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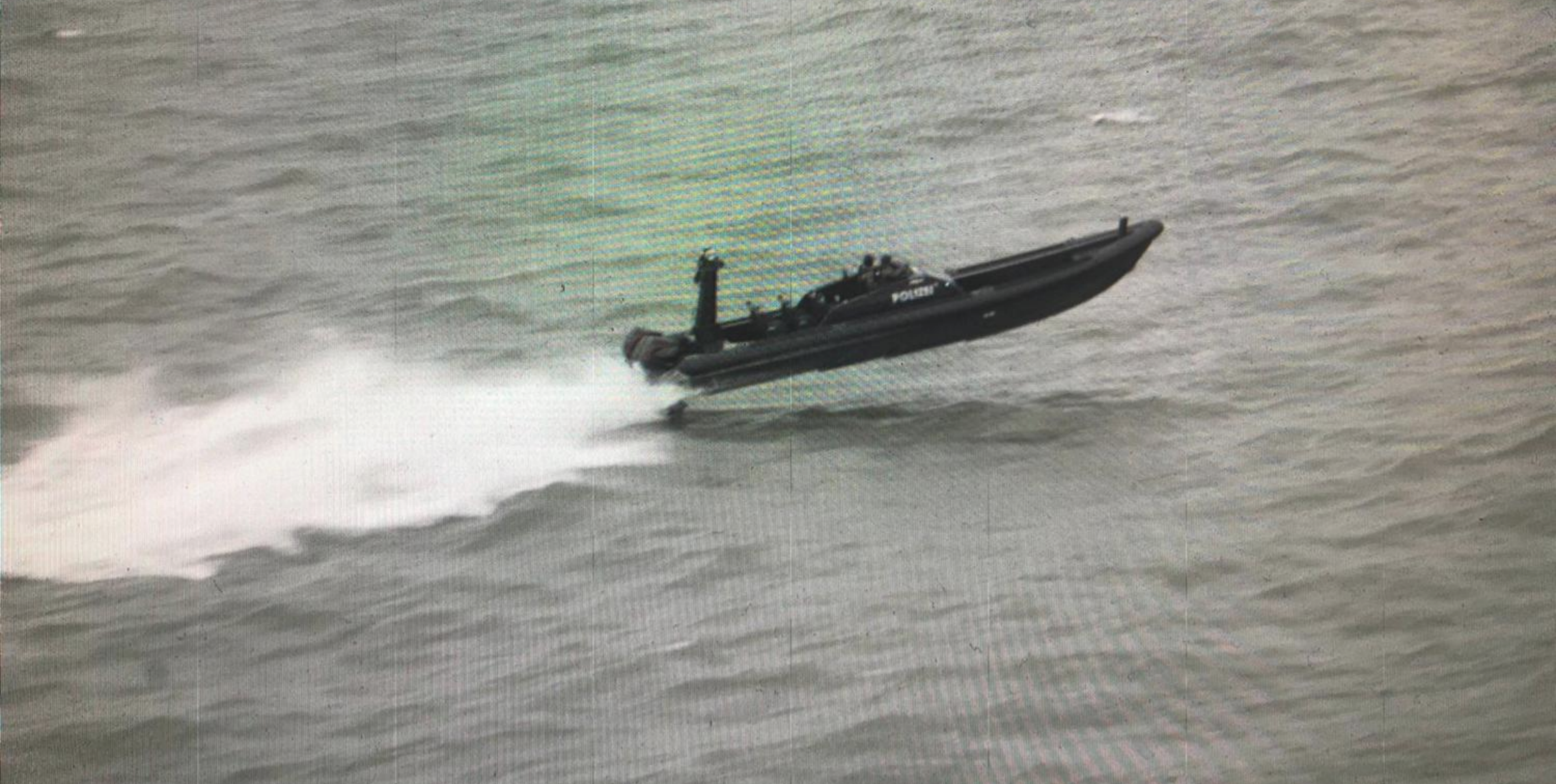
HULL DESIGN APPROACHES FOR LOWERING IMPACT EXPOSURE



Norson ZeroDark 12.8m RIB – 80 knot offshore proven platform. Record Cork Fastnet Cork Aug 2021 at max speed 83 knots

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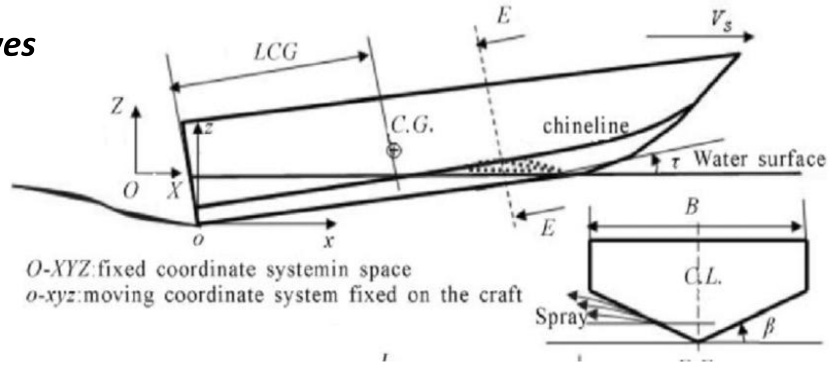
High Speed Vessel Design, Engineering, and Project Management

Andrew S.N. Lea B.Sc. Mrina

www.norsondesign.com

Parameters Affecting Hull Impact Load Magnitude

- Operational Requirements and Zones – Significant wave height, average of highest 1/3 observed
- Cruising and Max Speeds – dependent on vessel type
- Displacements – weight of vessel, mass distribution
- Center of Gravity's – Longitudinal and Vertical Center of Gravity
- Basic Hull Dimensions – length, beam, deadrise
- ***Balance of Trim System and Drive Line – Trimming issues at speed - off keel impacts – always some***
- ***Operators Skills– correct trim path and response in waves***
- ***Hull Optimization - multiple variants***



