Donald L. Blount and Associates, Inc.
Naval Architects/Marine Engineers

# Seakeeping By Design



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# INTRODUCTION

- What is seakeeping?  According to Wikipedia:
  - ***Seakeeping*** *ability is a measure of how well-suited a watercraft is to conditions when underway. A ship or boat which has good seakeeping ability is said to be very* ***seaworthy*** *and is able to operate effectively even in high sea states.*
- Dad says: "*They all go the same speed when it gets rough.*"
- Small Craft System
  - Vessel / Designer / Operator
  - Total system integration
  - Each must know the requirements / objectives of the other
- The operator can affect ride quality, but it's the boat geometry that has the primary influence.
- Selecting a good set of geometry for the hull is up to the designer, and it isn't just luck!
- How do we do it at DLBA??

# OUTLINE

- Background
- Vertical acceleration characteristics
- Design methodologies
- New concepts & technologies
- DLBA design techniques
  - Experimental
  - Analytical

# BACKGROUND

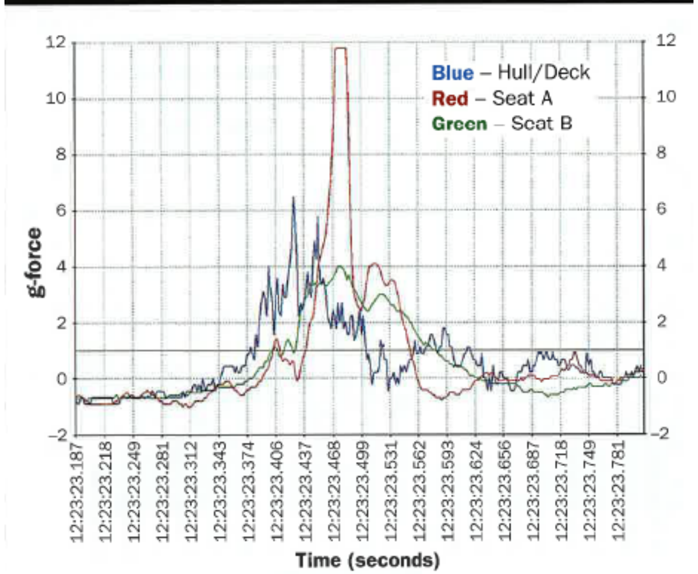
- Planing in a seaway is a tough environment
- Seakeeping qualities of a planing hull form have an (good/bad) impact on vessel efficiency and ride quality
  - Good seakeeping and low resistance require different qualities.
  - For open ocean craft, seakeeping is of primary importance
  - Traditionally, peak vertical acceleration has been the primary concern
- Recently other factors have been receiving more scrutiny
  - RMS accelerations
  - Whole Body Vibration (WBV)
  - Motion Introduced Interruptions (MII)
  - Motion Sickness Incidence (MSI)
  - Motion Induced Fatigue (MIF)
  - Injury (Sed8)
  - ISO 2631:1-5, MIL-STD-1472G, STANAG 4154
- This presentation focuses on reducing the peaks through the development of the hull geometry.

# VERTICAL ACCELERATIONS

- Dynamic
- Random
- Non-Linear
- Statistical relationships
- Difficult to predict accurately
- Predictions and trends *may* lead to hull geometry improvements
- A “fast” hull is not necessarily “sea-kindly”

- Analytical prediction techniques
  - Regression equations
  - Time-step simulations
  - CFD
- Experimental evaluation techniques

**Figure 3. Highest Impact, in Seat A**




*Ref: Mannerberg, J, 2013, “Practical Impact-Exposure Testing”, Professional Boatbuilder, April/May, pp. 52-60.*

# REGRESSION EQUATIONS

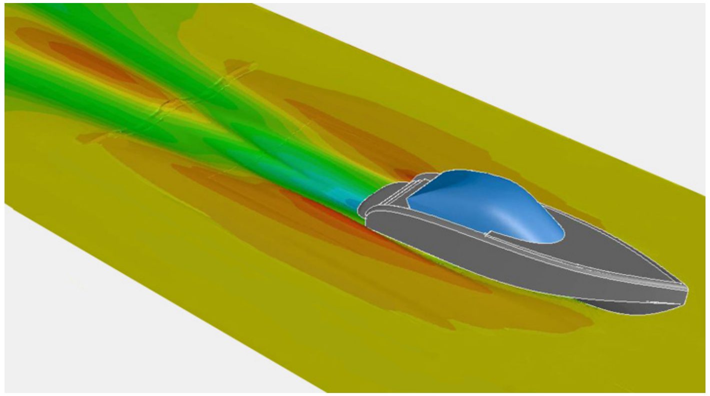
- Savitsky-Brown
  - Average acc @ CG and bow
- Hoggard-Jones
  - Average of the 1/10th highest acc @ CG & bow
- Classification Societies
- ISO 12215
- Structure vs. Human Factors
  - 1/100th vs 1/10th & RMS

