Effective Prototype to Full Scale Development Methods - Innovative High Speed Vessel Designs

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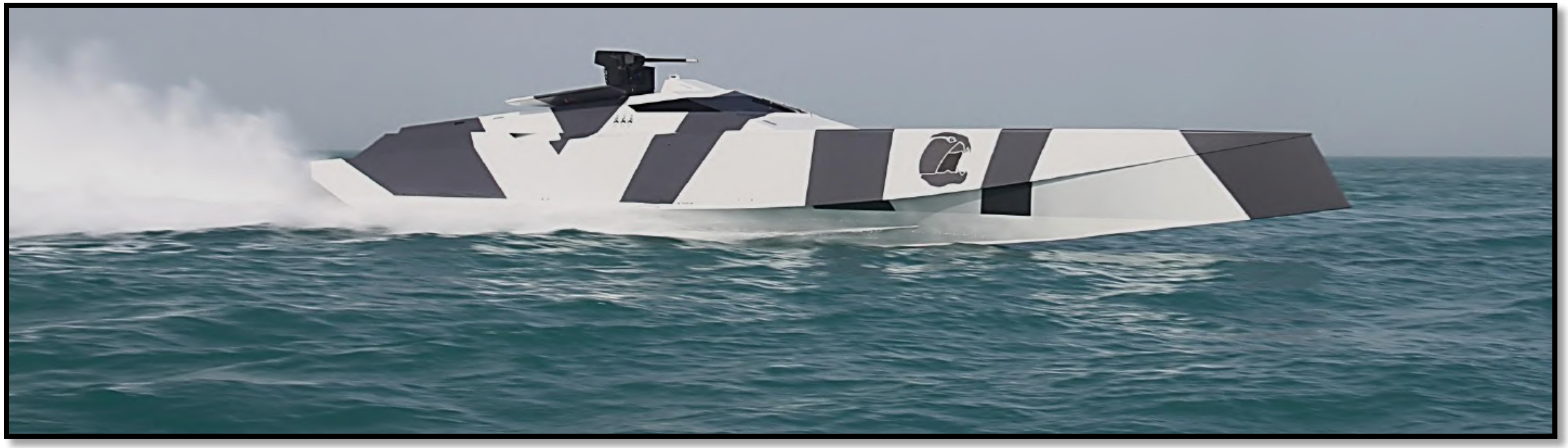

Introducing

The innovative techniques incorporated by the authors in their PX18 and AG30 programs.

The design methodology used by the authors is broken down step by step and the various comparisons of data identified

Contents

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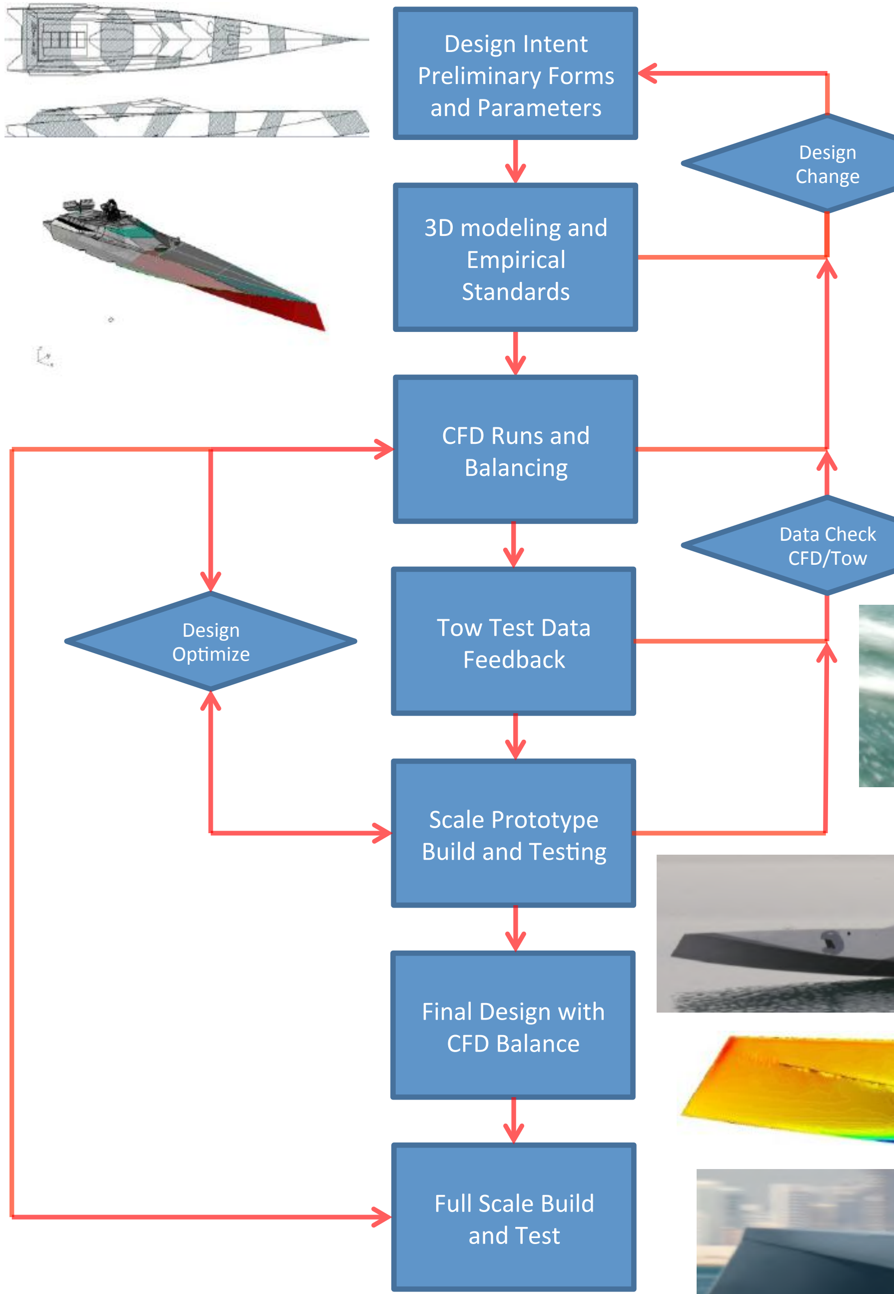
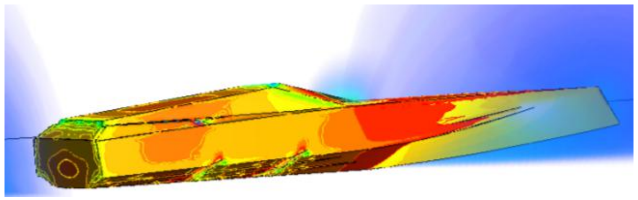
Innovative High Speed Vessel Designs