The Shock Mitigation Systems

Possible Levels of Reduction to Crew

SUSPENSION SEAT – Low frequency impacts – 25% Reduction

DECK FLOORING MATERIALS – High frequency – 20% Reduction

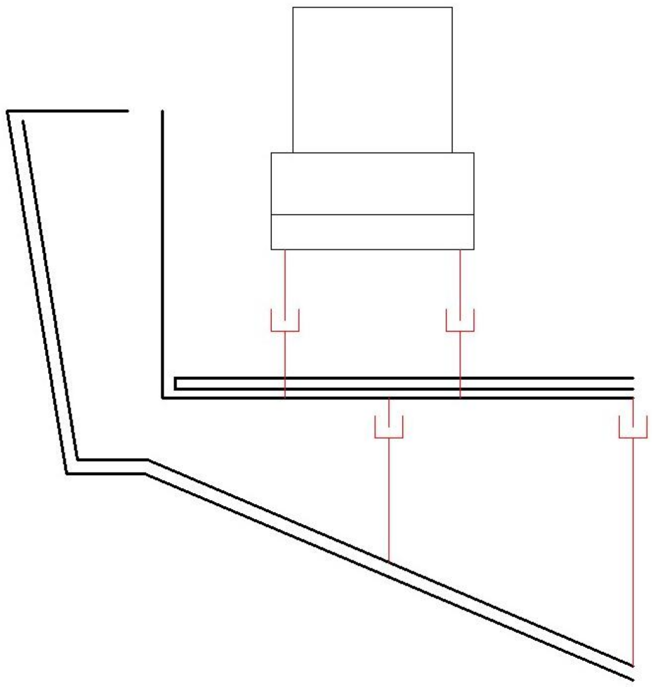
FLOATING COCKPIT – Mid frequency – Unknown Reductions

SANDWICH PANEL HULL DESIGN – Mid frequency – 7% Reduction

HULL DESIGN – Low frequency – 25% Reduction

Total – Low frequency 2-4 Hz– 50%

Total – High to Mid frequency 8-12 Hz– 27%



Defining Hull Design Interaction

Hull Design

Assumptions related to effective bottom pressure loads and impact load factors have resulted in tractable design approaches for the very complicated dynamic environment of small high-speed planing craft. However, the dichotomy of designing hulls with less than a maximum operational load (e.g., use of $A_{1/100}$, the average of the top one percent of wave impact loads rather than A_{MAX}) suggests that published planing hull design equations have unknown safety factors or margins that result in maximum environmental loads. Published equations are useful, but the unknown margins leave no room for flexible hull design optimization by individual

[4], Observation shared during private discussion with Donald Jacobson, Code 831, Naval Architecture Branch, Combatant Craft Division, Naval Surface Warfare Division Carderock s in 2013.

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designers. There is an opportunity for research that unravels the dichotomy and better defines equations with known allowances for design margins.

Hull Type	Reduction Factor
Monohull	1.0
Catamaran	1.0
Wave Piercer	0.9
Surface Effect Ship	0.8

Baseline Vessel - Parameters for Discussion

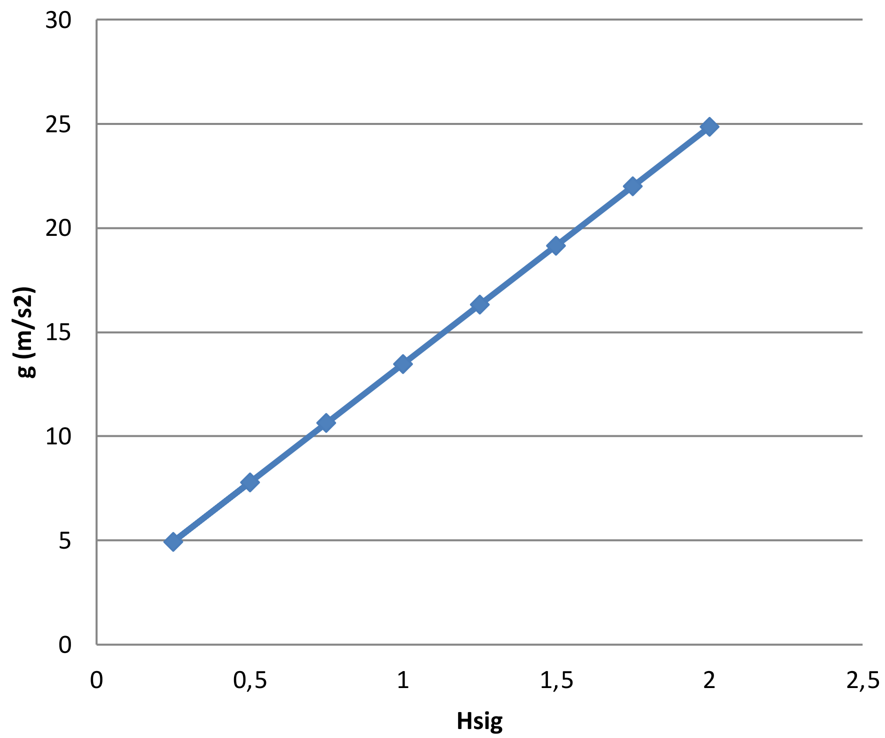
- Standard Advanced Composite Closed Cockpit Interceptor
- LOA 15m
- Beam WL1/2 2.3m
- Max Speed 60 knots
- Displacement 9 Tons
- Deadrise @ Cog 23 Degrees
- Hull Factor 1
- Wave Height 0.7m

