model tested



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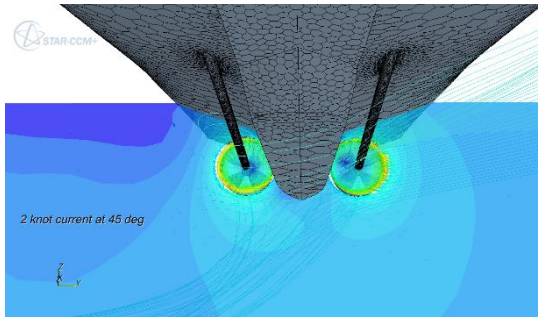
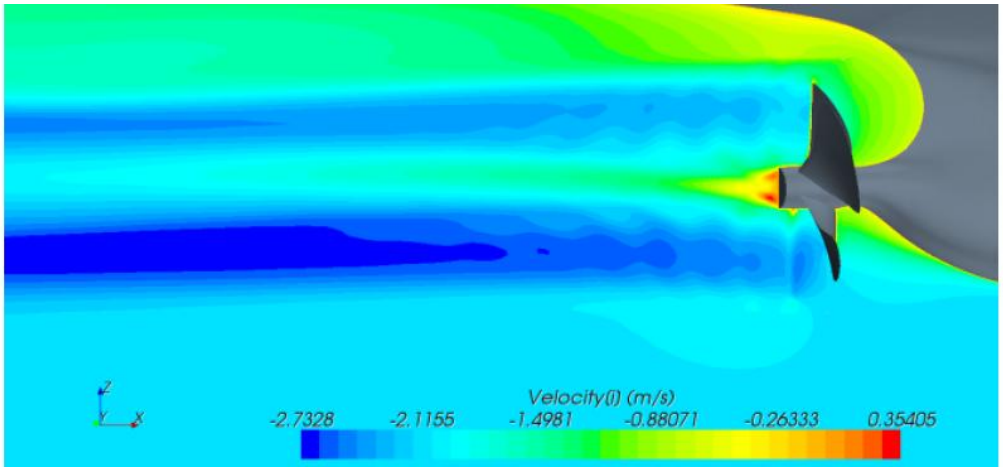
Vard Norway – Examples of R&D

- Low speed hull/propeller interaction (2008-2011)
  - 3 year R&D project with main focus on physical understanding on hull propeller interaction for DP-propulsors and main propulsors in low speed range
- Propscale (ongoing)
  - 3 year project owned and managed by Marintek. Vard Design partner in the project.
  - Focus on scale effects on different types of propulsors using CFD as a tool.