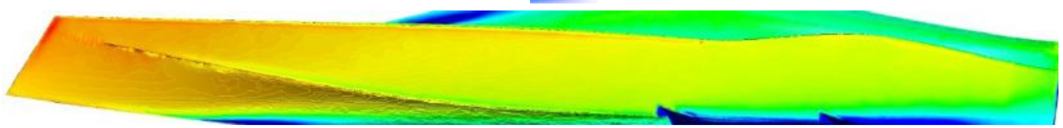
Benefits & Developmental Flow Logic

- Innovative designs proven prior to full scale builds
- Reduced costs to establish new design viability
- Quicker turn around and ownership of data
- Fast modifications and optimizations
- Real time attributes can be used as case studies to influence hull design changes
- Blending of tow and prototype testing lends perfectly to CFD analysis and optimization
- 3D Models can be easily adjusted to reflect improvements from CFD and FEA and verified with tow and prototypes

Developmental Flow Chart







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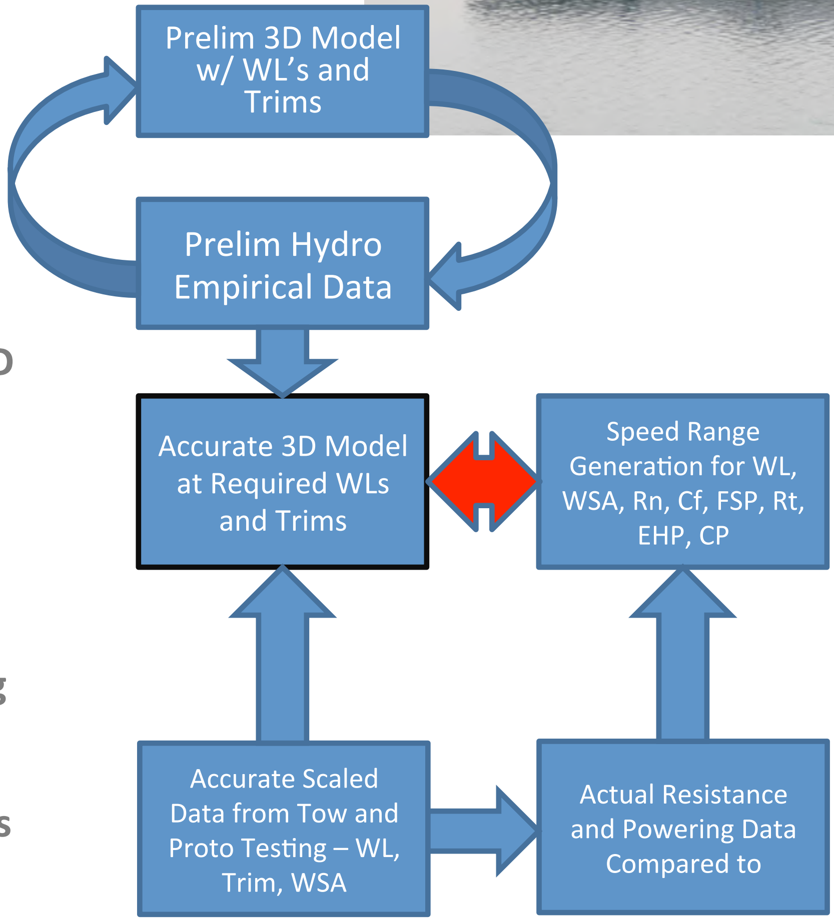
3D geometry is used to

- Accurately model the proposed geometry and make changes
- Investigate packaging concepts, in particular engine and drives
- Structural layouts

- Creating models for import into CFD and FEA

Particular outputs of interest

- Centre of volume, mass, and area positions
- Accurate mass and COG data, taking into account composite layups, and varying loads
- Data feed into Empirical calculations (i.e: keel length, WSAs and underwater volumes at varying waterlines and trim angles, etc)



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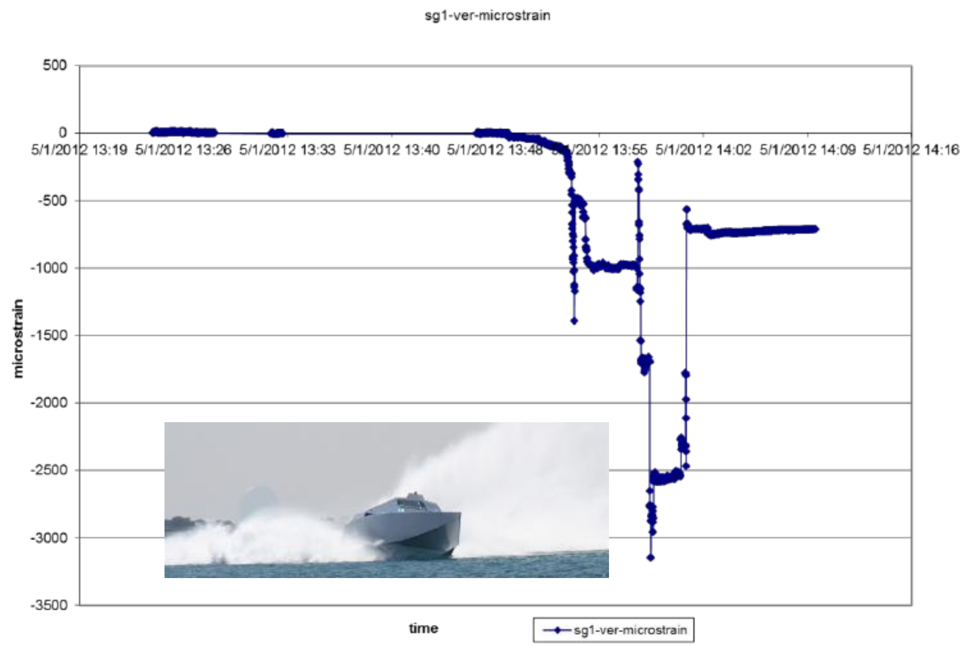
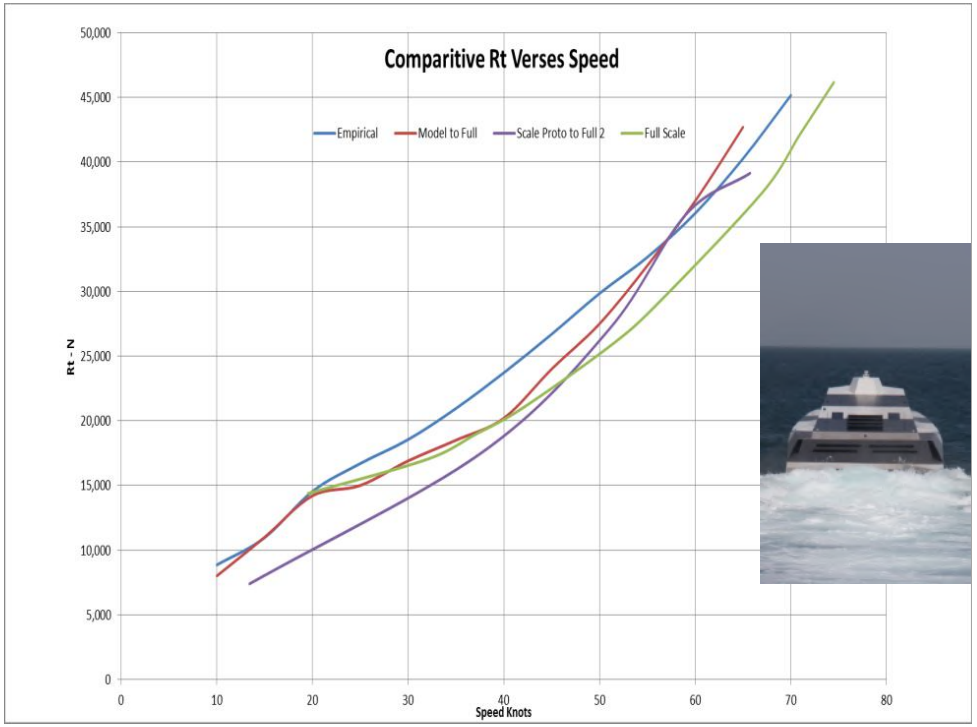
Comparison of Data