- **Wave Height Relation to Impact Loads Baseline Vessel at 60 knots**

- Linear Approach Class Empirical Methods

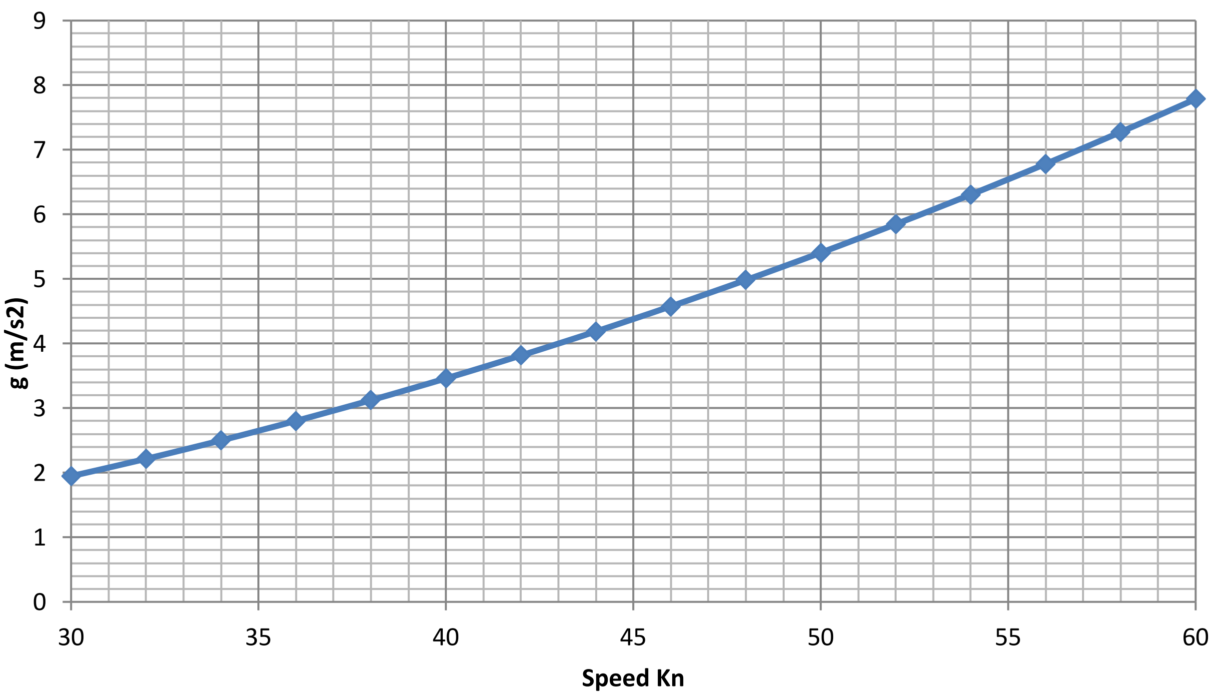
- Field Data Showing Alternative Scenarios

- Accelerations Can Decrease with Speed to a Threshold
  - **Vessel Design Dependent**
  - **Operator Dependent**
  - **Sea Type Dependent - Wave Length**



Speed Relation to Impact Loads

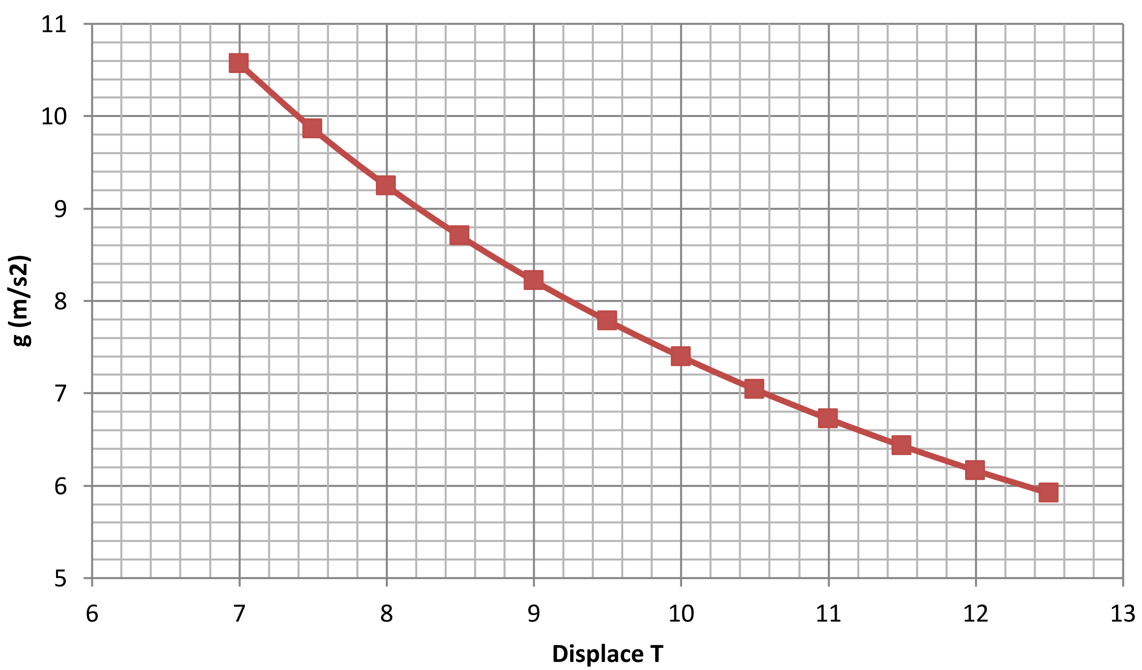
- Empirical Method Hsig at 0.7m
- Is this accurate?
- How to quantity based on the particular vessel?
- Can project specific test data be used to validate? yes
- Such impacts are probable but can FOS be reduced?



