HSBO 2012

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- Defense Equipment and Support

- Naval Architect

- Escape & Evacuation and Rescue Naval Authority

- Maritime Human Factors

HSBO 2012

- Activities in support of WBV mitigation –
- 1 POSTURE RESEARCH
- 2 HSC Seakeeping Assessment Tool - HydroDyna

HSBO 2012

- 1 POSTURE RESEARCH
- Why?

- Simple assumption that reclining individuals is beneficial to reducing WBV exposure in HSC.

- The Challenge. Identify research to support the assumption with a literature review.

- Objective. Identify and quantify the benefits of reclining individuals to mitigate WBV exposure and address operational aspects such as viewing instruments and C2.

HSBO 2012

- PROGRESS TO DATE
- Literature Review complete.
- Design of experiment agreed.
- Postures from 0 deg to 60 deg to be assessed.
- To include a reading test.

HydroDyna Assessment

- DES Sea Systems Group (SSG) have undertaken trials of two hull configurations of high speed planing craft:
  - A hard chine mono-hull: BAE Systems Arctic 28 RIB (A28)
  - A novel multi-hull: Ice Marine Bladerunner RIB 35
- The trials were undertaken to explore whether hullforms that differed from the current class of boat (Arctic 28) could offer an appreciable reduction to the crew and passengers' exposure to whole body vibration.
- To complement these trials SSG have requested Frazer-Nash to undertake simulation of the two craft. This study is to explore the application of simulation methods to assist decision making on hull designs prior to prototype testing.
- The simulation approach is two stage:
  - Smooth water simulation, using CFD, to determine the hydrodynamic pressure distribution on the hull.
  - Rough water prediction, using HydroDyna, (calibrated using the smooth water hydrodynamic pressures) to calculate craft motions for comparison with measurements.

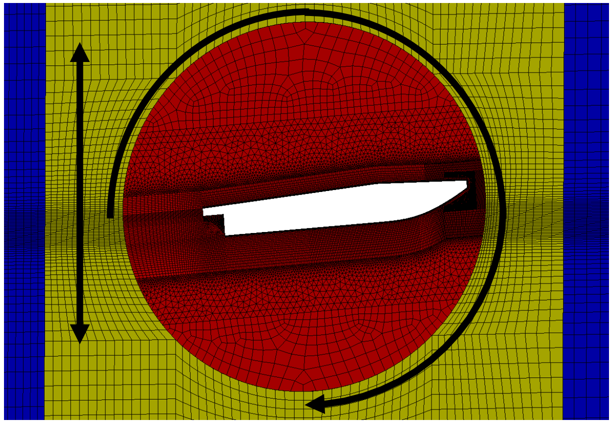
Approach

- An identical solution approach has been adopted for both craft.
  - The craft hull is encapsulated in a rotating zone to allow changes to trim.
  - The rotating zone is encapsulated in a translating zone to allow changes to sinkage.
  - The translating zone is encapsulated in a far field zone to capture wash propagation.
  - A schematic of the zones is shown below for a generic craft.
- The craft were solved at a single speed of 45kt.
- The modified HRIC volume of fluid scheme was used to capture the free surface.
- Turbulence was modelled using the SST k-ω turbulence model.
- Each craft is solved at a range of sinkage and trim to determine the equilibrium position and to explore sensitivity of the hydrodynamic pressure to craft attitude. Solving for a range of conditions also addresses uncertainty over the displacement and centre of mass of the craft during the trials.