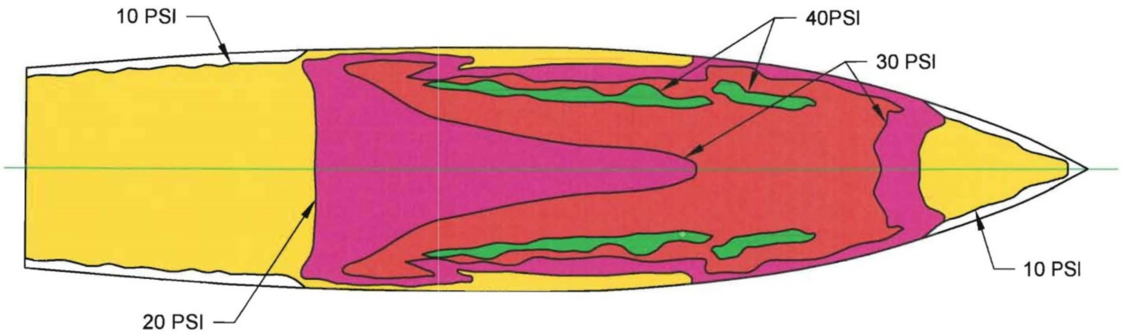
$$\eta_{Avecg} = 0.0104\left(\frac{H_{1/3}}{b} + 0.084\right)\frac{\tau}{4}\left(\frac{5}{3} - \frac{\beta}{30}\right)\left(\frac{V_k}{\sqrt{L}}\right)^2\left(\frac{L/b}{C_\Delta}\right)$$

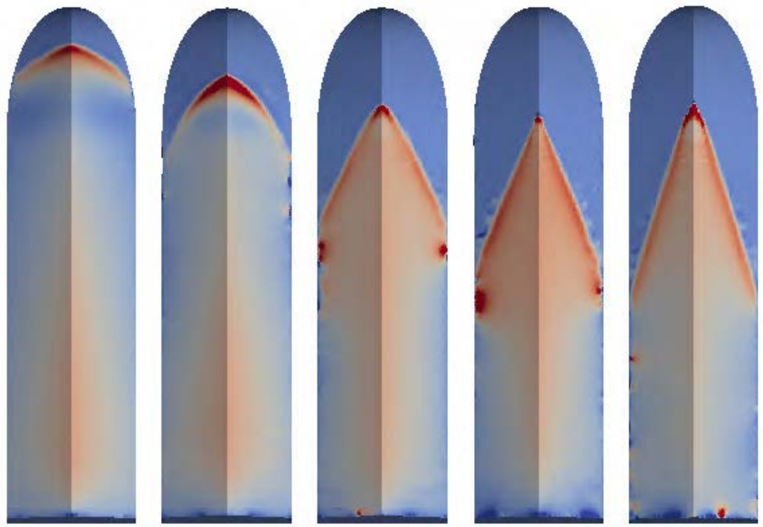
$$\eta_{1/10cg} = 7.0\left(\frac{H_{1/3}}{Bpx}\right)\left(1 + \frac{\tau}{2}\right)^{0.25}(F_{n\nabla})^{1.0}/\left(\frac{Lp}{Bpx}\right)^{1.25}$$

# SIMULATIONS & CFD

- Strip theory / time step & computational fluid dynamics
- Increased accuracy (maybe)
- Look at pressure distribution on the hull
- Analytically intense
  - Not fast to perform
  - Increased cost
- Very good for comparative analysis





