



NOAA Class B Charting and Mapping Bubble Sweepdown Five Phase Study



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FEMME 2026



AGENDA



- Introductions - Organization and Company Roles
- Acknowledgements
- Bubble Sweepdown History
- NOAA Fleet
- NOAA Class B Program Background
- Contract particulars
- The Challenge
- The Solution
- Impacts to construction
- Lessons Learned



Introductions

Organization and Company Roles



- Speaker Introductions
 - Vedran Vickovic, Senior Mechanical Designer KONGSBERG
 - Sin Suen, Director of Ships, PAE Platforms
- National Oceanic and Atmospheric Administration
 - Office of Marine and Aviation Operations
 - Platform Acquisition Executive (PAE) Platforms
 - Ships, Aircraft, Infrastructure

Acknowledgements

- KONGSBERG
- Thoma-Sea Marine Constructors (TMC)
- TAI Engineering
- FORCE Technologies
- Gates Acoustics



Graphics and videos from reports delivered by TAI Engineering for each phase



A Short History of

Bubble Sweepdown

Bubble Sweepdown History

It started with a simple observation:

**Calm sea, good acoustic data.
Rough sea, sometimes no data at all.**

The equipment worked. So what was happening beneath the hull?



Picture courtesy of Copilot AI

Sources of air bubbles:

- Natural aeration
 - Breaking waves (rough sea)
- Vessel-induced air entrainment
 - Breaking bow wave
 - Bow/bulb re-entry
 - Pitching, heaving and slamming
 - Air trapped by the hull during wave impact



How did it start?

- Early 1920s | Echo sounding enters practical use
 - Can we measure depth with sound?
- 1950s-60s | More advanced sonar and scientific acoustics
 - Why does acoustic performance sometimes deteriorate
- 1970s-80s | Bubble Sweep-Down is investigated
 - Where do the bubbles come from?
- 1981 | we could quantify the problem
 - Wind-generated bubbles shown to degrade hull-mounted acoustic measurements.

Bubble Sweepdown History

From understanding to solutions

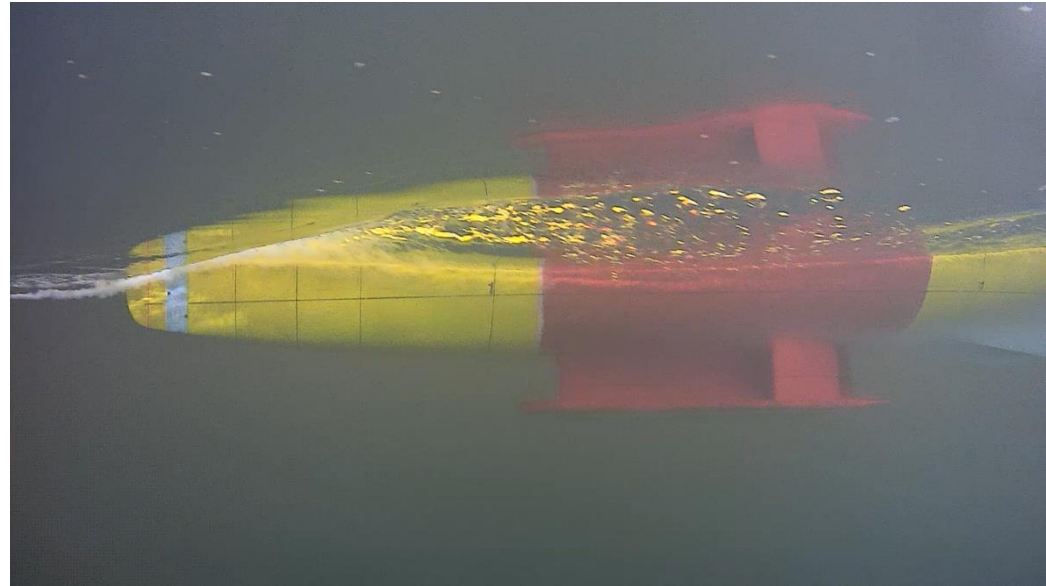
- 1990 | If you can't avoid the bubbles... go below them
 - Transducer mounted on a 4 m protruding keel
- 1990s–2000s | We learned from experience
 - Different vessels showed very different sensitivity to bubbles.
- Today | Visualization + CFD
 - Predict and control BSD during vessel design

