Improving Effectiveness of CFD Self-propulsion Analysis With a Proxy Propeller and Engine Constraints

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INTRODUCTION

- CCGS Navaids tenders maneuvering study

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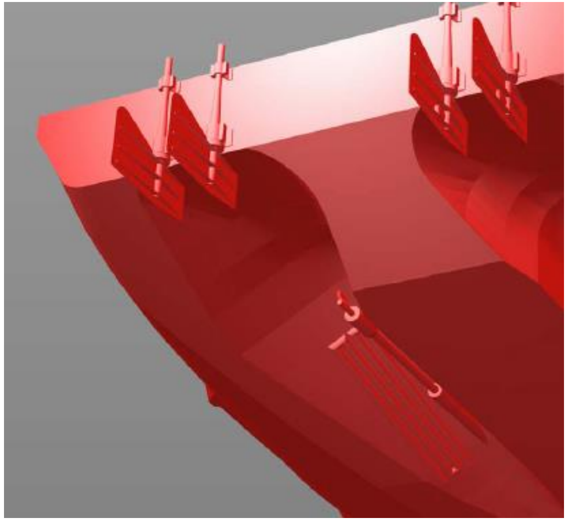
CCG PURPOSE FOR THE PROJECT

- Improve Eckaloo maneuverability
- Upgrade propulsion systems on both
- Stern tunnel modifications
- Common components
  - Engine, gearbox, rudder, propeller
  - Reduce spares;
    simplify procurement



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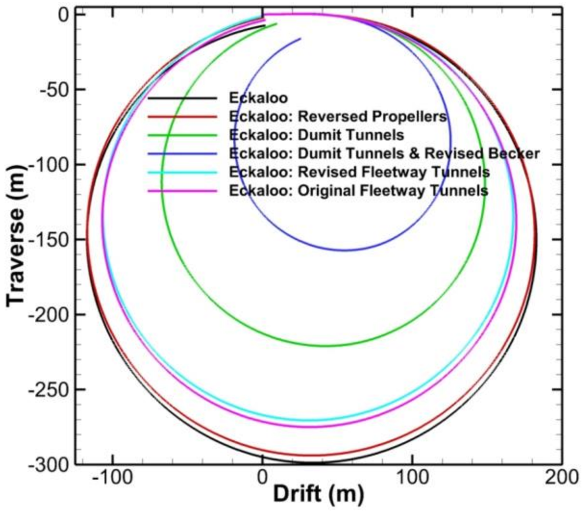
CRITERIA AND LIMITATIONS

- Speed
  - In various conditions and water depth
- Maneuvers
  - Reverse course, crash stop, full turn
- Equipment
  - Rudder stern mounted
  - New package within existing space



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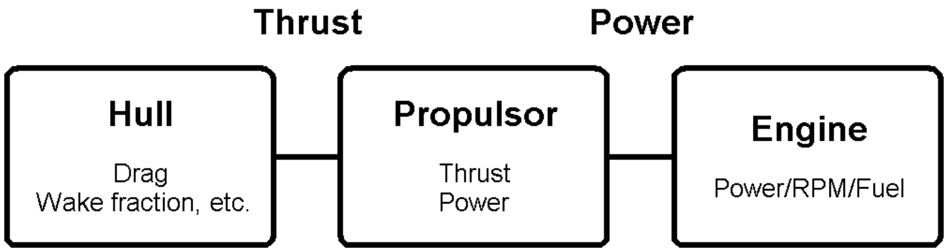
PROJECT TEAM

- Lengkeek Vessel Engineering
  - Prime contractor
- Lloyd's Register Applied Technology Group
  - CFD sub-contractor
- HydroComp, Inc.
  - Propeller design, propulsion system analysis

COMPUTATIONAL MODELING

- Variables for “design of experiments”
  - Stern, rudder, engine models
  - Corresponding optimized propeller
- Identify and predict performance
  - Existing and proposed
  - Framework:

NavCad
STAR-CCM+



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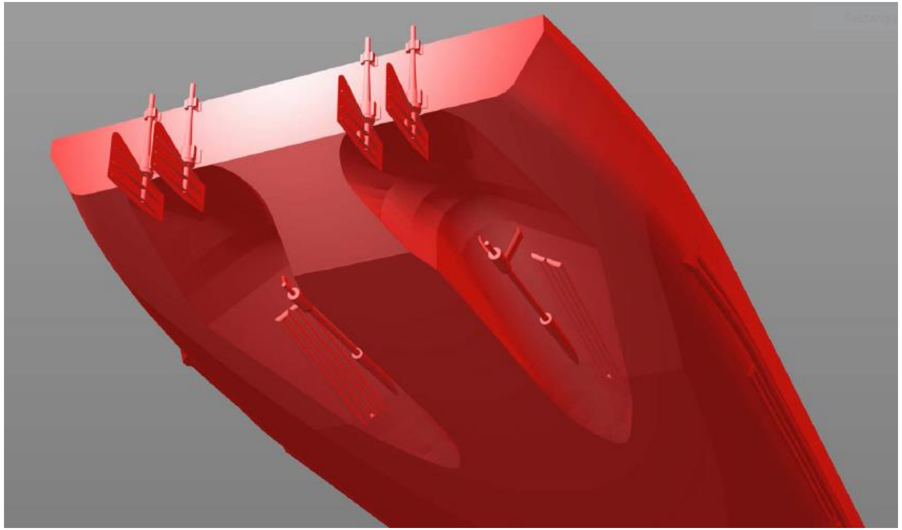
APPLICATION OF CFD FOR SIMULATION

- Creation of geometric models
- Hull, shafting, appendages
- Propeller performance
  - Key to flow over rudders and maneuvering



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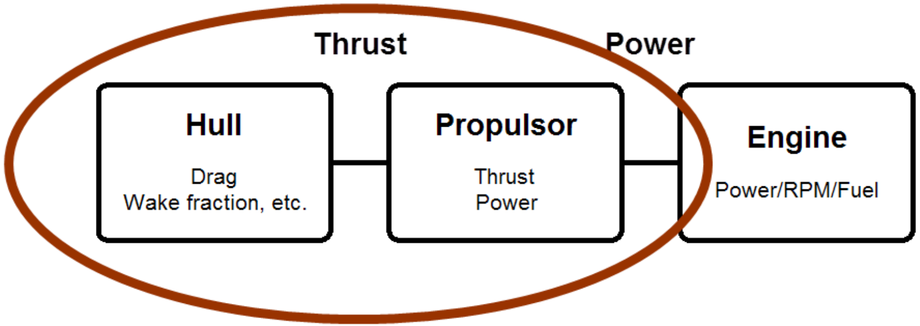
APPLICATION OF CFD FOR SIMULATION

- Full propeller geometry needed
  - Conditions exist with exposed tip in tunnel
  - Simplified actuator disk insufficient
- Engine/drive “uncoupled” from hull/prop
  - Yet the engine influences maneuvering!



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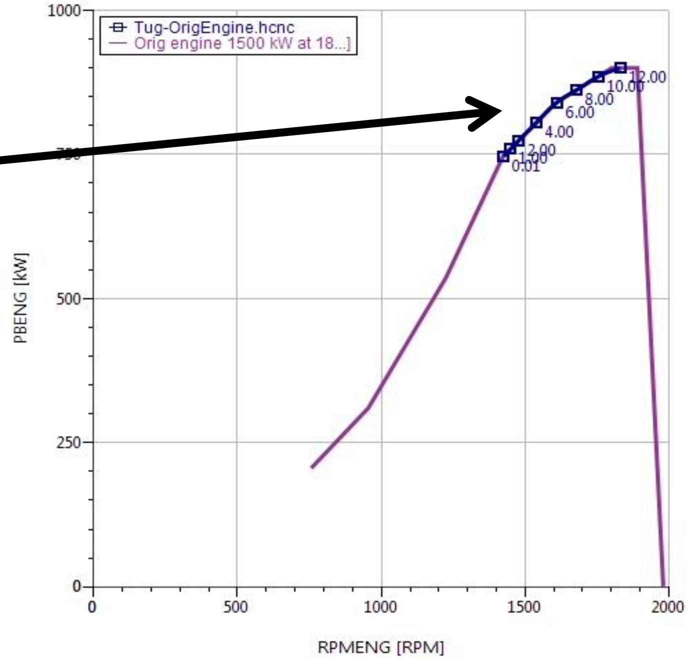
AN ENGINE'S CONTRIBUTION

- Maneuvering: multiple high-thrust bursts
  - Prop power demand at RPM constrained by engine curve
  - Example of WOT during maneuvering
  - So how do we consider the engine's influence?