🟦 Fixed far-field zone

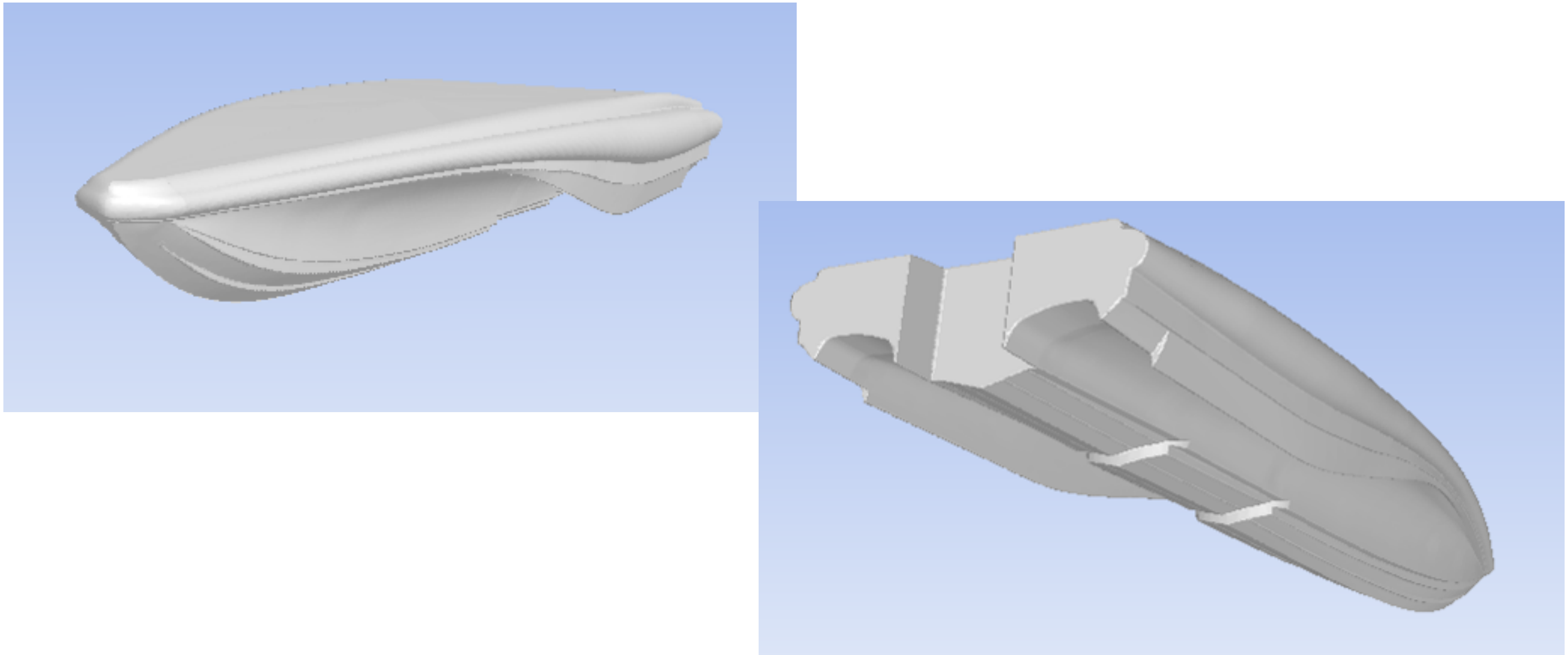
🟨 Translating zone (sinkage)

🟥 Rotating zone (trim)