Bubble Sweepdown History

Visualize the flow:

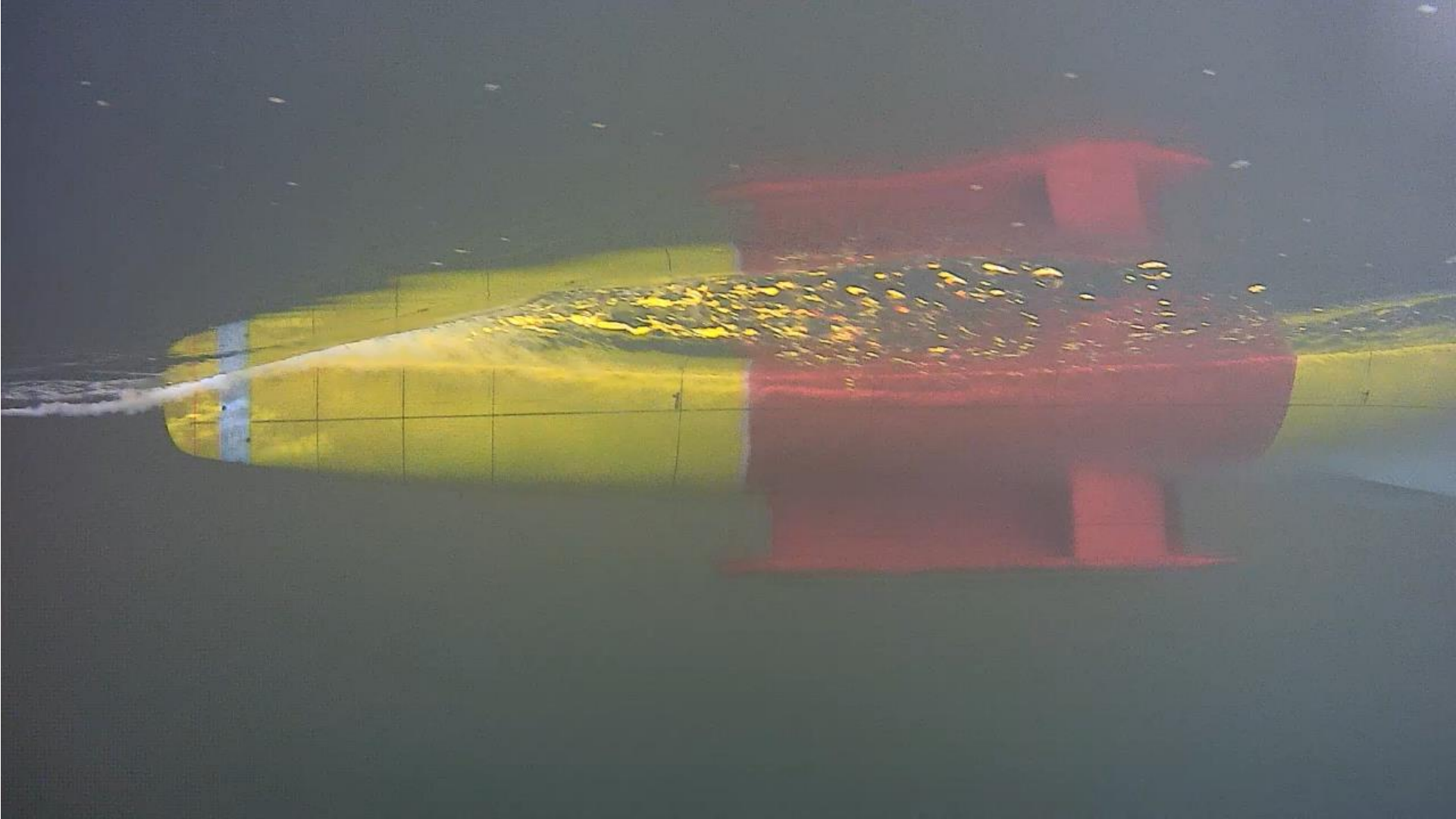
Model Basin Testing