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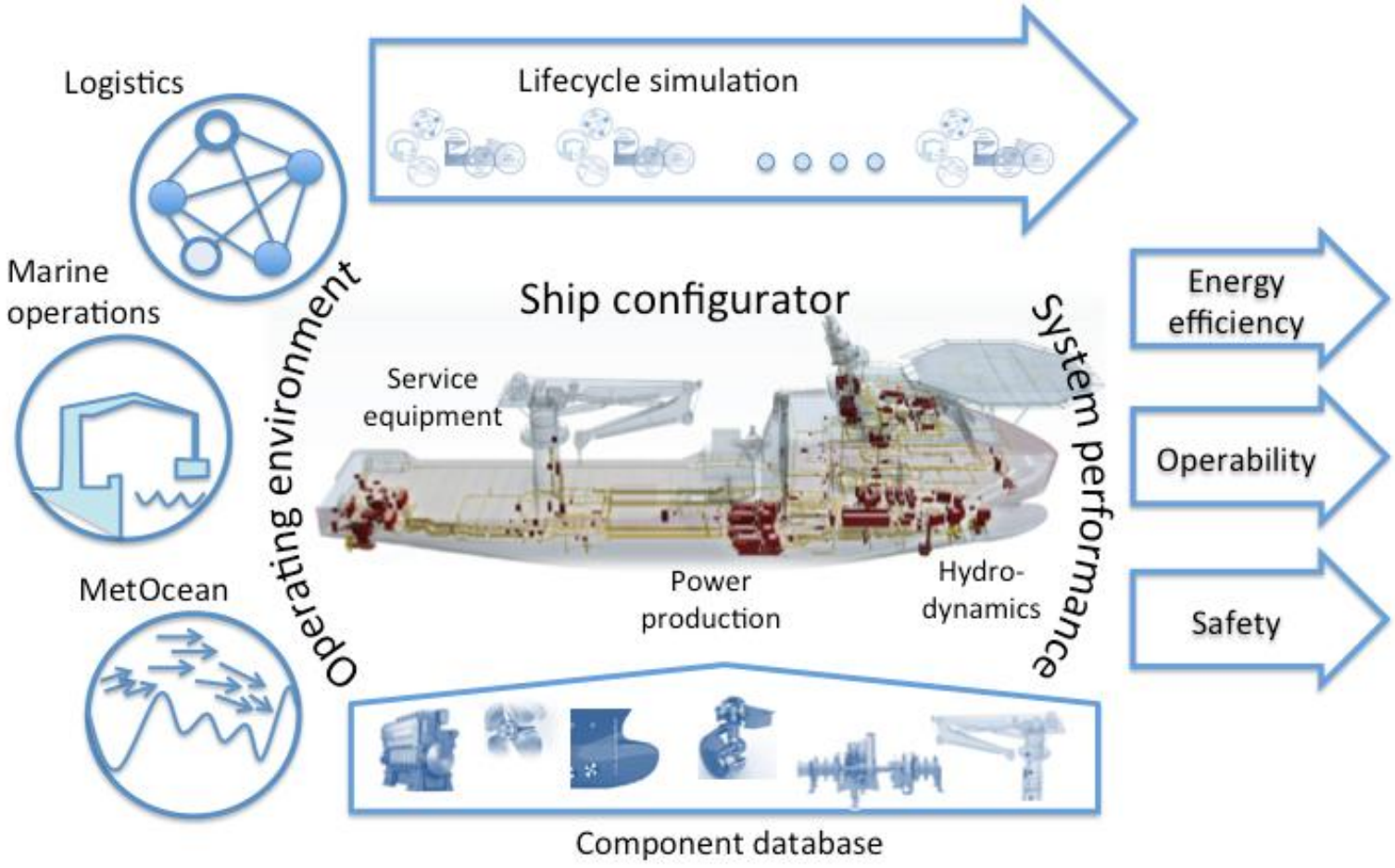
VISTA – Virtual Sea Trial

Co-simulation of dynamic systems in realistic operational scenarios and weather.



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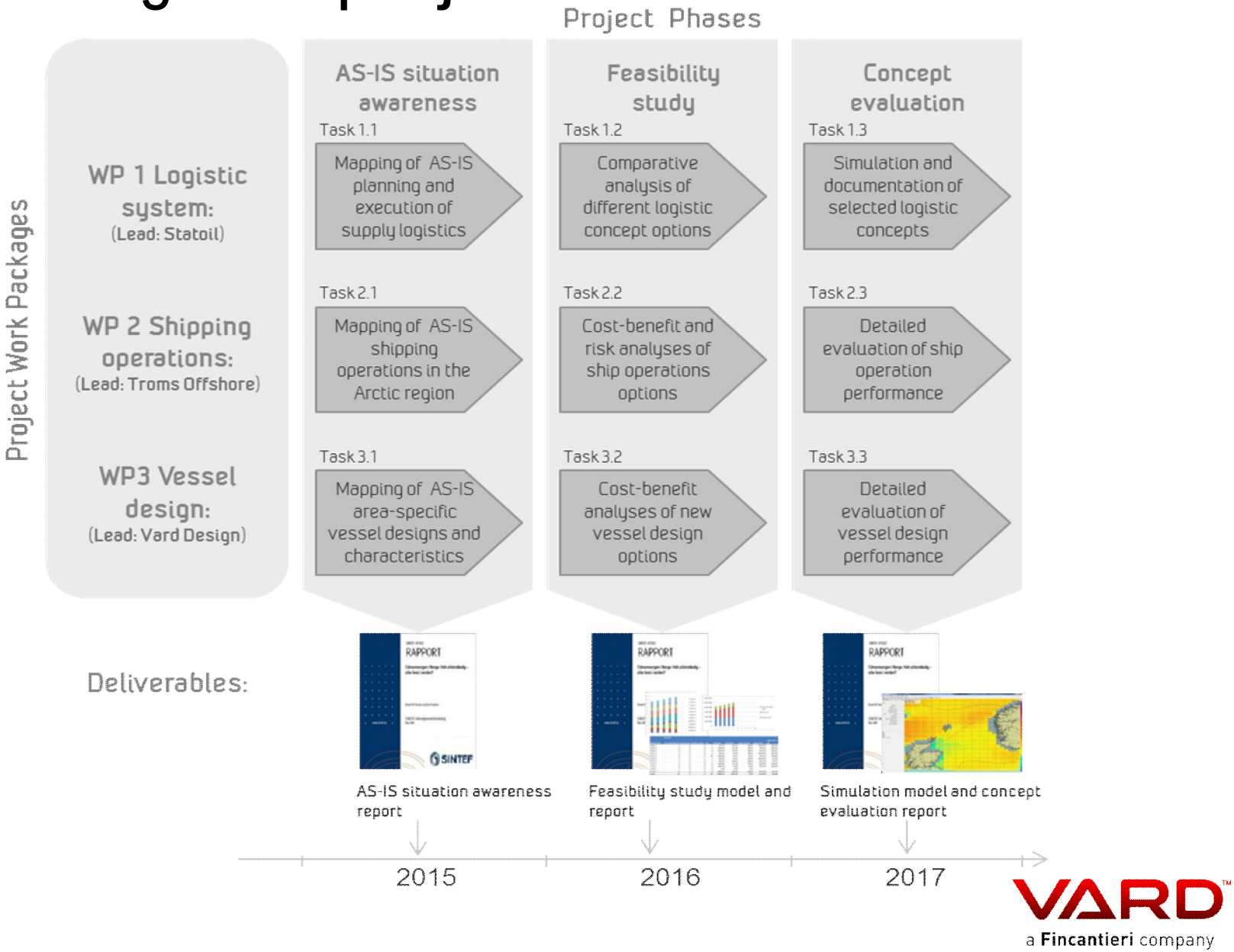
Arctic logistics project