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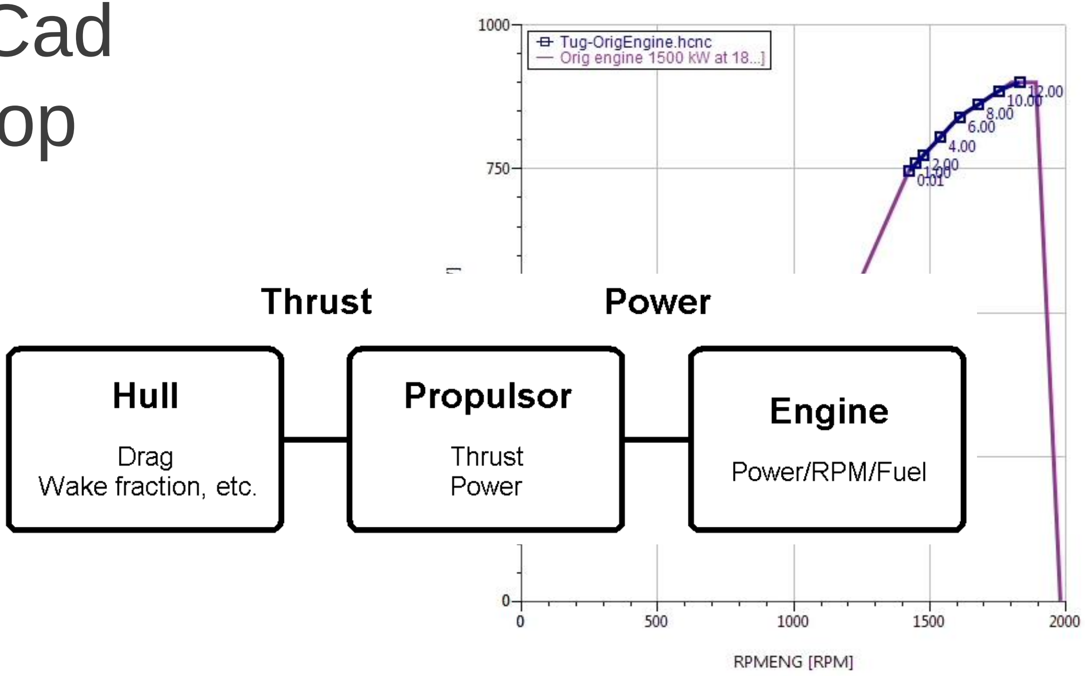
VIRTUAL COUPLING AS ENGINE CONSTRAINT

- Set limits in CFD on propeller RPM, thrust
- Calculated in NavCad for each variant prop
- A lot of propellers!
  - Or is it?



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A "PROXY" RE-USABLE PROPELLER

- True simulation needs a unique optimized propeller for each variant in the study
  - Each propeller calculation took about 8 hours
- Idea! Replace each propeller with a single "proxy"
  - Greatly reduces time for model creation validation, and a bit for computation

PROCEDURE

- Steps to develop “proxy” limits for CFD
  1. Hull-propulsor condition for stern variants
  2. Size optimum prop for each engine variant
  3. Run propulsion simulation to find towpull for optimum propeller (at multiple speeds)
  4. Replace with “proxy” propeller
  5. Find RPM that delivers equivalent thrust at speed
  6. Use as limits for CFD