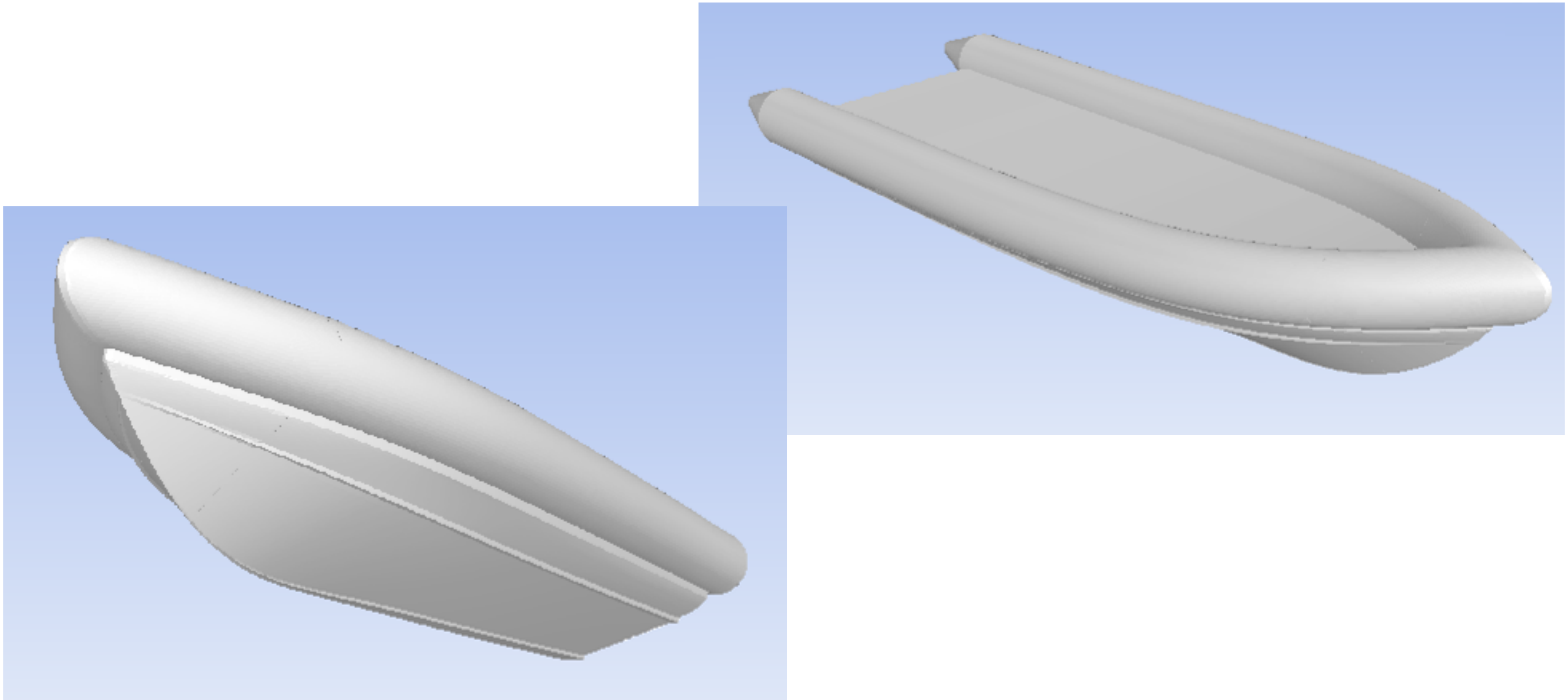
Bladerunner hull geometry

- The Bladerunner model was constructed from hull lines for a similar craft, which was modified as a result of manual measurements of various hull features, discussion with Lorne Campbell and Jeremy Watts, and a laser scan of the hull.