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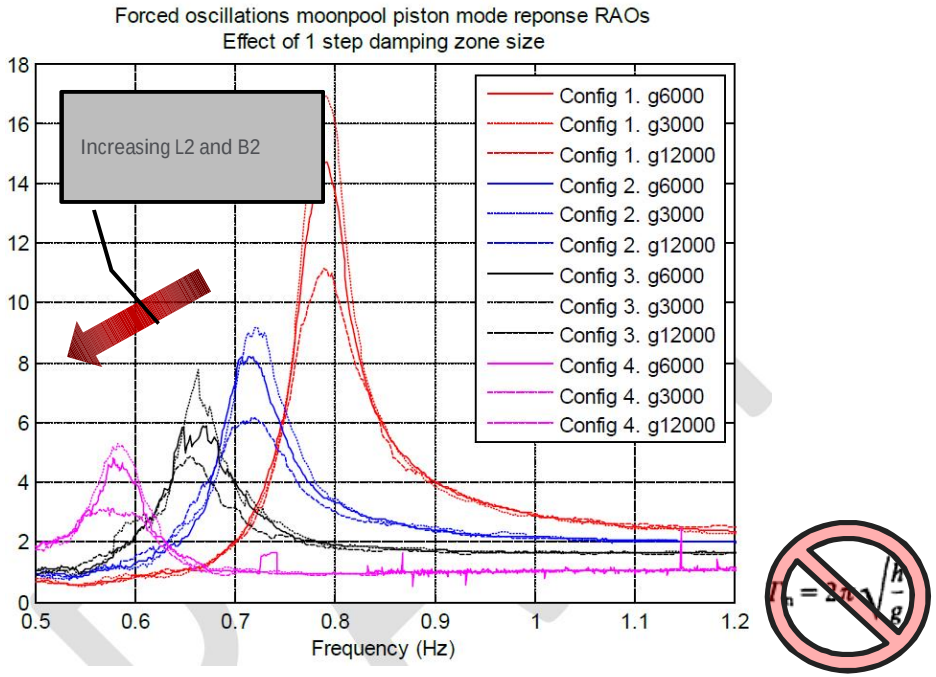
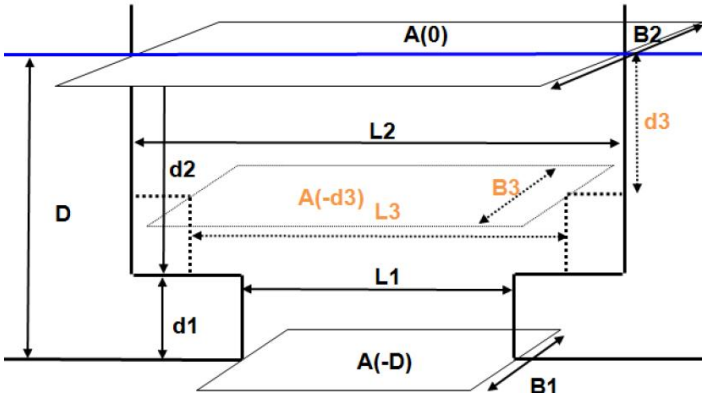
Moonpool R&D Project

3 year program developing knowledge and design guidelines for moonpools





$$T_0 = \frac{2\pi}{\sqrt{g}} \sqrt{\int_{-D}^{0} \frac{A(0)}{A(z)} dz + \frac{A(0)}{A(-D)} \cdot \kappa \sqrt{A(-D)}} \quad [s]$$

By using the formula for natural period of moonpool piston mode response in DNV rp. 103 (formula 3.5.4.6) we got good estimates when including the volume from damping zone / cofferdam and comparing with the measured data.