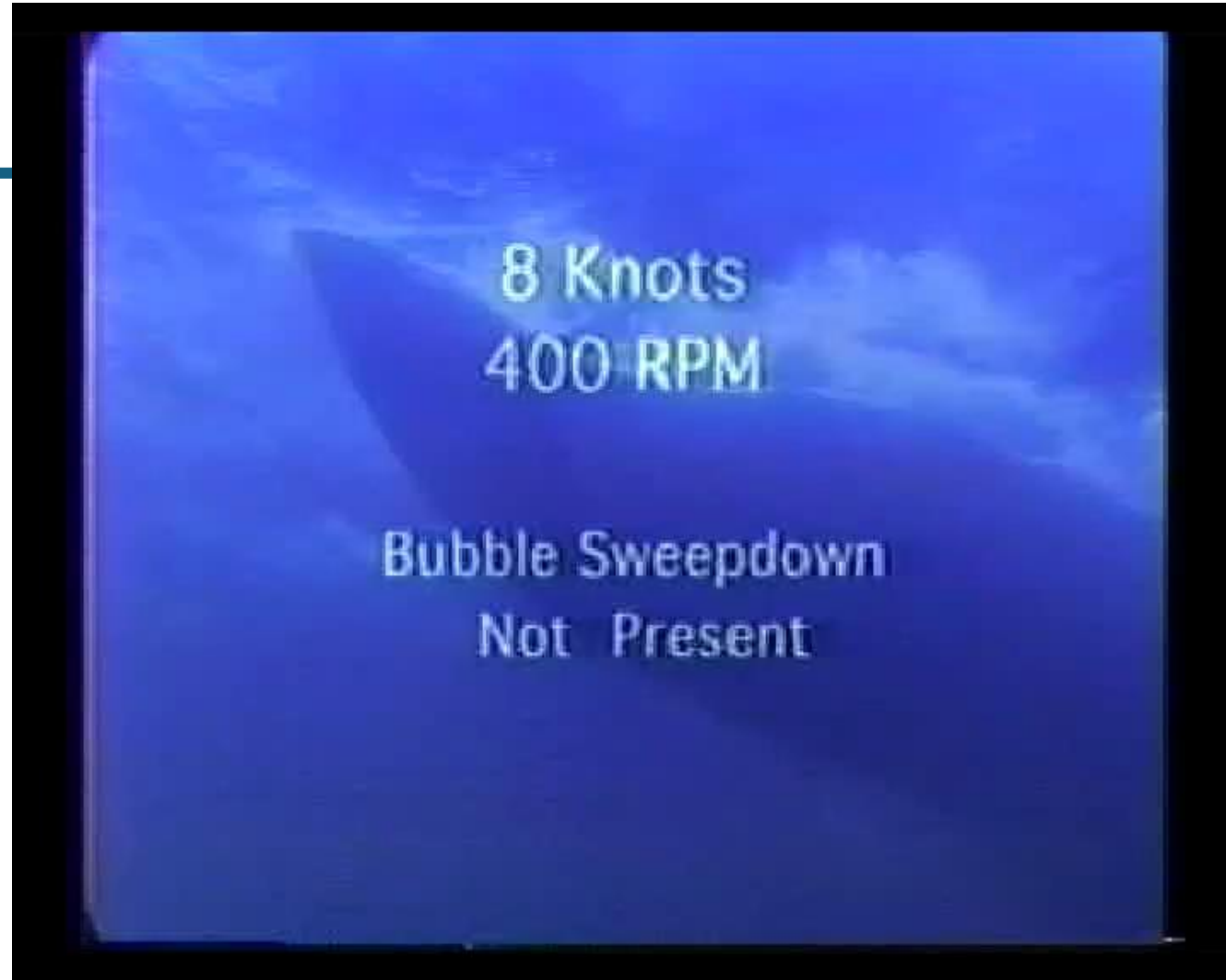
Dye helps us visualize the flow path that can carry the bubbles.