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NavCad

APPLICATION OF THRUST CONSTRAINTS

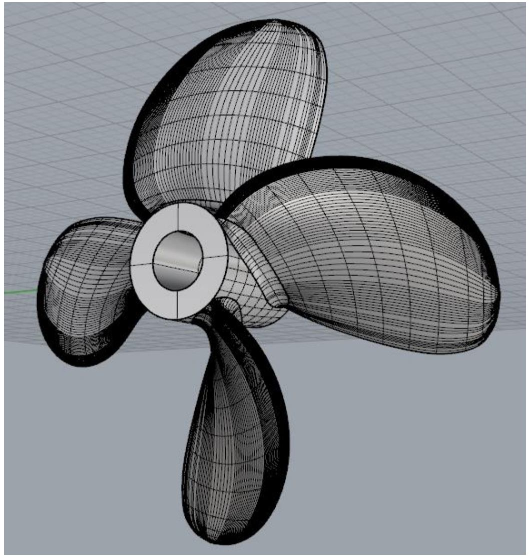
- Maneuvering is an iterative calculation
  - Start at rest; RPM ramped up; thrust allows acceleration
  - Convergence is reached at thrust equilibrium
  - Is Thrust-RPM-Speed within constraints?
  - Modify as needed and re-iterate
- Works for any system with Hull-Propulsor in CFD and Drive-Engine uncoupled

POTENTIAL SAVINGS

- Principal savings is in 3D model creation and validation
  - Up to 80% CFD project cost [Bertram 2010]
  - Dozens of 3D propeller models down to one!
- Supplemental savings in calculation time
  - Better starting conditions

WHAT WAS THE OUTCOME?

- Dozens of stern-rudder-engine variants
  - Two variants successfully met all criteria
- Now in hands of the CCG
- And the “proxy” propeller?
  - Cost and time savings; Improved outcomes
  - Now living a quiet life on a hard drive somewhere…



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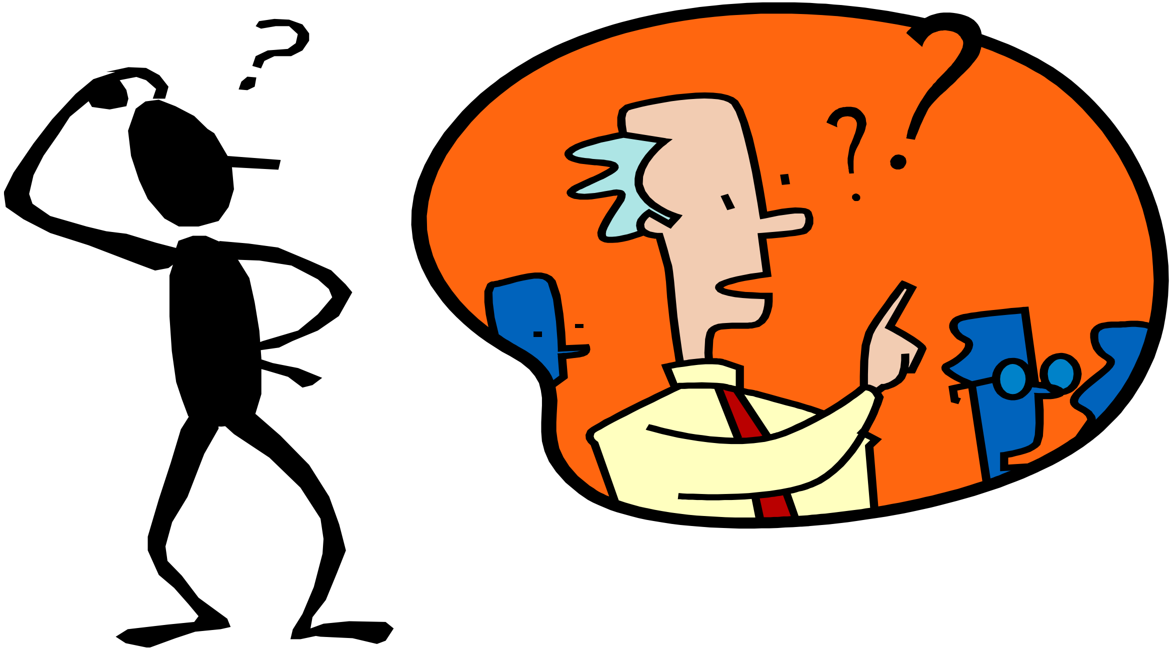
THANKS! QUESTIONS?



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REFERENCES

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