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Future R&D Activities

- Computational Fluid Dynamics
  - Self propulsion analysis for ships
  - Further work on semi-planing and planing hulls
  - Anti-roll tank analysis
  - Dispersion analysis (eg. Gas, contaminant, mixing, fire/combustion)
  - More complex HVAC problems.
- Seakeeping
  - Multi-body dynamics
  - Operability
  - Slamming analysis
- Ice Loads and Resistance
- Manoeuvring
  - Continuation of CFD work
  - Enhancement of in-house ship simulator model
- Full Scale validation

MARIN – Cooperative Research Ships (CRS)

- The CRS was started in 1969 with the intention to obtain general data about the hydrodynamics and related problems of large and high-powered ships.
- The research carried out by the CRS is focused on hydrodynamics, structural and related problems of all kind of ship types from a fundamental, design and operational perspective.
- The various ship types include full block ships, but also container ships, frigates and high-speed mono-hulls and multi-hulls.
- CRS consists of 27 member organizations and companies carrying out a joint work program, sponsored equally by all members. In principle the research is carried out by the members only. The research results are the sole property of the members.
- More info at: www.crships.org

MARIN CRS – Current Projects

- Broadband Propeller Noise
  - Develop software for marine propeller-induced broadband noise and vibration prediction.
- Hull Pressure Calculation
  - Further development of the program PRECAL and the time domain ship motions program PRETTI-2
- Structural Assessment Including Nonlinear Aspects
  - Develop software for ship structural loads (STRUC) for fatigue and ultimate strength assessment.
- Off-Axis Propeller Loads and Structural Response
  - Improve the capability of PROCAL to predict off-axis loads and moments leading to a capability for predicting transient loads such as during maneuvering.
- Manoeuvring in Waves
  - Develop a code to predict course keeping, track keeping and astern course keeping.
- In-Service Monitoring
  - Validation of computational tools against full scale data.
- Whipping and Slamming
  - Update of PRECAL program to include flexural modes. Development of a 3D theory for slam force calculations.
- Ducted Propellers
  - Develop a BEM tool (PROCAL) and a protocol for a coupled RANS-BEM tool for analysis and design of ducted propellers

Suggestions Regarding the iSMART Network

- iSMART should be coordinated with the National Shipbuilding Strategy (NSS) and support the objective of enhancing Canada's ship design and shipbuilding capability.
- In the short term, iSMART should act as a point of contact between the R&D community and the NSS projects, helping to identify potential partners in Value Proposition (VP) projects.
- In the longer term, it could help provide funding and direction to sustain activities initiated during the definition phase of CSC (and other government programs).
- iSMART should provide the following functions:
  - Have regular meetings to coordinate research and share knowledge.
  - Provide funding to support collaborative research projects.
  - Have a web site to share research results and information to members.
- iSMART should receive funding from NSS Value Propositions and the Canadian Government (sources to be determined).

Draft CSC Value Proposition Requirements

CSC Definition Sub-Contract
Value Proposition – Proposed Scoring Approach

Objective	VP Criteria and description
VP.5 R&D **Increase the amount of R&D undertaken in Canada by Canadians in any sector** **Provide specific R&D opportunities in priority areas:** • **Clean technology** • **Cybersecurity** • **Marine sector**	**VP.5 – R&D** VP.5 is divided into two categories, VP.5a and VP.5b. R&D activities that may be credited against these commitments may include: • R&D performed by the bidder and its Eligible Parties • R&D contracted out by the bidder and its Eligible Parties to Canadian companies, post-secondary education institutions, and public research institutions. All R&D opportunities must be indirect. **VP.5a – R&D during the Definition Contract** **This accounts for 6 of the 10 available points under VP.5.** Bidders will be required to make a commitment as a percentage of the Definition Contract value of R&D (along with their eligible parties) that will be performed in Canada.

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