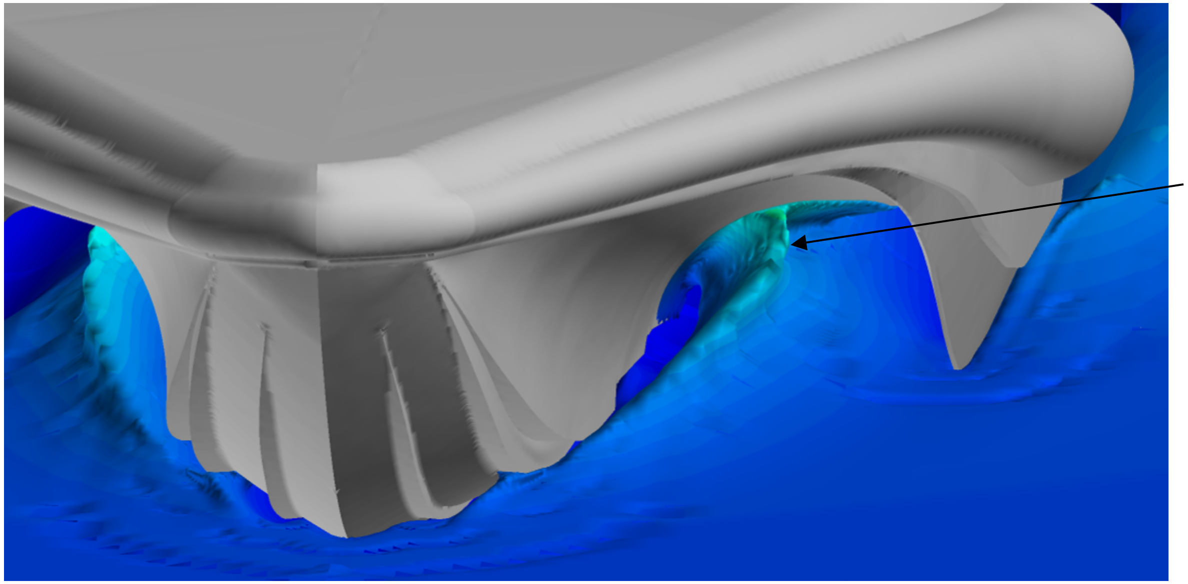


Arctic 28 hull geometry

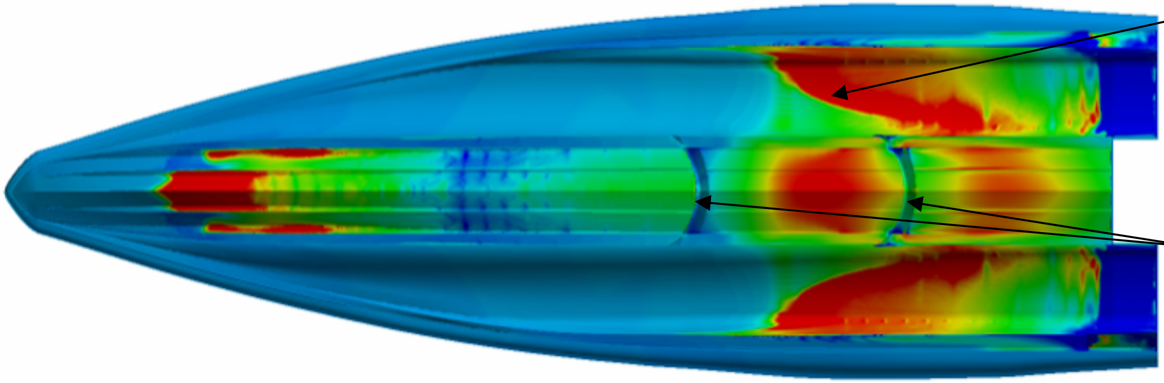
- Arctic 28 was constructed from a Parasolid model of the hull provided by BAE Systems.



Bladerunner near field wake



CFD captures the separation of the bow wave from the sprayrail, which then impinges on the aft end of the tunnel roof.

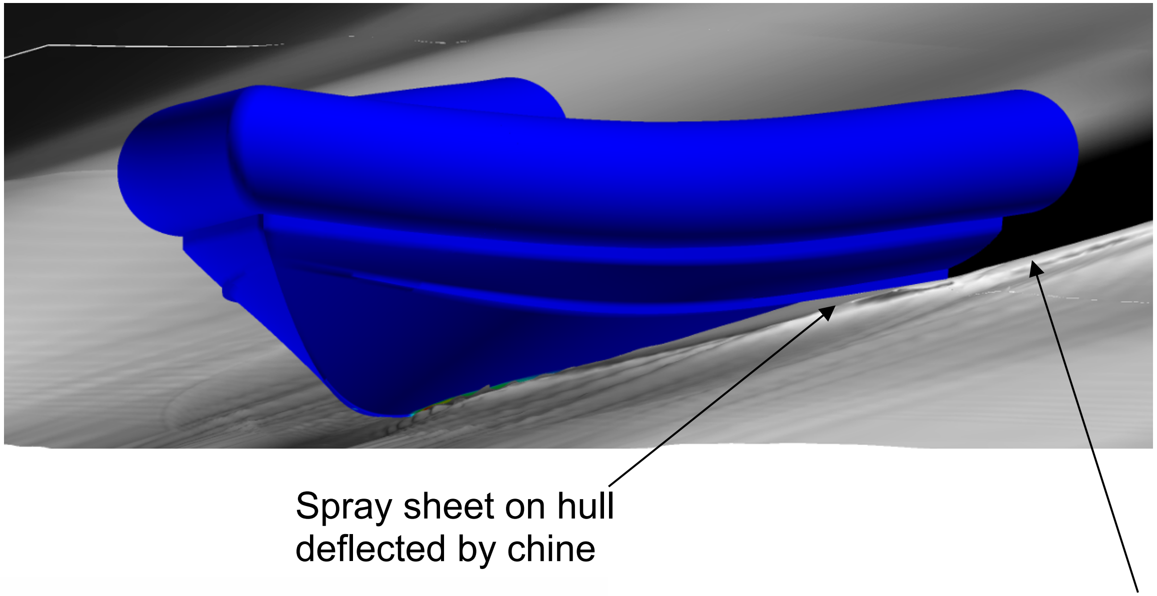


Impingement on the tunnel locally increases the pressure.

Low pressure regions immediately aft of hull steps where air is entrained from tunnels.