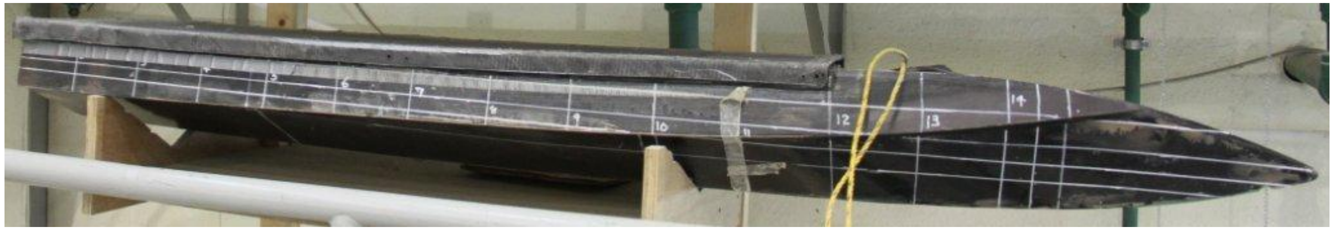
- Prelim CFD compare to empirical and initial design, for order of mag and dynamic parameter validations
- Tow tests for follow up comparison to above and incentive for prelim design changes – delta value checks
- Scale prototype trials - comparison of powering and dynamic parameters as second iteration – delta value checks
- Scaled prototype used as platform for structural and human factor analysis – Strain Gauge, Accels, Motion Capture
- Scaled prototype used to verify sea keeping, handling, accelerations, hs turning, CG variation effects, displacement variation effects
- All data can now be established as a strong predictive tool for validation of full scale design
- Final full scale parameters fed back into CFD and FEA – correlation established
- Verification of full scale design, BOM, and particulars to match results, have target to aim for
- Build full scale vessel and trial, then feed info back into loop for final similitude
- Run CFD optimizations for increased performance





Scale Model Testing

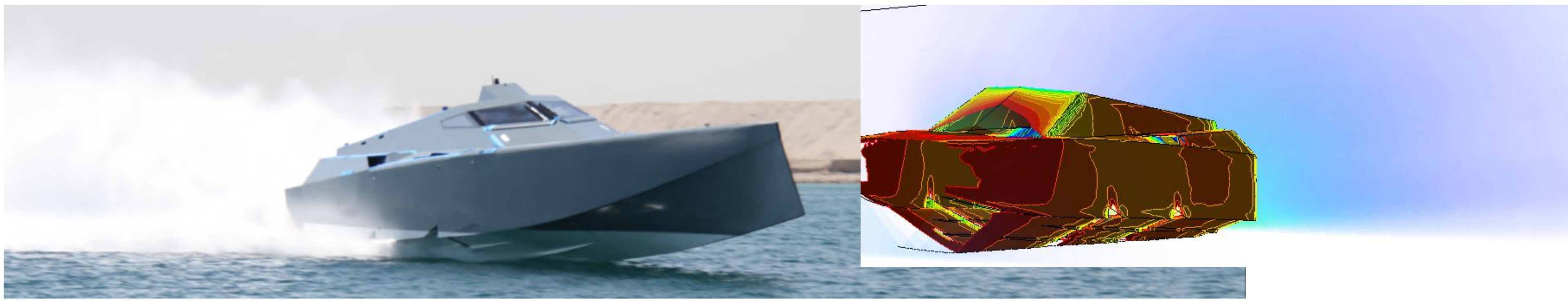
- **Scale 2m Models**
- **Remote Control**
- **Resistance Towing**
- **M Ship in House Solution**



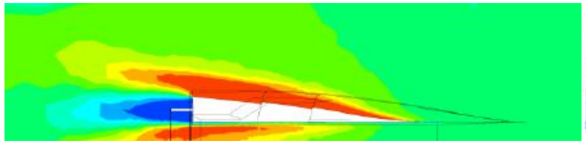
Computational Fluid Dynamics
CFD

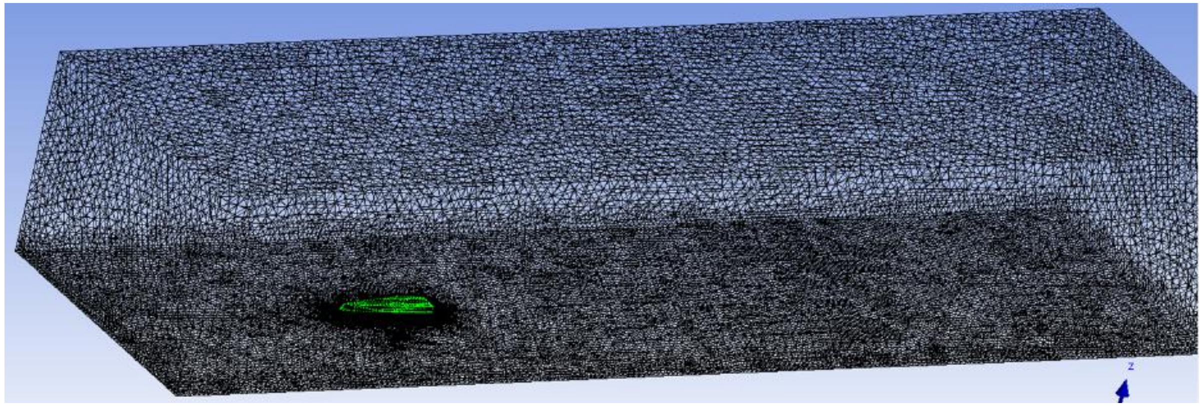
CFD Analysis is used to:

- Compare against predicted behaviour from Empirical calculations
- To validate against scale model tests
- To optimise geometric features in order to achieve design goals
- Run sub analysis (e.g: varying mass and COG, engine room flow, exhaust, prop ventilation)