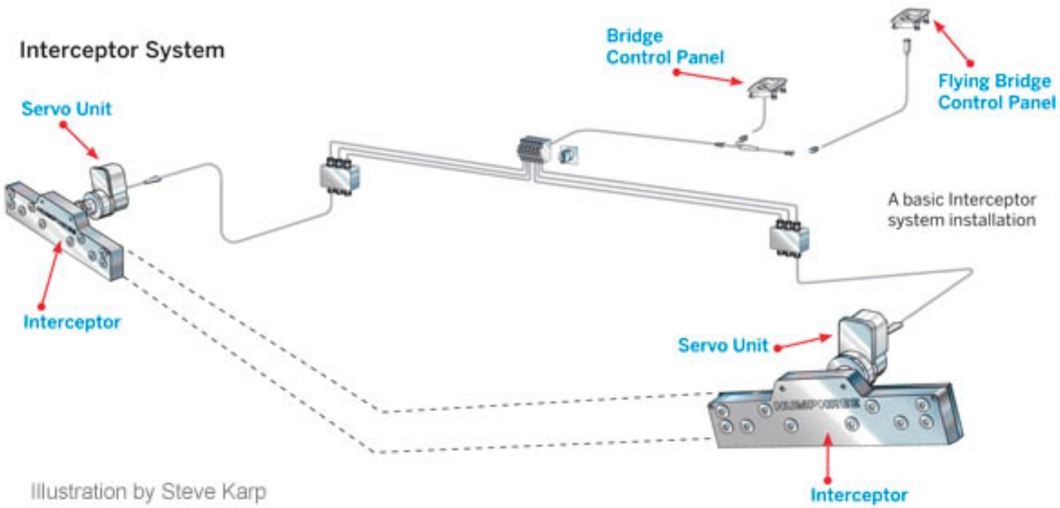



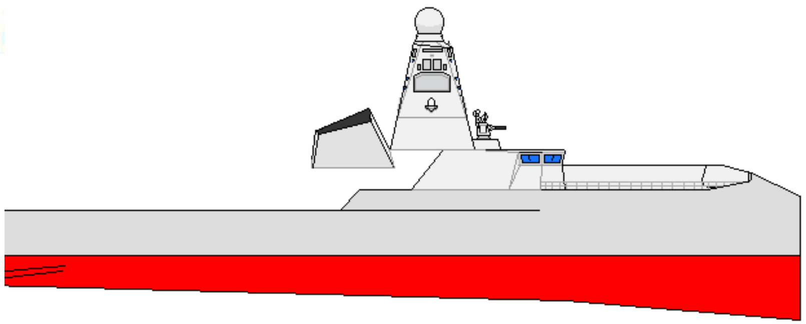
# EXPERIMENTAL MODEL TESTS

- Hydrodynamic model testing in random waves of the representative wave period provides the highest accuracy
- Test Matrix
  - # Models, Loading conditions, speeds, sea state definition
- Data Capture
  - Accelerometer locations, frequency, foundation stiffness
- Data Processing
  - Peak counting, filters, data scaling (Standard G)
- Note:
  - Results are very much affected by the waves in the seaway.
  - Hull response is due to wave contact, and a statistical distribution has a broad range of wave heights, periods, and therefore slopes.

# NEW CONCEPTS AND TECHNOLOGIES

- Enlarged Ship Concept
  - Moves crew away from bow
  - Increases hull length
- Axe Bow Concept
  - Reduces the probability of bow emergence
- Interceptor based ride control systems
  - Pitch & roll