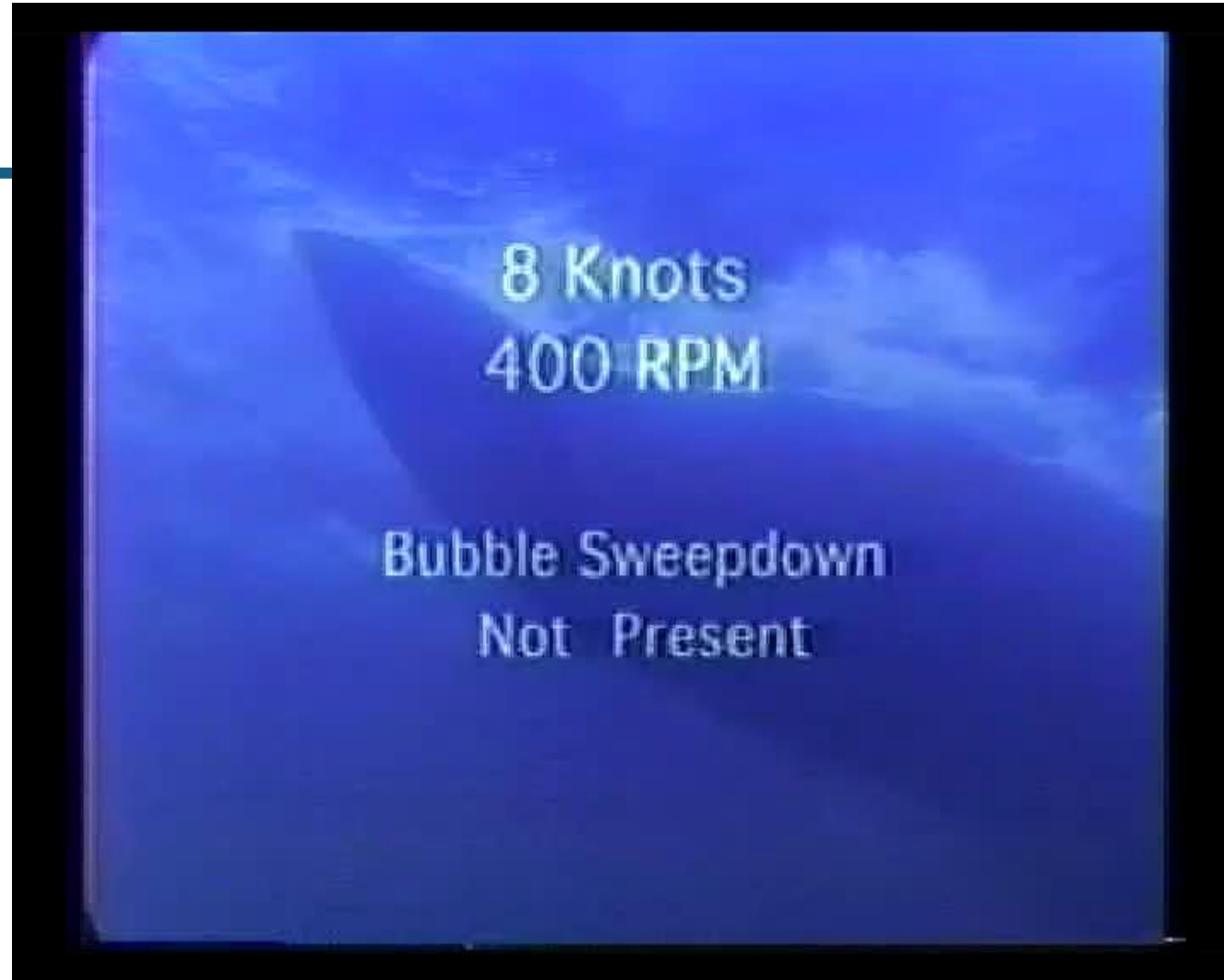
"Early attempts to capture aerated water below the hull. Videos courtesy of Timothy Gates, Gates Acoustics."

Bubble Sweepdown History





"Early attempts to capture aerated water below the hull. Videos courtesy of Timothy Gates, Gates Acoustics."