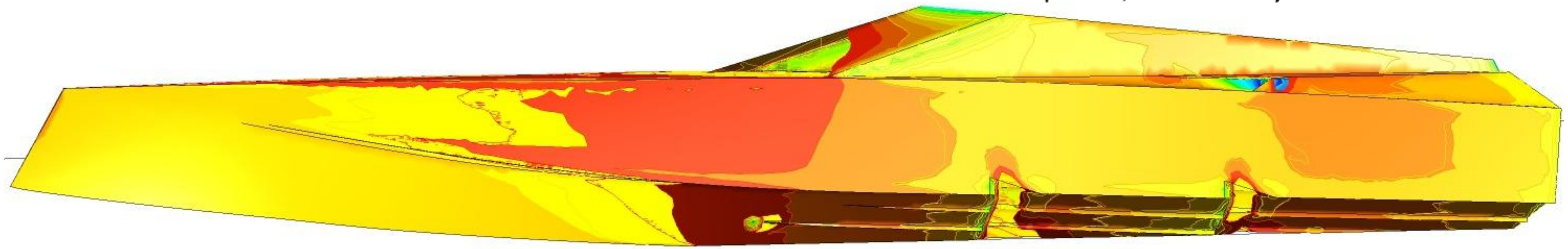
Computational Fluid Dynamics CFD

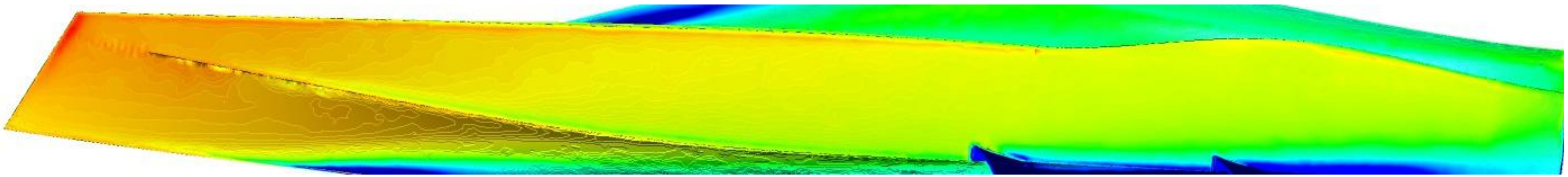




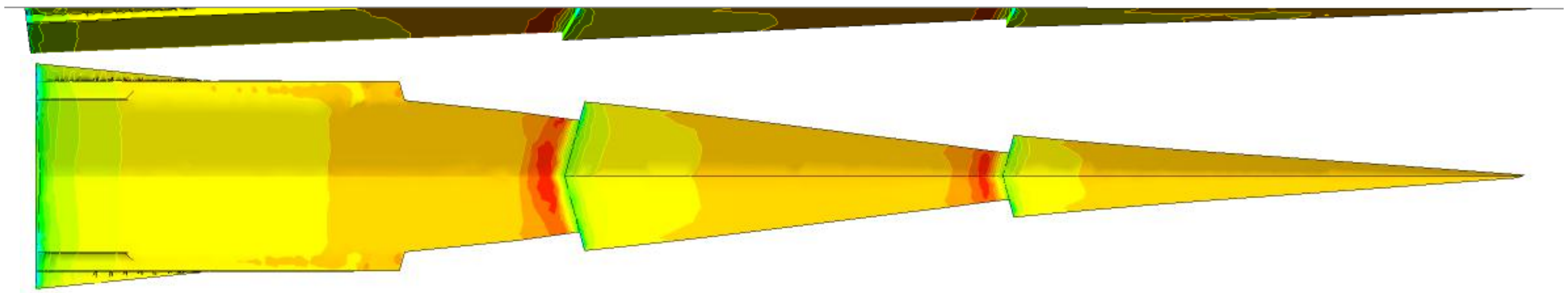
Post-processing outputs of interest

- Location of Centre of Lift
- Quantify magnitude of Lift and Drag components
- Quantify magnitude of inherent pitch, roll and yaw moments