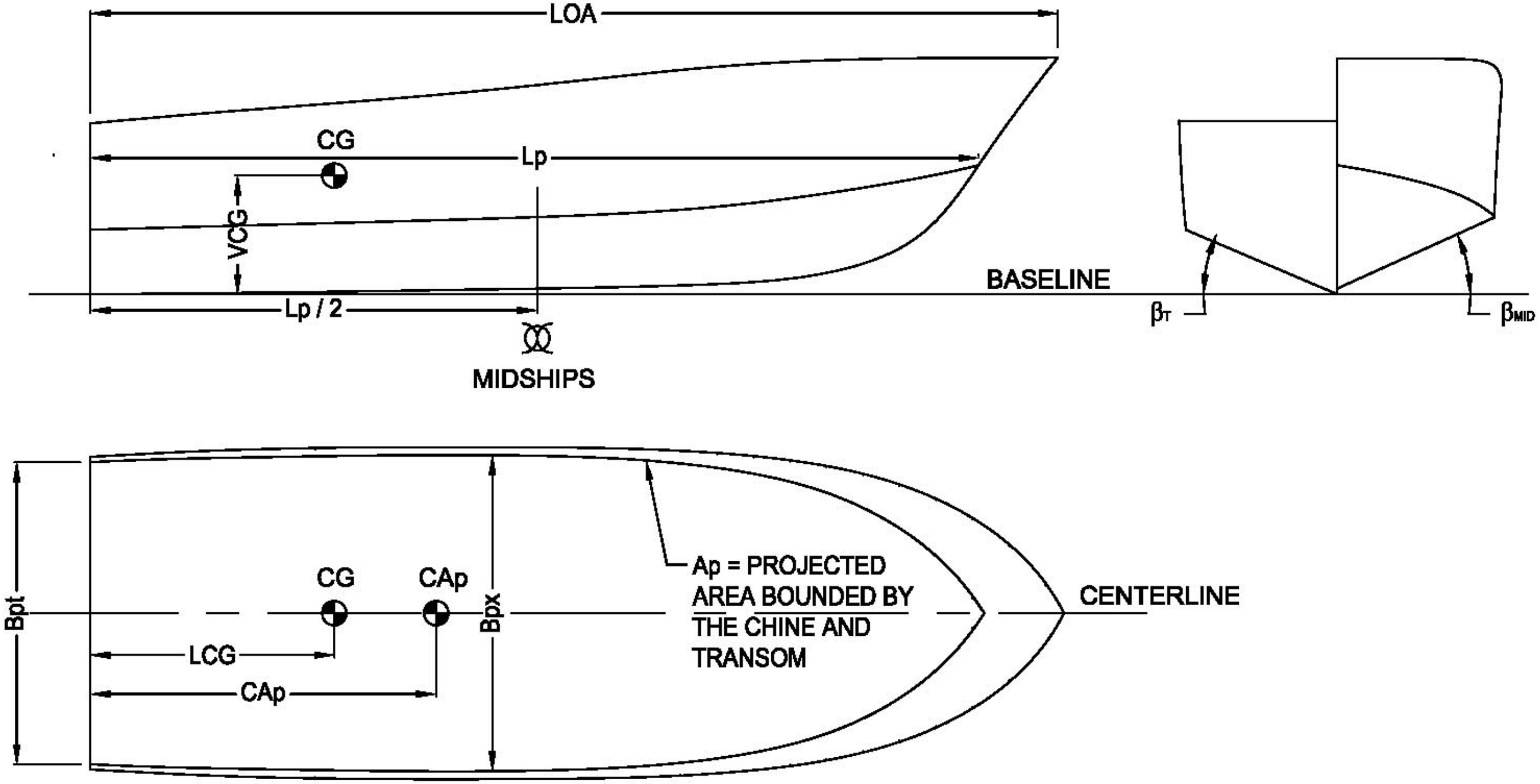
# DLBA EXPERIMENTAL DESIGN TECHNIQUES

- Hydrodynamic Model Testing
- Test Matrix
  - # Models > 1 if funding can support
  - Loading conditions = 3 < X <9
  - Speeds = high and low
  - Sea state definition = $H_{1/3}$ & $T_w$
- Data Capture
  - Location = More than 1 longitudinal and transverse
  - Frequency =  1000 hz
- Data Processing
  - Standard G (peak counting, filters)
  - Don’t rely on statistical relationships for scaling

Show video of Seakeeping Model Test

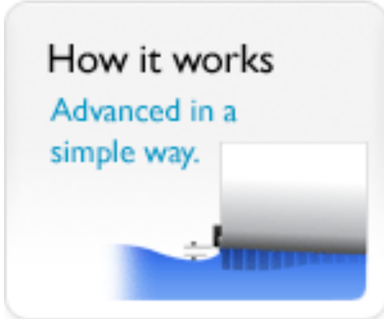
# DLBA ANALYTICAL DESIGN TECHNIQUES

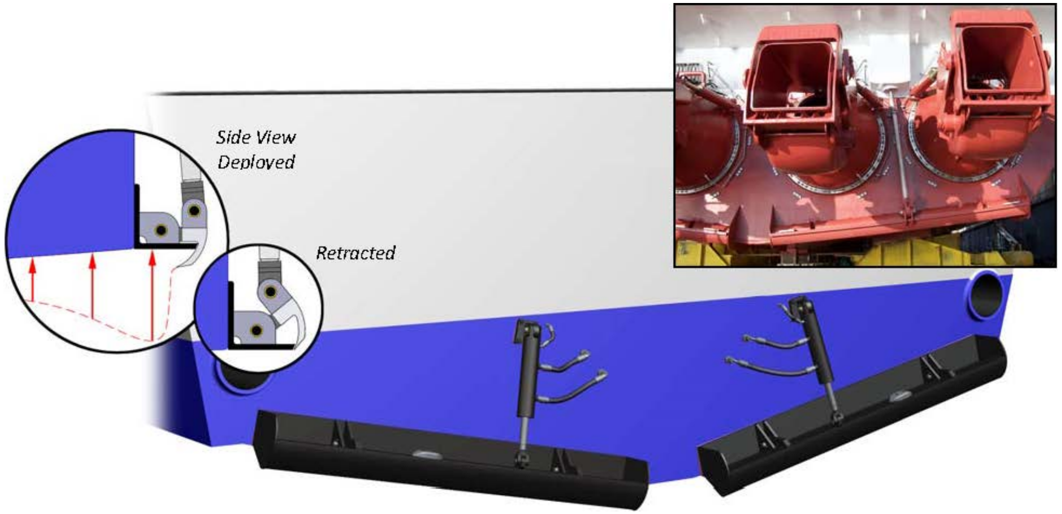
- $H_{1/3}/\nabla^{1/3} <= 0.25$
- Bottom loading ($A_P/\nabla^{2/3}$)
  - Full load between 5.75 and 7.0