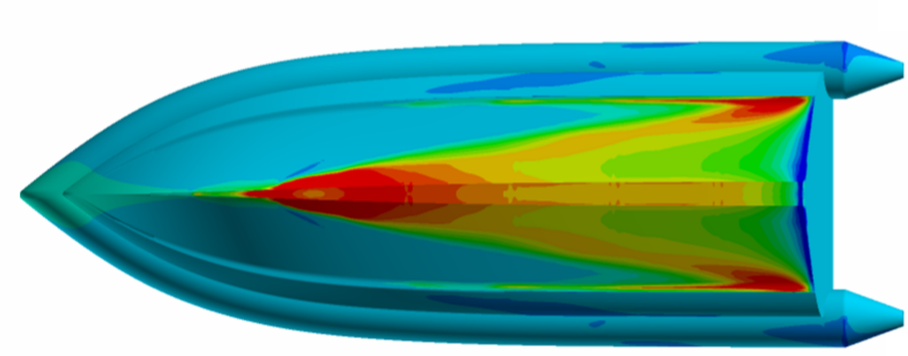
Hydrodynamic Pressure

Arctic 28 near field wake



Spray sheet on hull deflected by chine

Ventilated transom

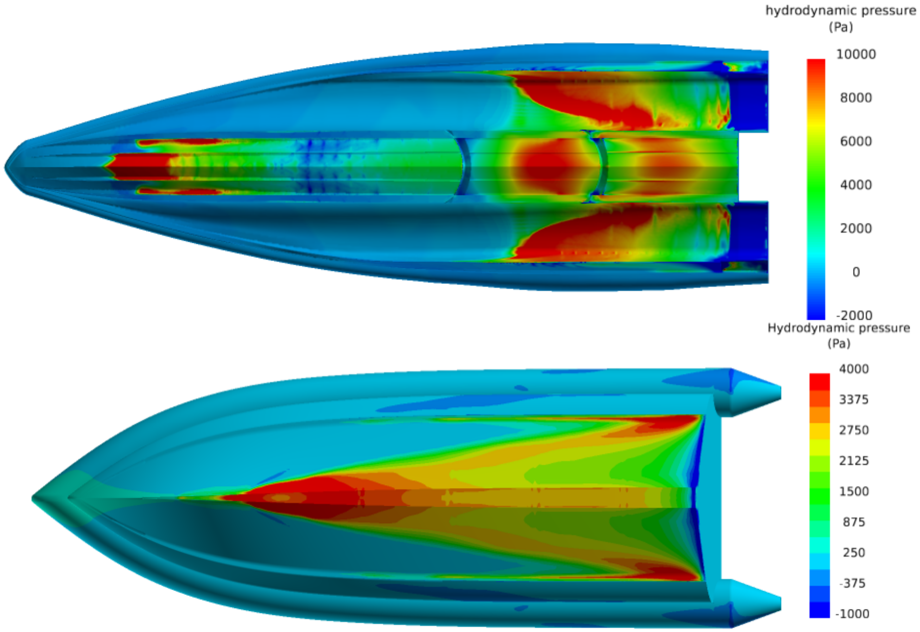


Hydrodynamic Pressure

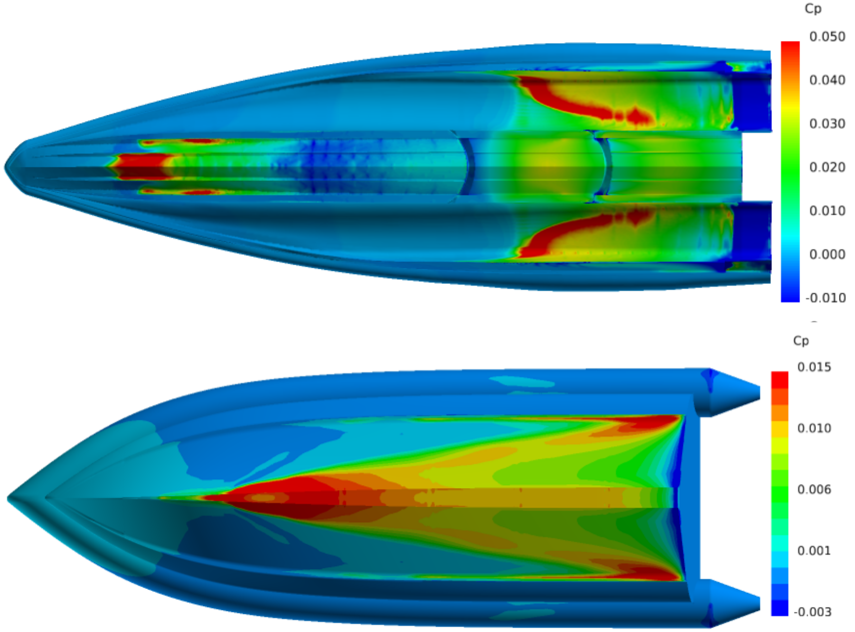
Characteristic pressure distribution typical to all hard chine, planing mono-hulls: elevated pressure at bow and along water line; pressure decays longitudinally towards transom.