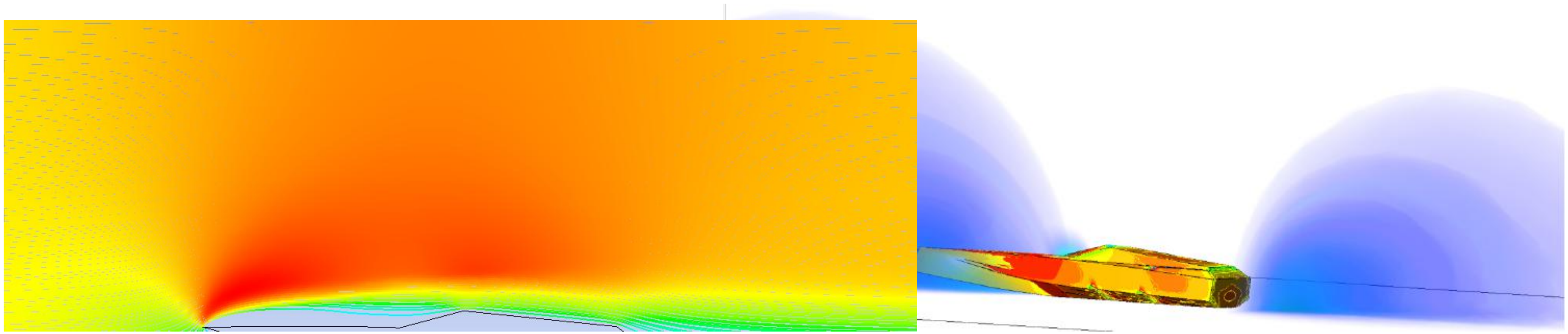


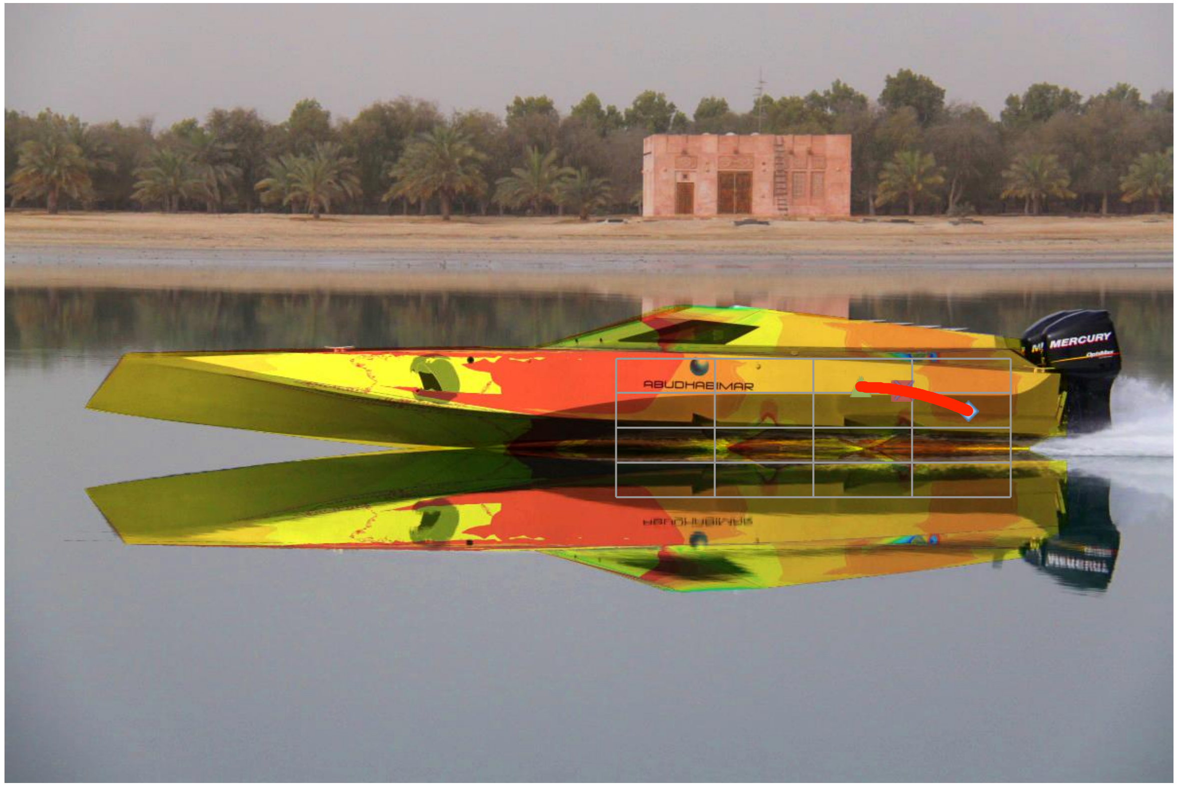


Computational Fluid Dynamics
CFD

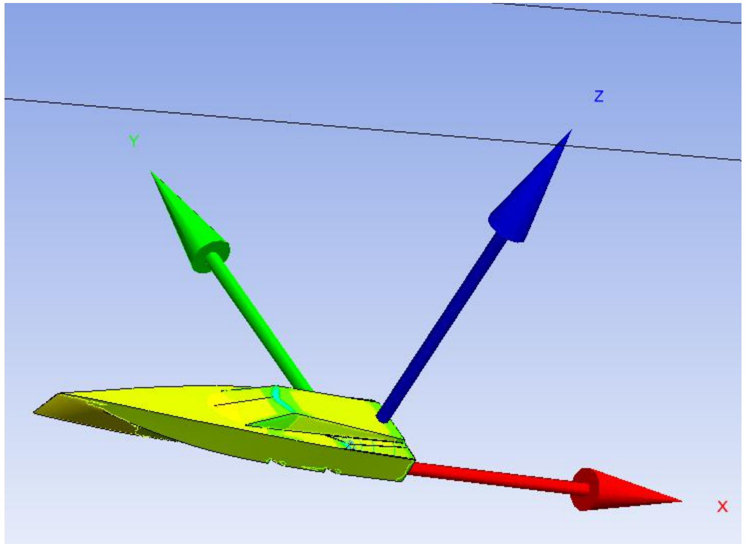


- Split Fluid Analysis for optimisation
- Reduce computational time by analysing hydro and aero separately
- Debate over validity of CFD numerics, esp. Hydro. Variation between CFD codes and analysis settings, but useful data can be acquired by amateurs