# DLBA ANALYTICAL DESIGN TECHNIQUES

- Dynamic trim control
  - Reduce trim when necessary

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# DLBA ANALYTICAL DESIGN TECHNIQUES

- Fixed trim control
  - May be necessary if dynamic trim is always too high
  - Appendages or hull geometry

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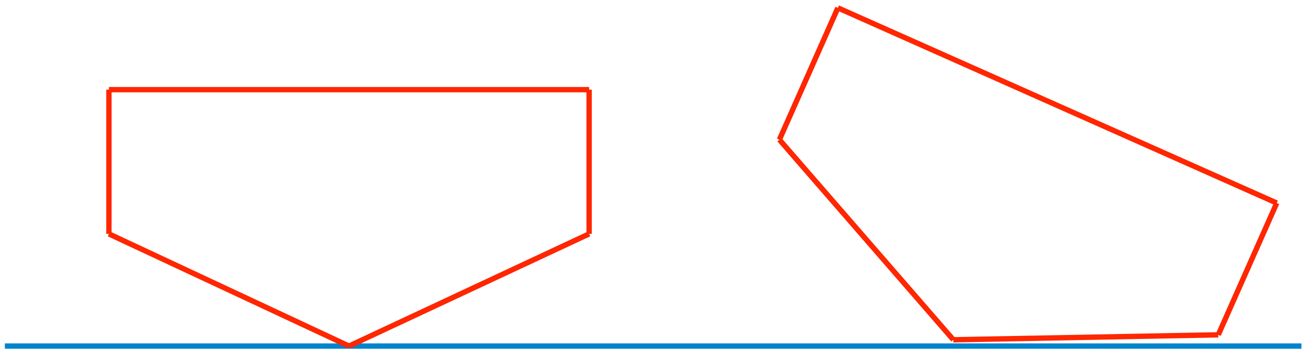
# DLBA ANALYTICAL DESIGN TECHNIQUES

- High L/B
  - Increases dynamic trim angle
  - Higher beam loading
    - Water slap analogy
    - Less “frontal area”
- Moderate deadrise
  - No more than 22 degrees midships

$$\eta_{1/10cg} = 7.0\left(\frac{H_{1/3}}{Bpx}\right)\left(1+\frac{\tau}{2}\right)^{0.25}(F_{n\nabla})^{1.0}/\left(\frac{Lp}{Bpx}\right)^{1.25}$$



# DLBA ANALYTICAL DESIGN TECHNIQUES

- Double chine / lifting strake
  - Flow of water must separate and clear above hull geometry

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# DLBA ANALYTICAL DESIGN TECHNIQUES

- Transverse section shape
  - Concave section provide drier ride
  - Convex sections provide softer ride
  - Oxbow is the best of both worlds???

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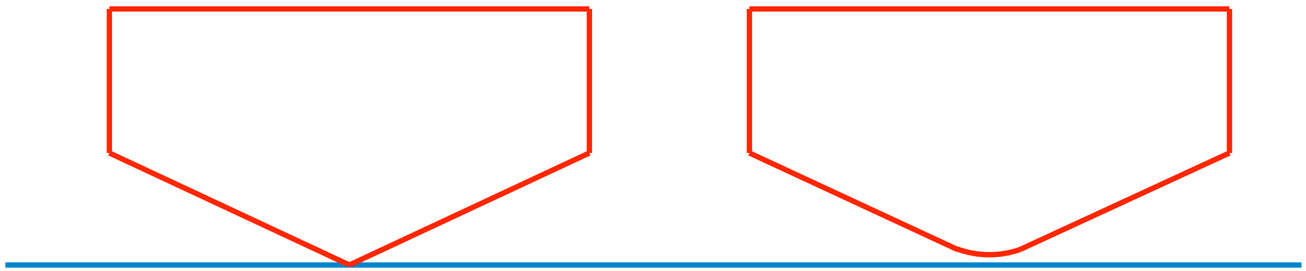
# DLBA ANALYTICAL DESIGN TECHNIQUES

- Round keel
  - Distributes the load upon impact



COMMENTS?
QUESTIONS?
SUGGESTIONS?
RECOMMENDATIONS?


THANKS!



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