Hull pressure comparison

Hydrodynamic Pressure



Pressure Coefficient



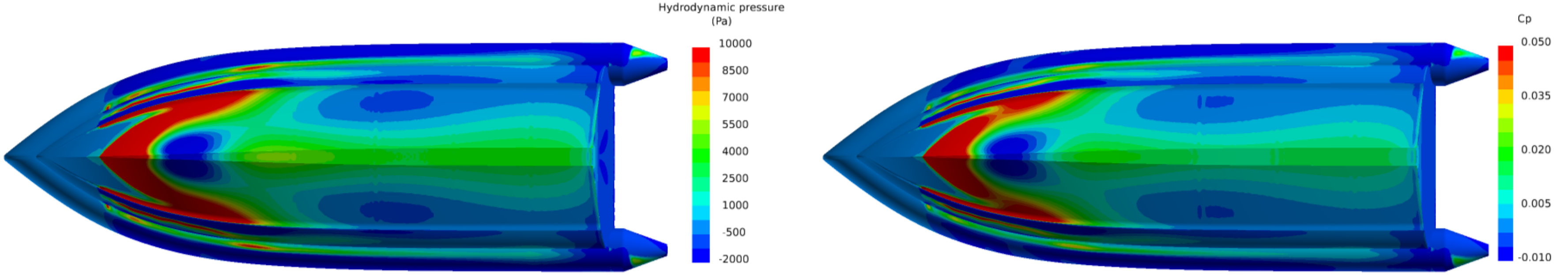
The pressure coefficient is defined accordingly: $C_p = \dfrac{p_{hydrodynamic}}{{}^{1}\!/_{2}\,\rho v^2}$

Note: different contour ranges are used for each craft

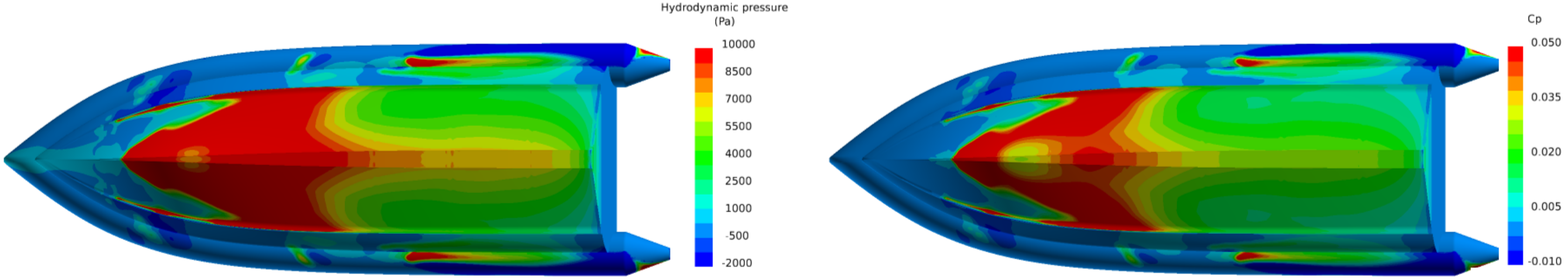
Arctic 28 – Influence of trim on hull pressure for identical sinkage

Hydrodynamic Pressure

Pressure Coefficient



- Trim = 2°

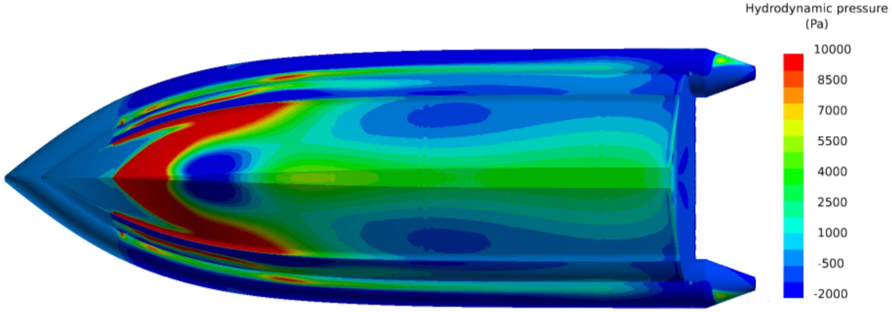


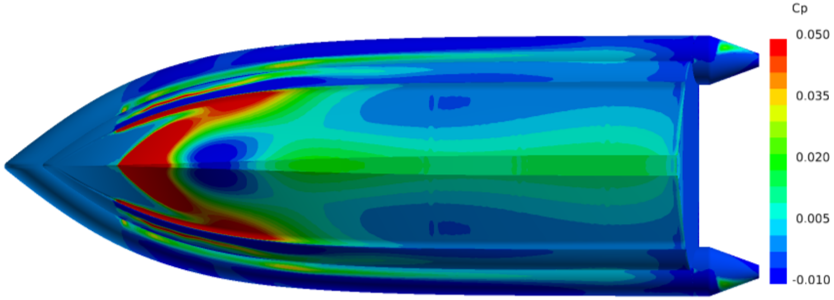
- Trim = 4°

Arctic 28 – Influence of sinkage on hull pressure for identical trim (2°)