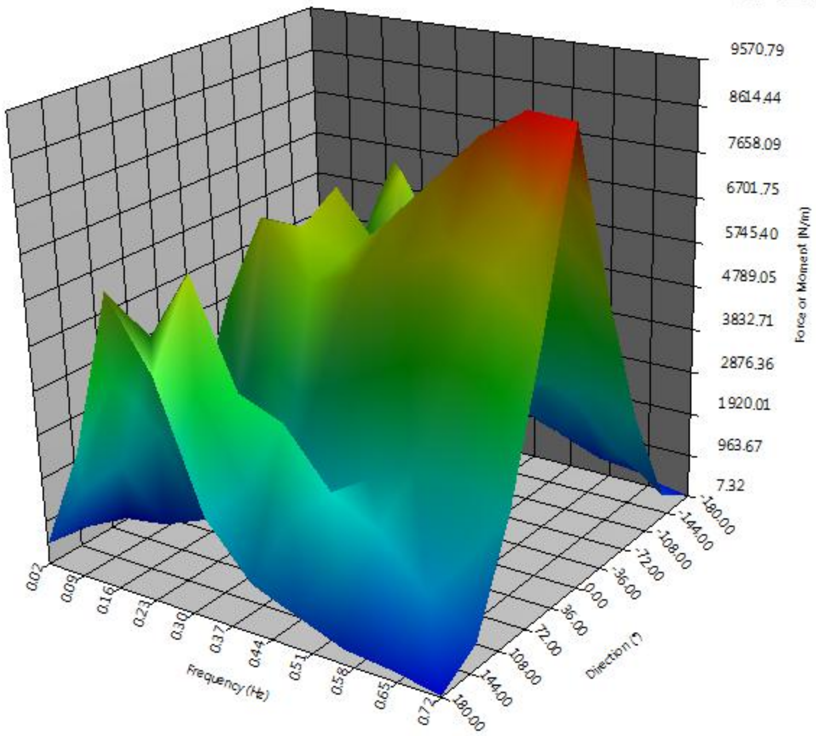


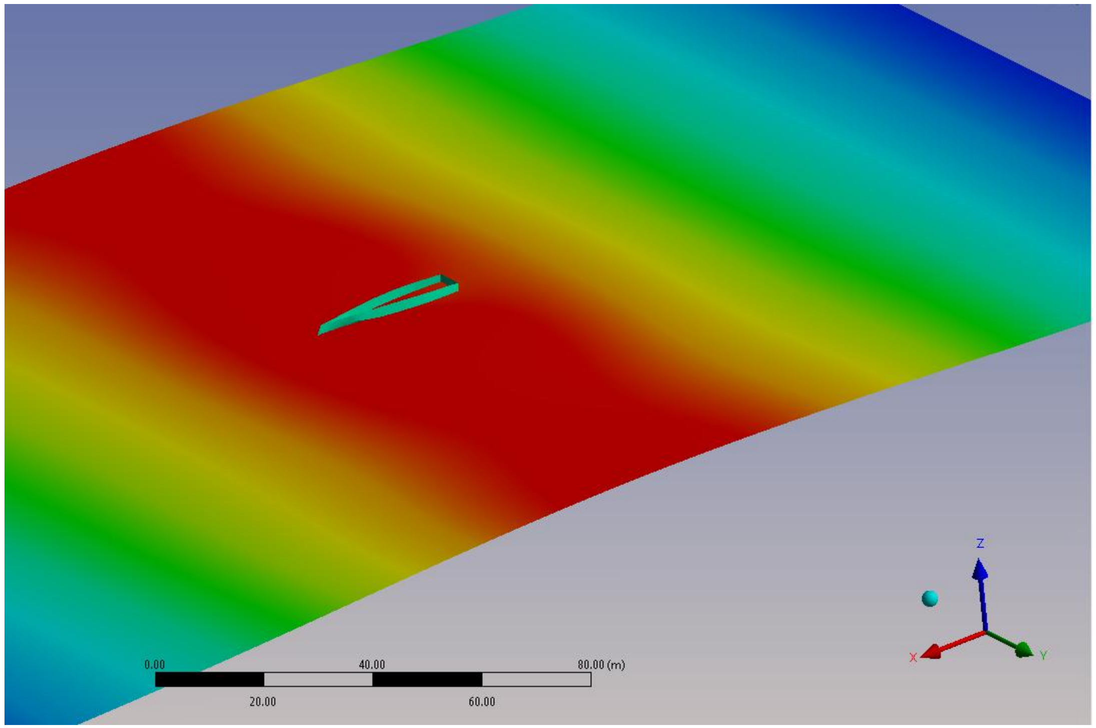
Aero centre of pressure calculation



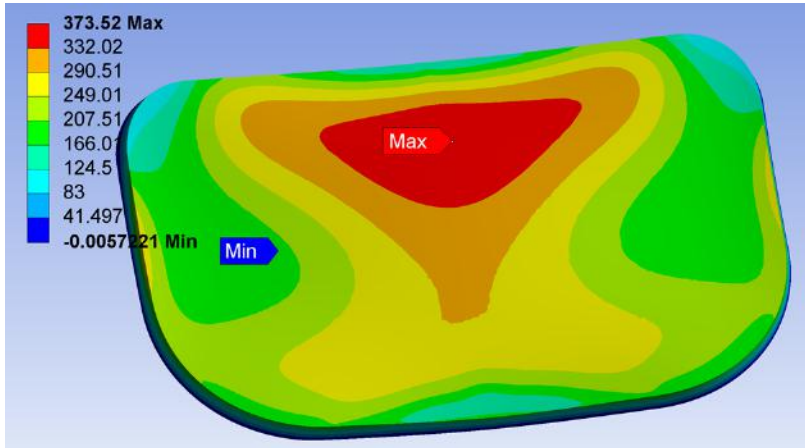
CFD – Wave Analysis:

- Analyse wave performance over a variety of heights, frequencies and directions
- Produce RAO (Response Amplitude Operator)
- Establishing pitch and roll moments along with reaction forces in varying conditions and running attitudes



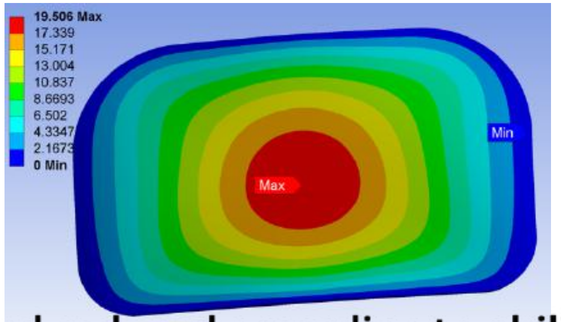


Finite Element Analysis FEA



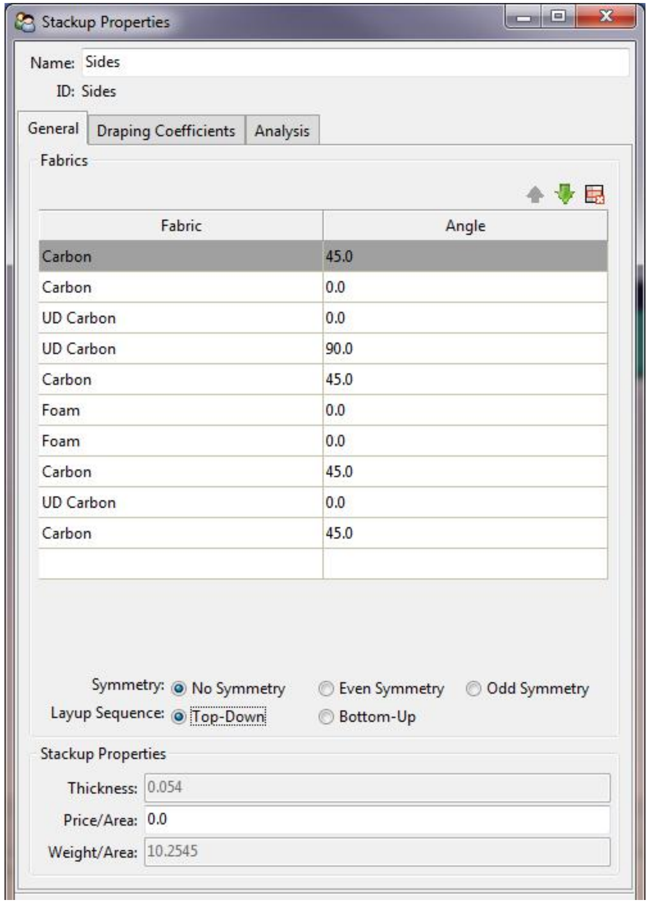
Finite Element Analysis is used to

- Establish potential structure (metallic/composite) and evaluate performance
- Optimise structure to minimise weight, maximising strength and stiffness to given loadcases
- Design to pre-determined loads, along with fatigue criteria to establish life of product.
- Used for global models as well as substudies (e.g: hatches, engine mounting brackets, trim tabs, etc)

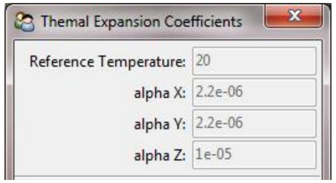


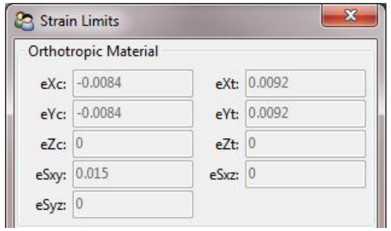
Particular outputs of interest

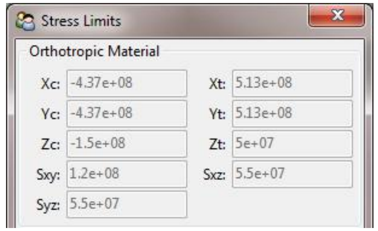
- Strain output for composite structures
- Anticipate design life (fatigue runs to 10e9/12 cycles)
- Mass optimisation of structure, as layups can be evaluated and reduced according to ability to meet determined loadcases
- Impact simulation – crash performance (e.g: in case of flip or stuff)
- NVH performance, modal analysis to determine inherent natural frequencies