- Lower Speed Means
  - Less Acceleration
  - Longer Voyage
  - Less Speed More Exposure

Displacement Relation to Impact Loads

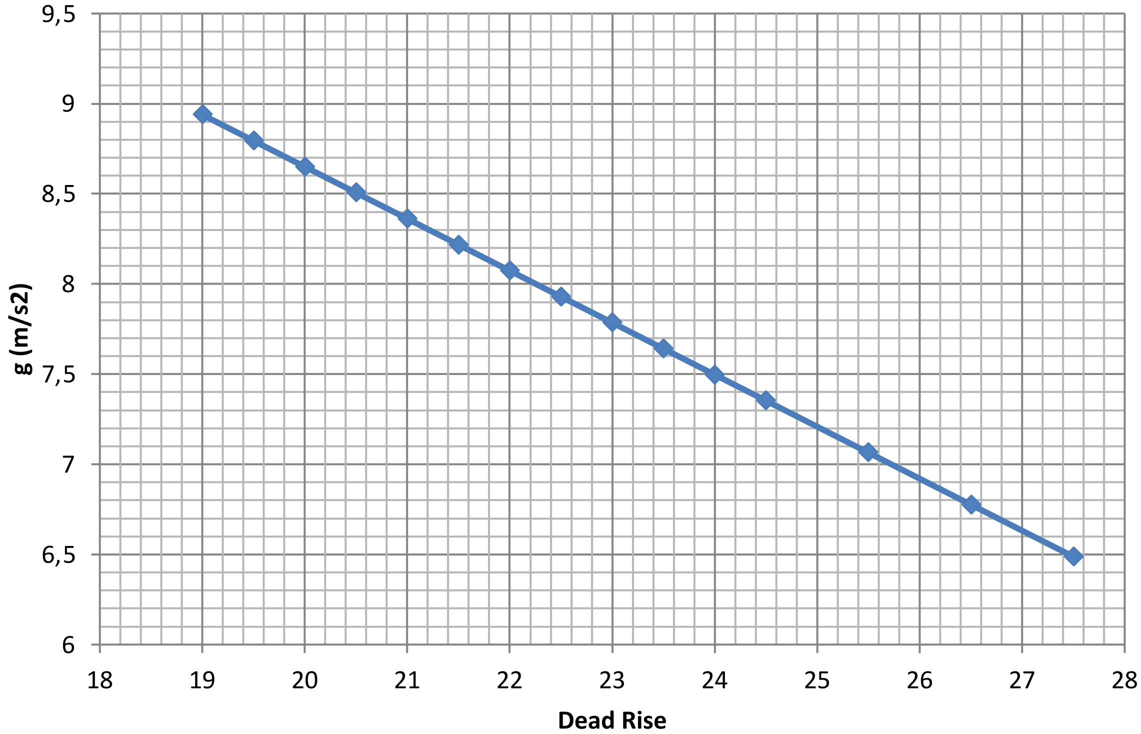
- Empirical Method Hsig at 0.7m
- How to quantity based on the particular vessel?
- Can project specific test data be used to validate? yes
- Can vessel use ballast systems on board to increase displacement to lower g's?



- Higher Displacement
  - More Power Needed
  - Less Range
  - Less Accelerations

Deadrise Relation to Impact Loads

- Empirical Method Hsig at 0.7m
- How to quantity based on the particular vessel, variable transverse sections?
- Can project specific test data be used to revalidate? yes



- Higher DR
  - less Acceleration
  - More Power Needed
  - Less Hull Volume
  - Less Range (more power)

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EFFECTS OF HULL DESIGN VARIANTS