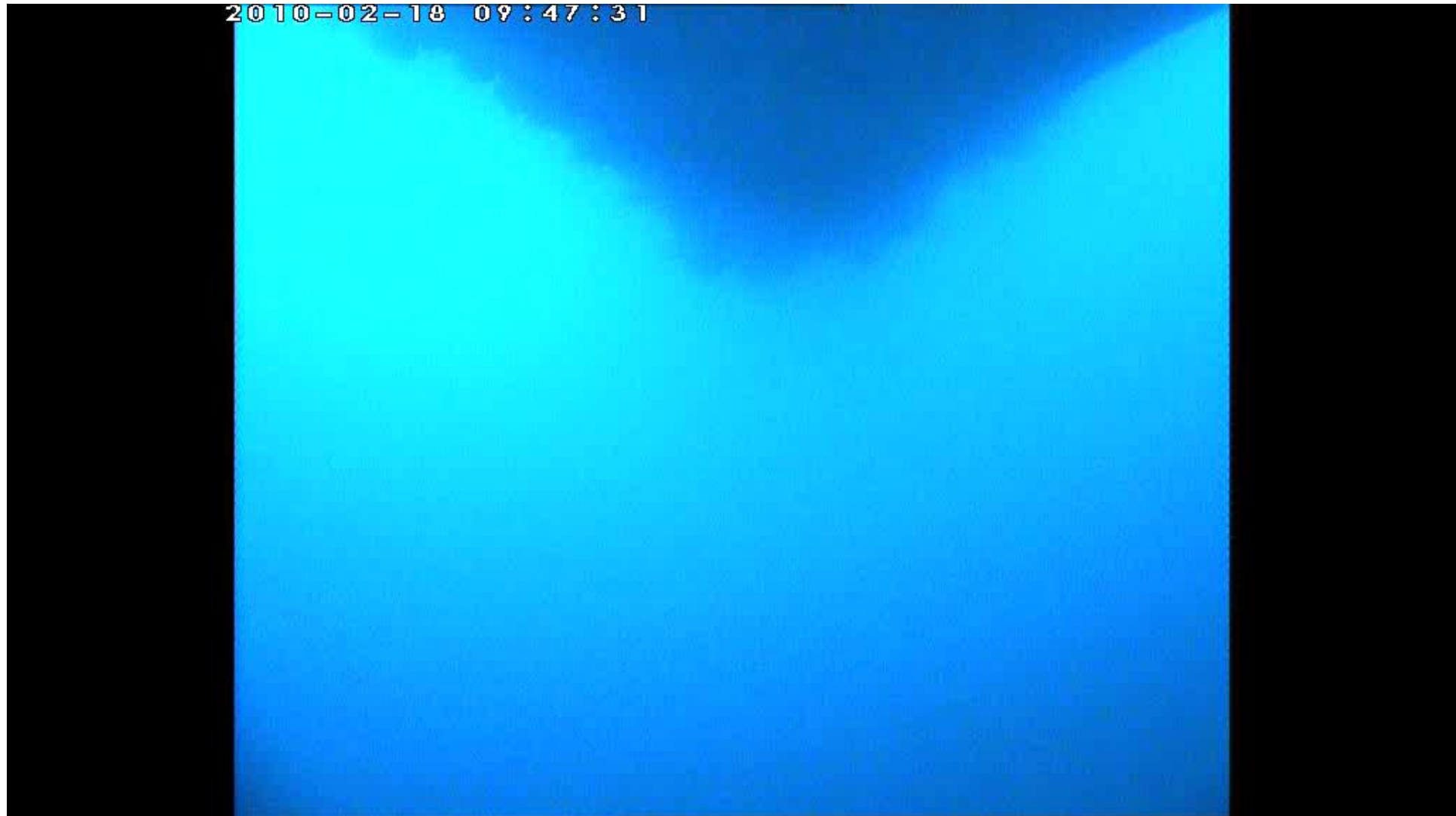
"Early attempts to capture aerated water below the hull. Videos courtesy of Timothy Gates, Gates Acoustics."