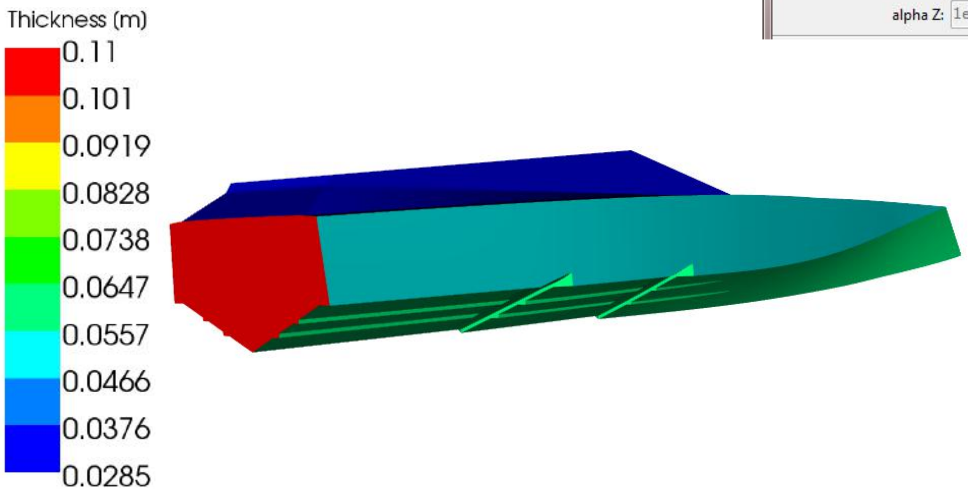


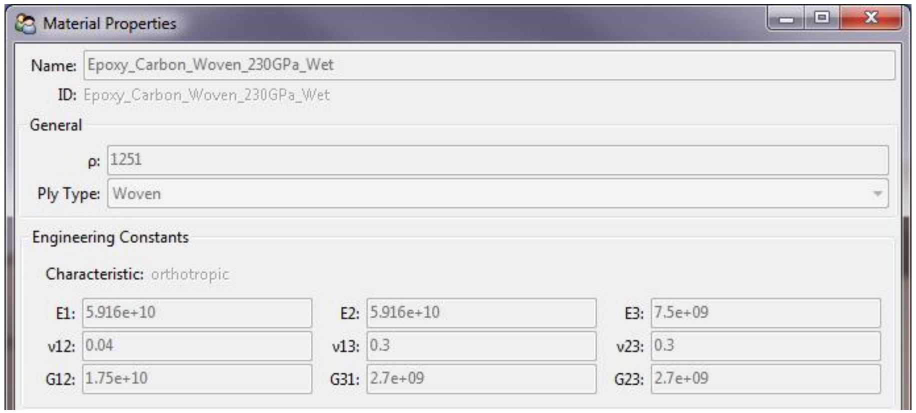
- **Material Input**
- **Layup and Stack-up Representation**
- **Representing computationally the real layup**
- **Composite Failure criteria (Hoffman, Tsai-Wu, etc)**