Norson V3. 20m 100mph Offshore Endurance Class

Five Hull Types Under Discussion

- Standard Deep Vee – Baseline Vessel

- Advanced Deep Vee

Parameter deviation factor from Baseline -0.5g

- High Speed Cat

Parameter deviation factor from Baseline +1.6g

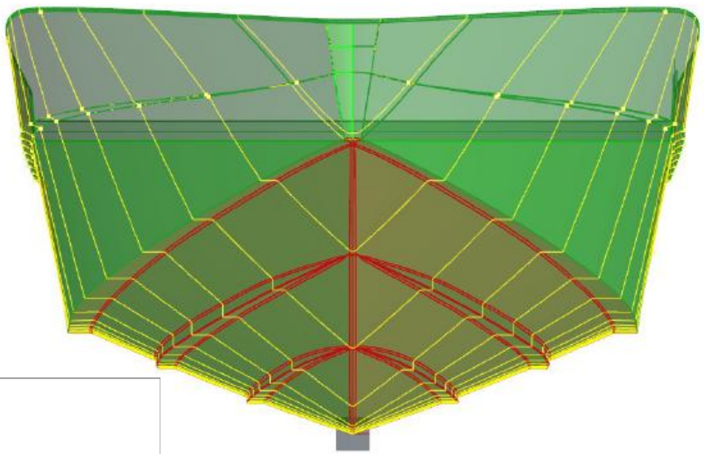
- Advanced Cat

Parameter deviation factor from Baseline +4.2g

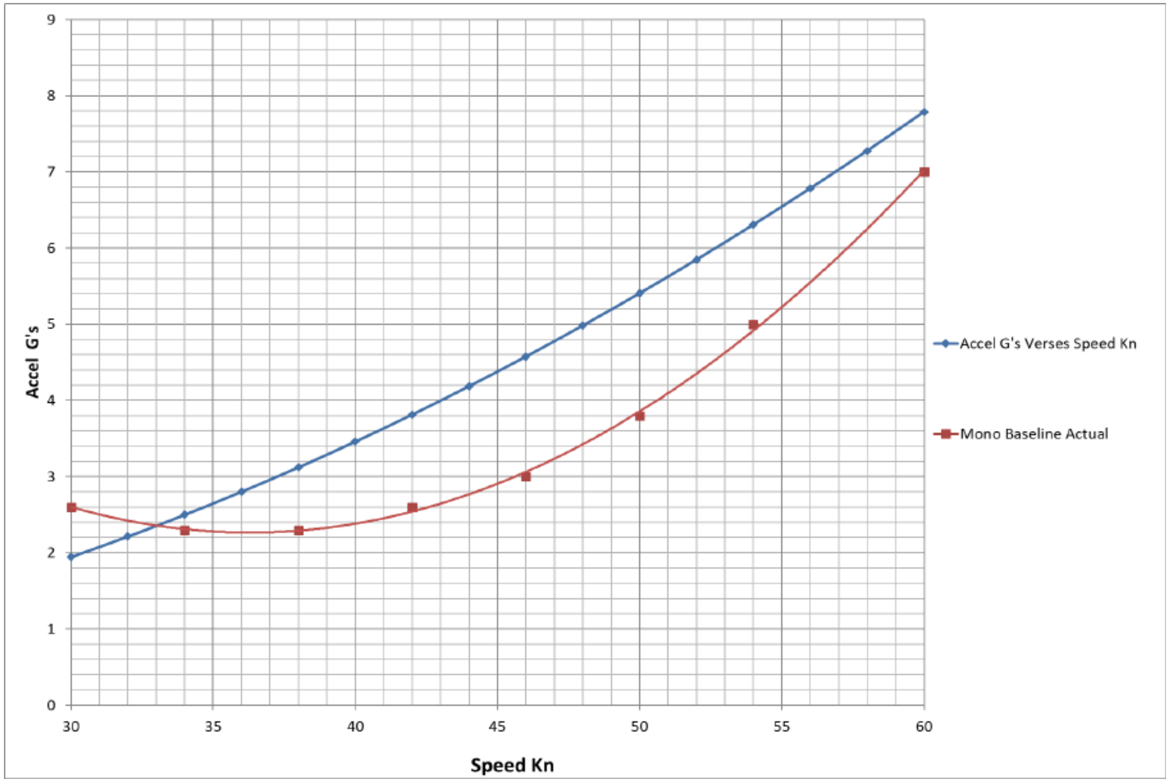
- Wave Piercer

Parameter deviation factor from Baseline -2.0g

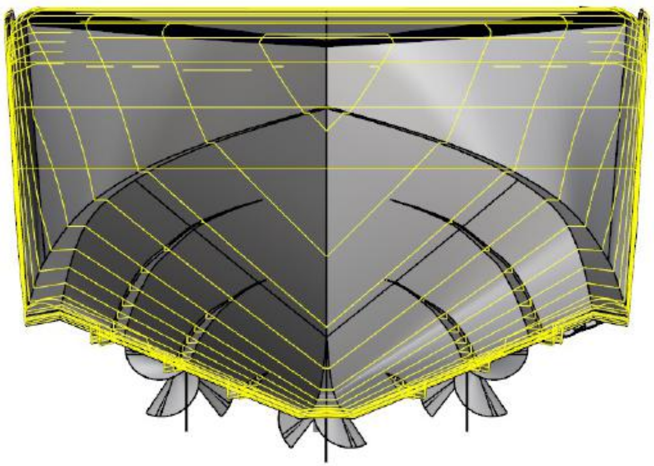
Standard Deep Vee

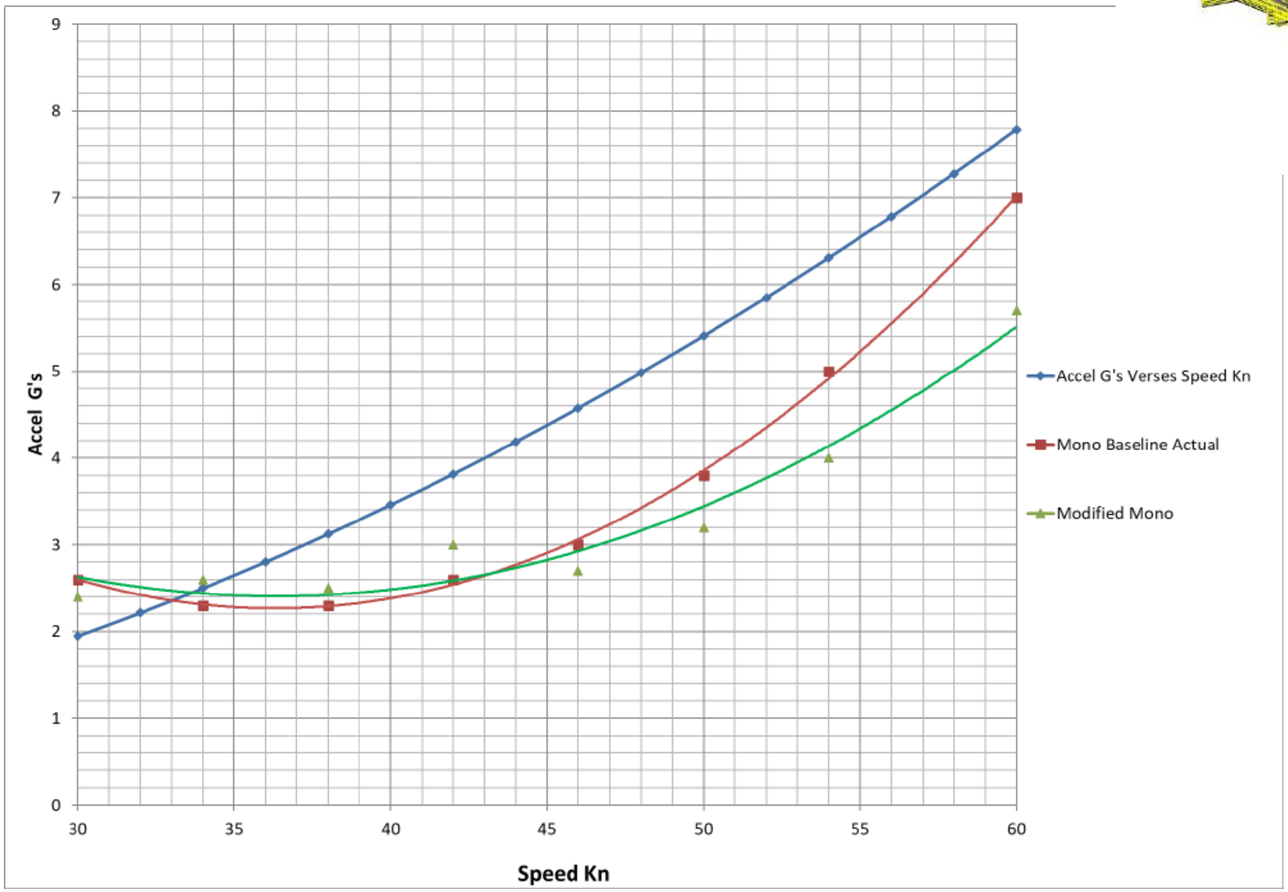