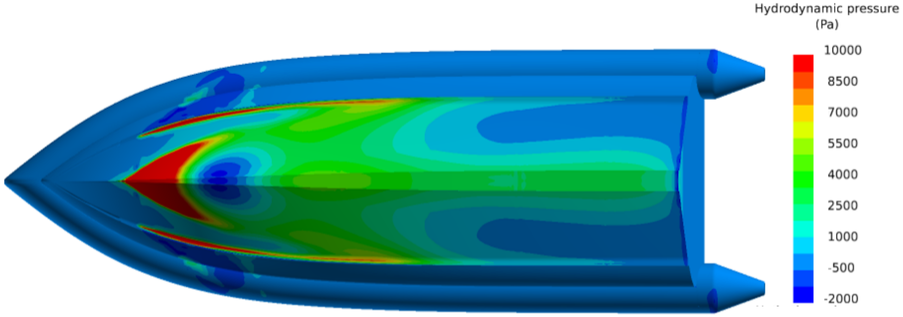
Hydrodynamic Pressure

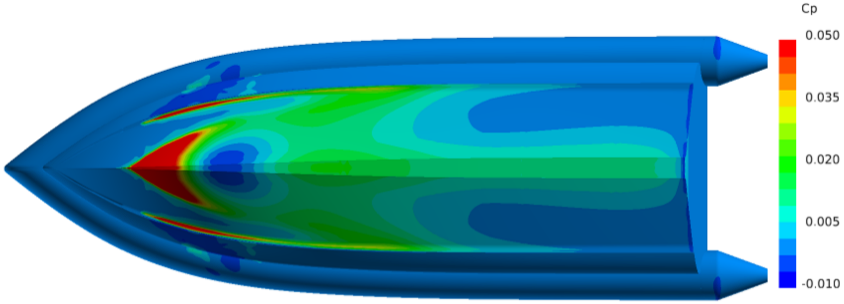
Pressure Coefficient





- Sinkage = 0m





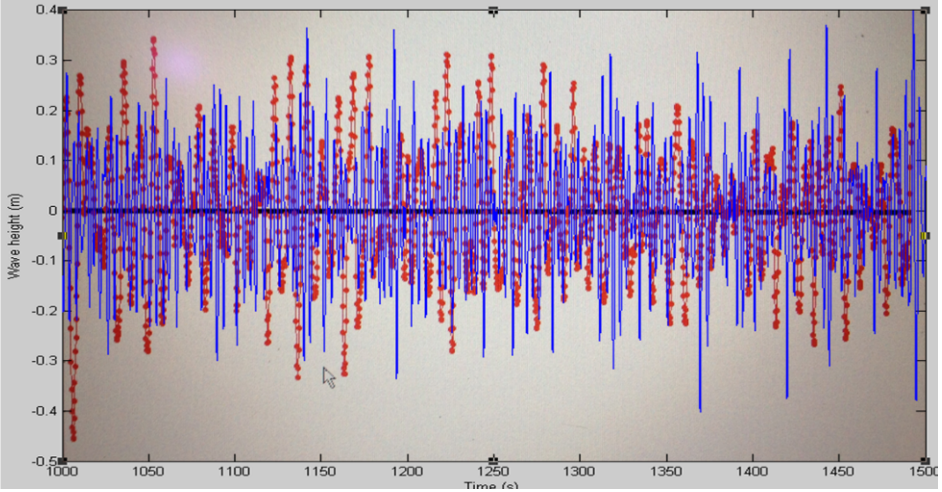
- Sinkage = 0.1m

HydroDyna

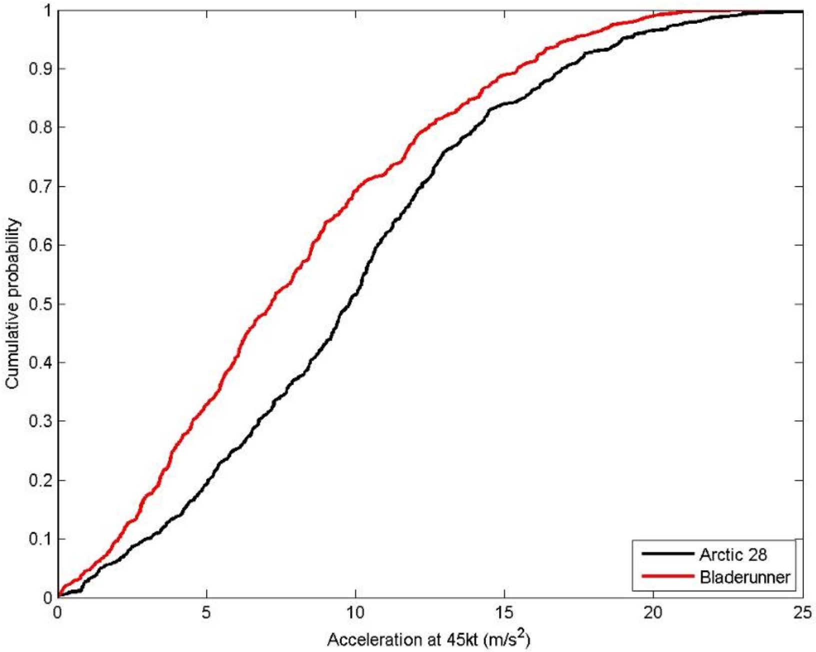
- The hydrodynamic pressures predicted by the CFD have been used to calibrate the HydroDyna models for Bladerunner and Arctic 28.
  - Uses high fidelity resolution of the flow field to calibrate hydrodynamic coefficients in HydroDyna.
  - Minimises computational cost.
  - Allows long transits to be solved.
  - Simulated transits can be compared to trials using population based approaches.
- Mass and balance of craft defined according to available data.
  - Uncertainty over:
    - Rotational inertia of both craft (Radius of gyration set at 25% LPP for both craft).
    - All up mass of Bladerunner and its centre.
- Models solved at 40kt and 45kt in head seas.

Wave climate

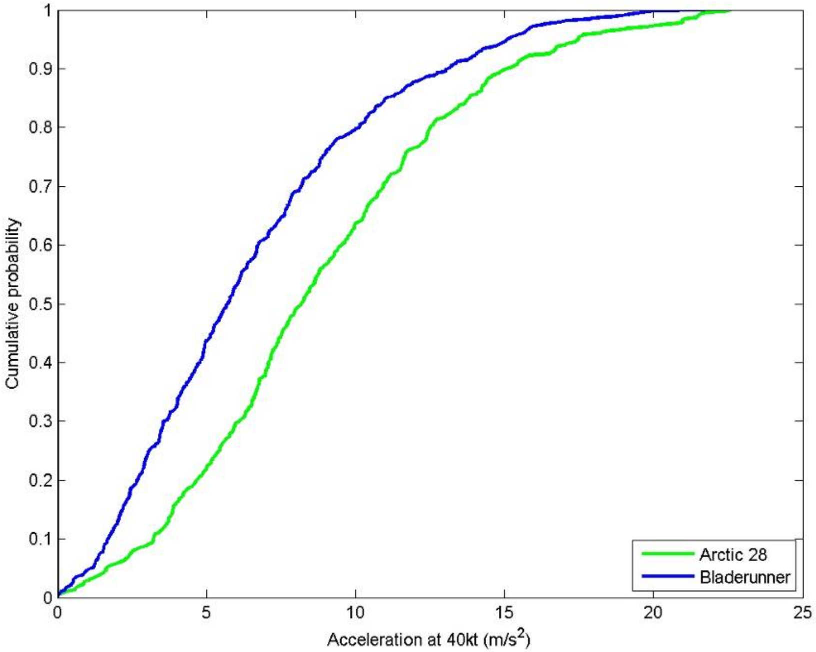
- Wavebuoy data
  - Corrupted by deployment of buoy (peak wave height of 18m, Hs of 1.5m).
  - Wave defined by doubling trough history (Hs=0.4m, Tp=3.96s, Tz=2.81s).
  - Pierson-Moskowitz spectrum used.
- Time history of mathematical waveform compared to wavebuoy data.
  - Data extracted from trials laptop using a camera.



Acceleration comparison – HydroDyna



50th percentile at 45kt
Bladerunner = 7.2m/s^2
Arctic 28 = 9.8m/s^2



50th percentile at 40kt
Bladerunner = 5.7m/s^2
Arctic 28 = 8.2m/s^2

Summary

- At the speeds considered, spray recovery provides significant lift (2/3 of sponson lift) on Bladerunner.
    - Aerodynamic contribution smaller by comparison (1/3 of sponson lift).
- Uncertainty around prevailing wave spectrum during trials will influence the simulated performance of both craft.
- HydroDyna simulations reproduce the same trend of Bladerunner experiencing lower accelerations than Arctic 28.
- HydroDyna tends to reproduce fewer very large accelerations than trials. This could be attributed to:
    - The low confidence in wavebuoy data.
    - Sensitivity of simulations to chosen wave spectrum and mathematical wave form.

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