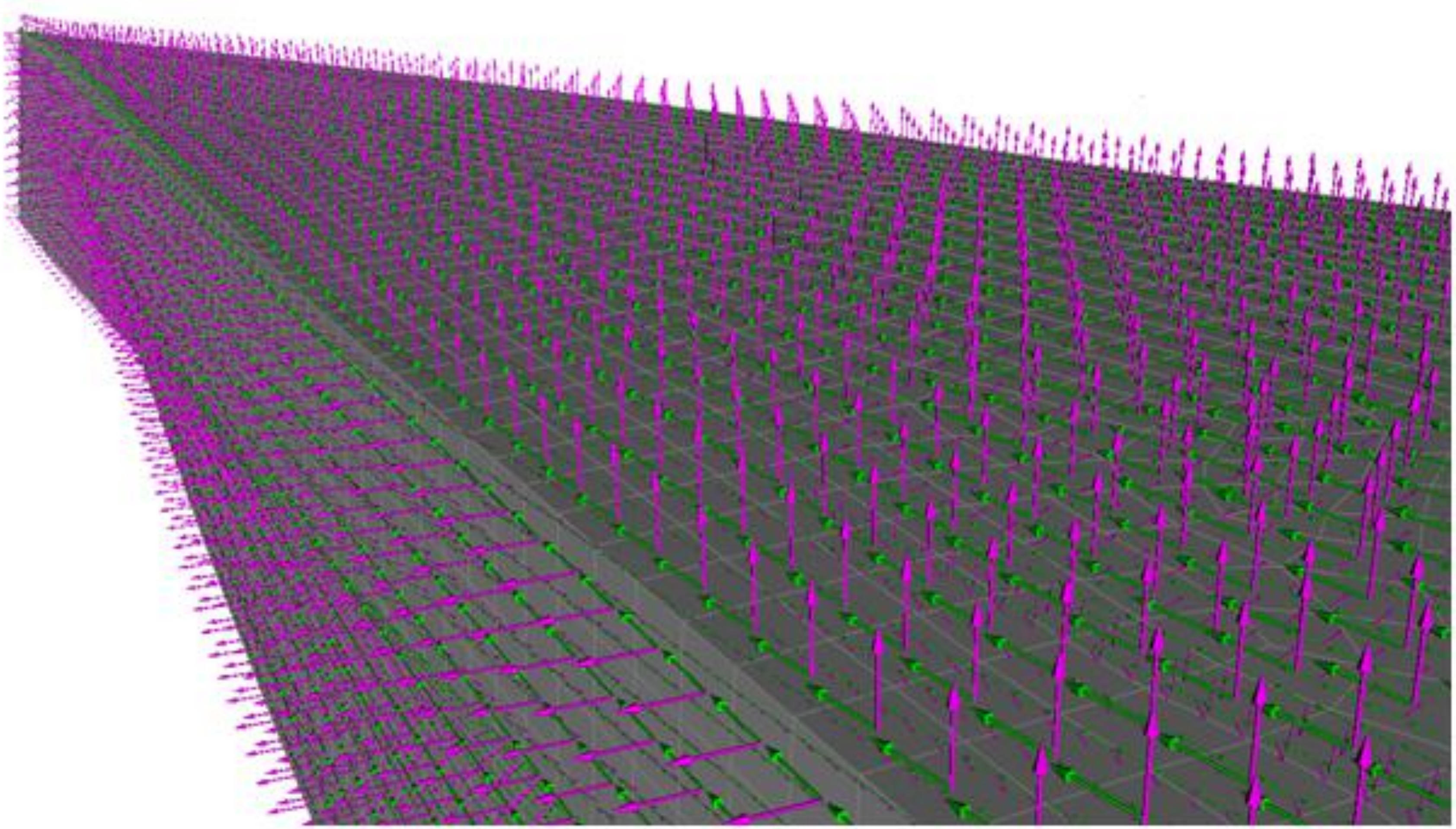










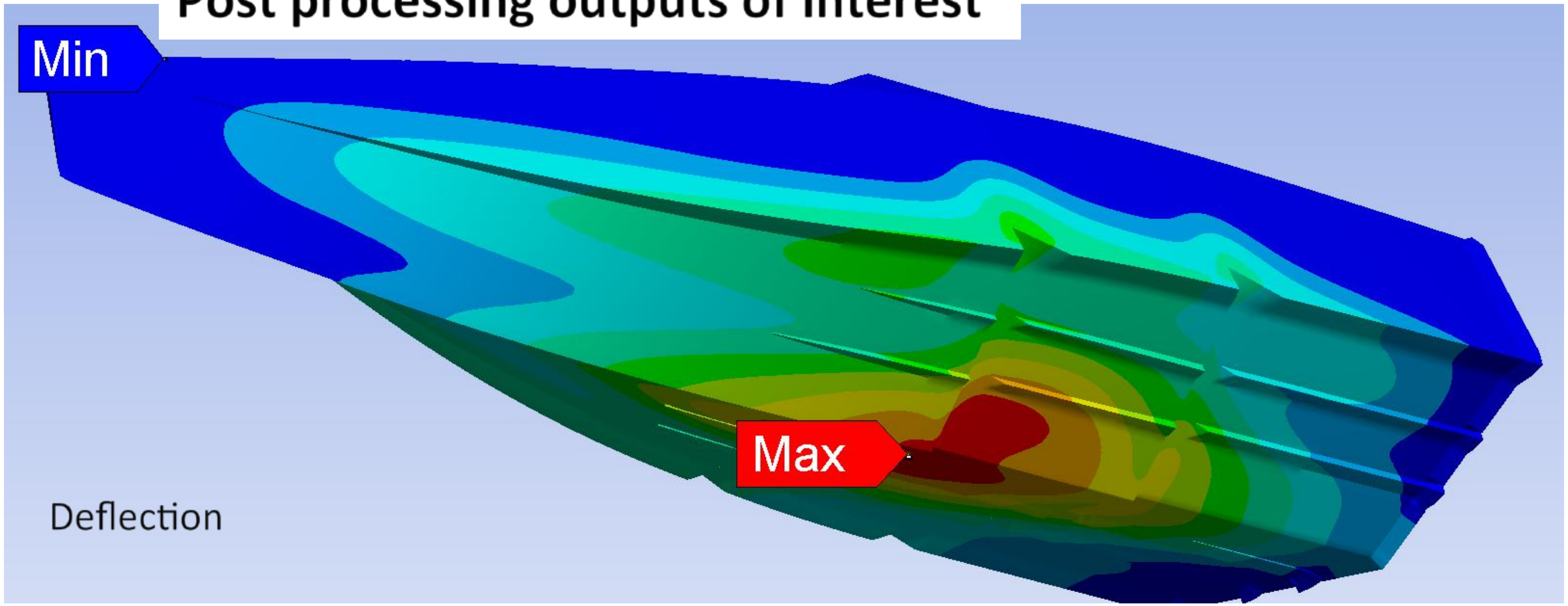


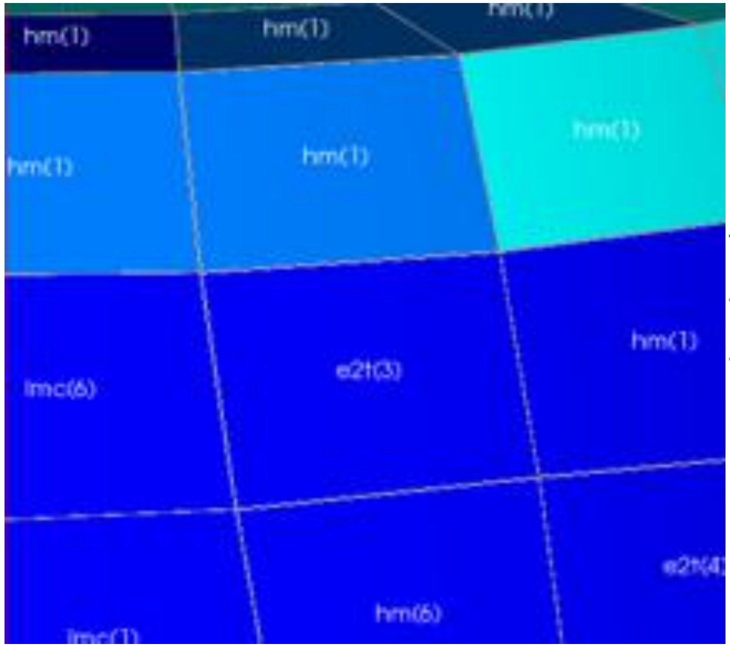
- Meshing – element shape, quality and density
- Element co-ordinate system – representation of isotropic (metallic) and orthotropic (composite) materials
- Contact elements, bonded joints – improve realism of analysis
- De-featuring geometry and preparing models for:

FEA = (interfacing surfaces on frames and deck/ hull, stringers – meshed in shell elements

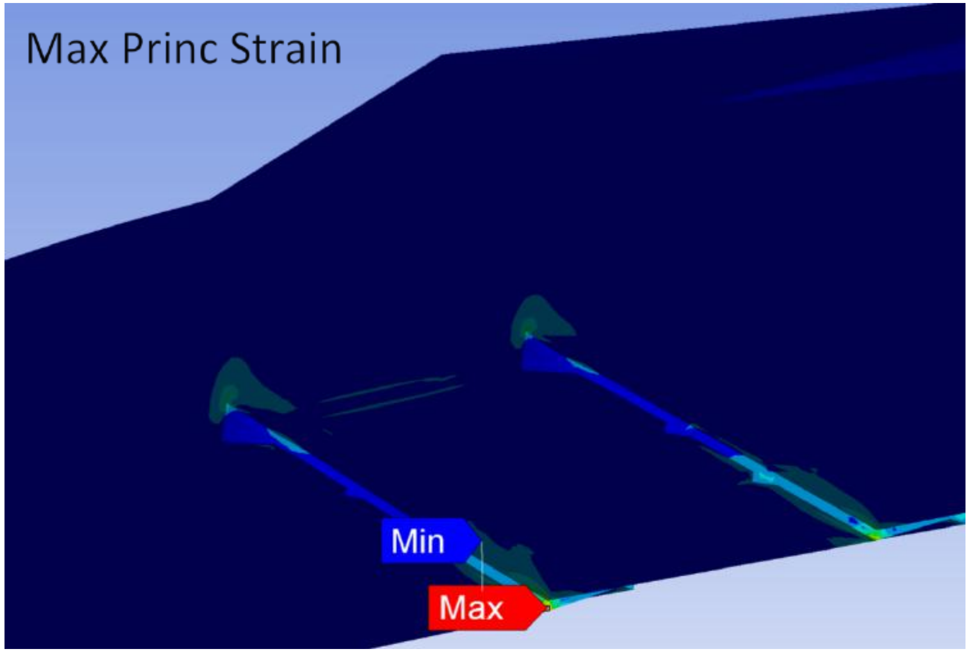
CFD = (creating negative of vessel in fluid, careful to remove boundary effects, particular meshing criteria)

Post processing outputs of interest





Through thickness failure criteria



Thank You