- Standard Deep Vee Red Line
- Blue Line as per Class Baseline
- Pros – Good Sea Keeping/Versatile/Efficient /Maneuverable
- Cons – Roll/Narrow/Payload/High Power to Lift



- **Advanced Deep Vee**
- Pros – Enhanced Sea Keeping
  Enhanced Maneuvering/Lower Drag/High Lift Coeff





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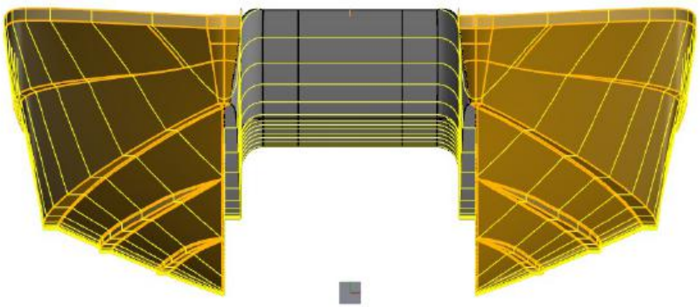
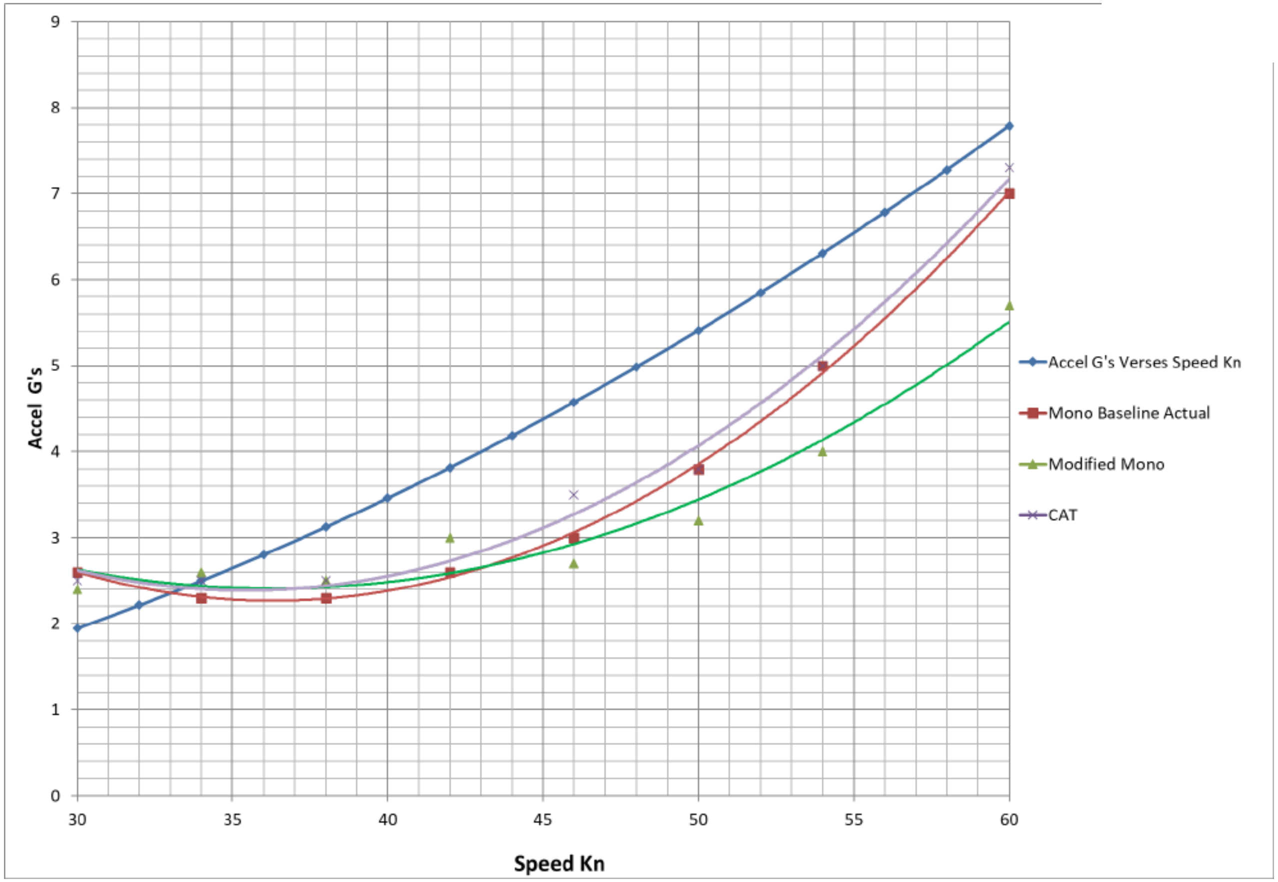
- **Catamaran**
- Pros – Air Cushioning Effect/Performance/Lower Drag
  Stability/Aero Lift
- Cons – Poor Wave Deflection/Payload Sensitive
  Tunnel Slamming/Trim Sensitive

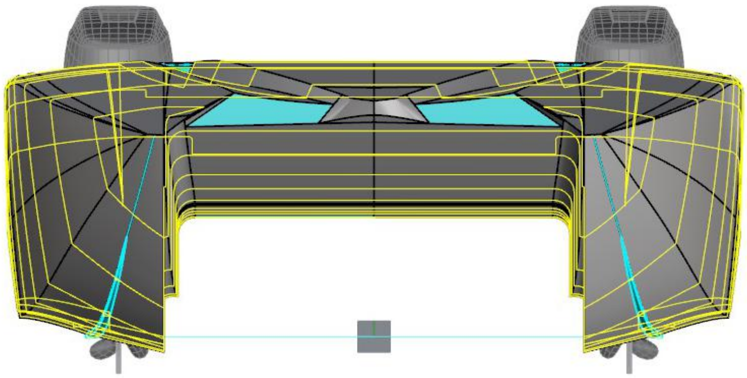


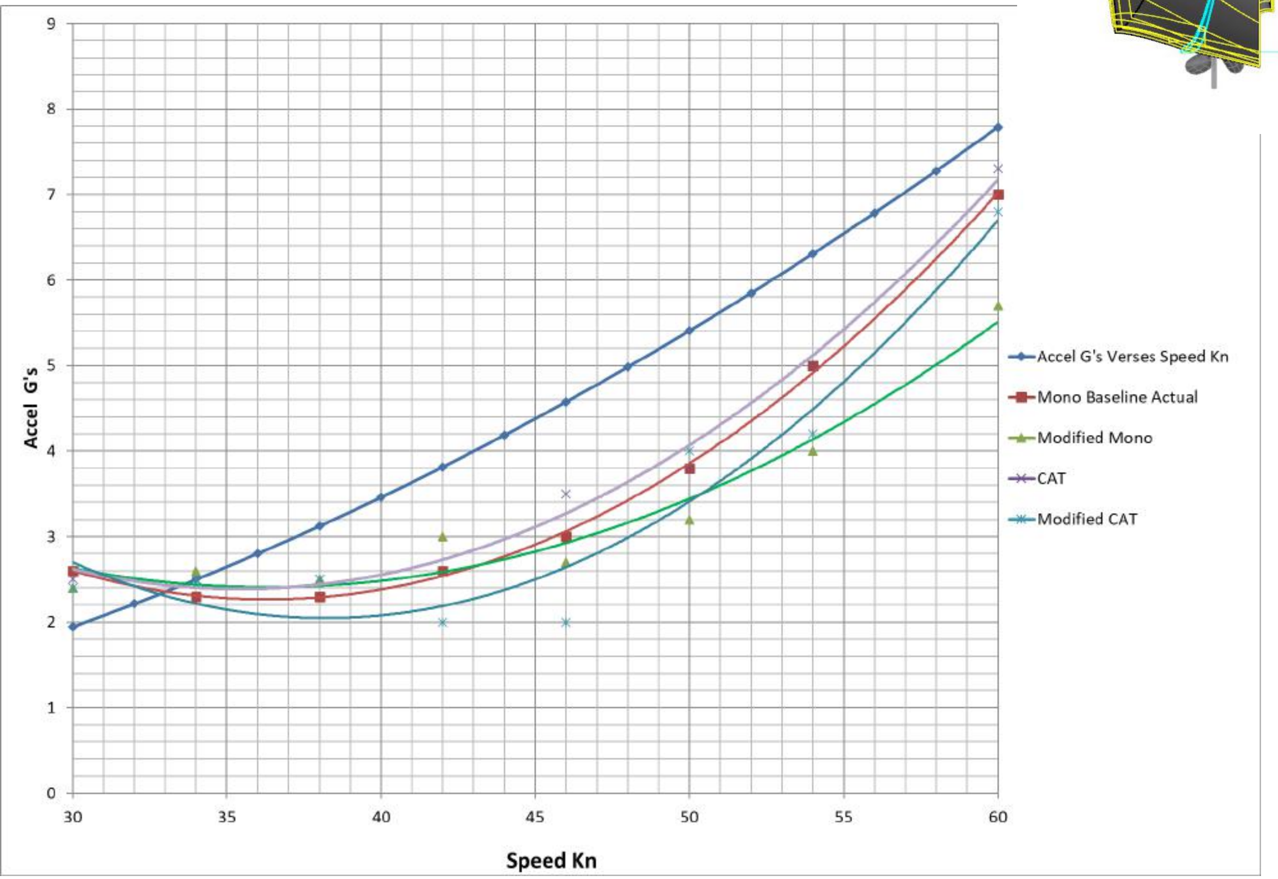


Advanced Catamaran

- Pros – Better Cushioning/Enhanced Performance
  Lower Drag/Better Trim Stability

  Cons- Tunnel Slamming at Certain Hsigs





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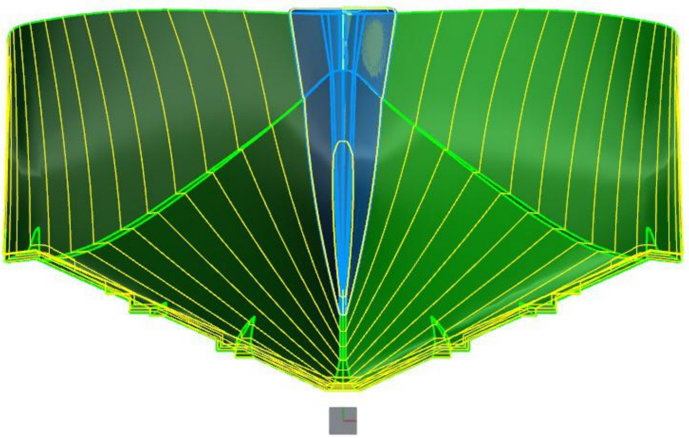
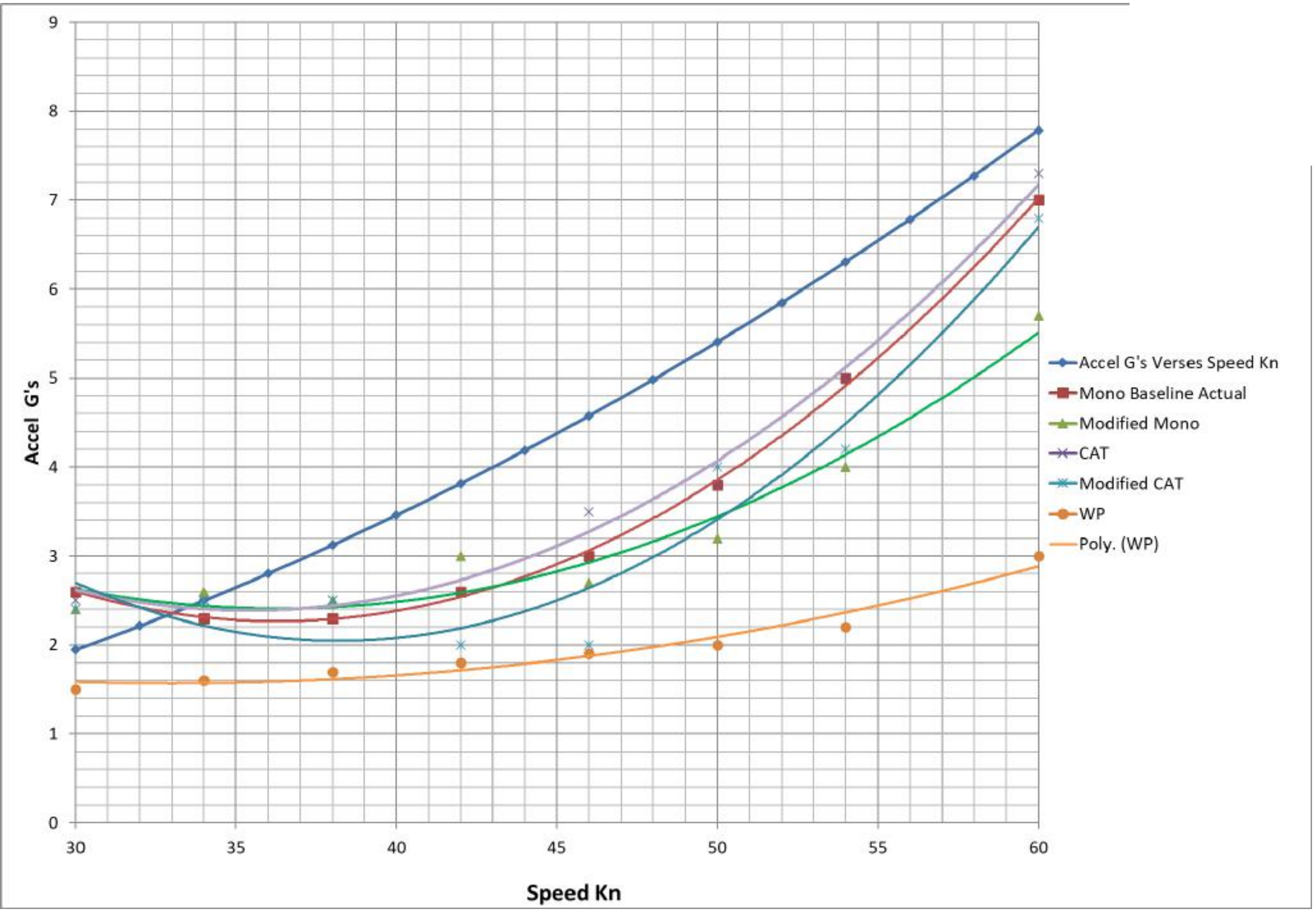
Wave Piercer Hull

- Pros- Stability/Performance/Maneuvering/Comfort/Customizable
- Cons- Wave Deflection/Following Seas





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CONCLUSIONS

- Sea trial data from advanced hulls (esp. Cats and WP's) indicate significant deviations (reductions) from empirical methods. Not all hulls are created equal.

- End users should work directly with designers who have verified impact data supporting their designs.

- Data should be acknowledged and accepted by Class, to better engineer efficient bespoke vessels according to real world scenarios.

- Data collection should be an industry standard. Ease of modern data recording systems.

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Thank you

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