Bubble Sweepdown History

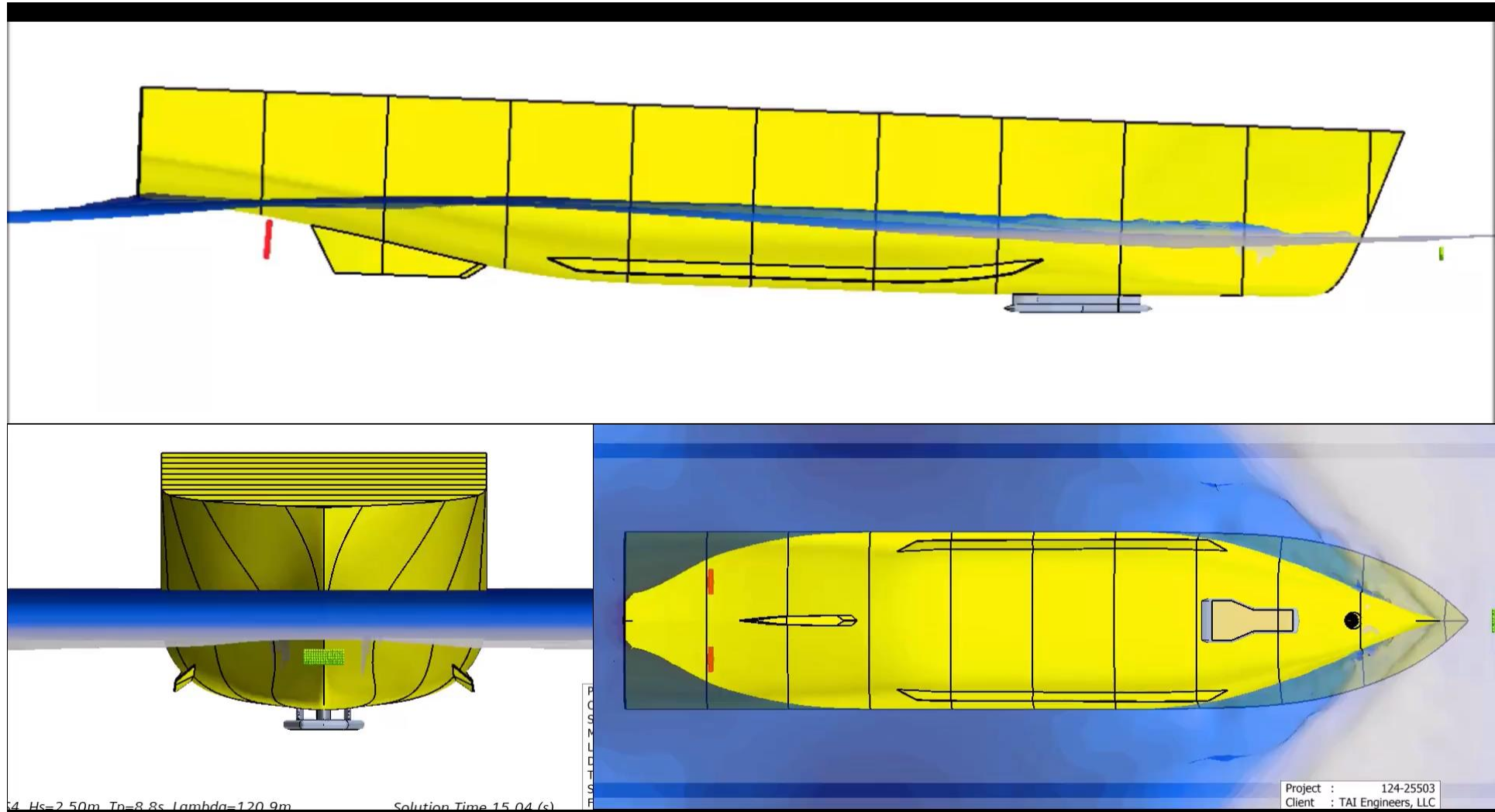




Bubble Sweepdown History



Bubble Sweepdown History



Bubble Sweepdown History



We started by **observing** the problem.

Then we learned to **see** it.

Now we are learning to **predict** it.

And perhaps the next step is not only to understand Bubble Sweep-Down, but to **design vessels** where it is much less of a problem.



- Fifteen research vessels
 - Class A Oceanographic (2)
 - Two new construction Oceanographer 2022 Discoverer 2028
 - **Class B Charting and Mapping (3)**
 - **Two new construction Surveyor 2028, Navigator 2029**
 - Class C Fisheries/Coastal Science (5)
 - Planning stages
 - Class D Fisheries/High Endurance (5)
 - Mid life Technology upgrades
- Uncrewed Systems (UsX)
 - Uncrewed Aerial Systems (UAS)
 - Uncrewed Maritime Systems (UMS)
 - Uncrewed Surface Vehicles (USV)
 - Unmanned Autonomous Vehicles (UAV)



NOAA Fleet



NOAAS Surveyor

NOAA Fleet



NOAAS Navigator

Class B Program Background

PROJECT MILESTONE SEQUENCE



The Challenge

Bubble Sweepdown Study Phase 1-5

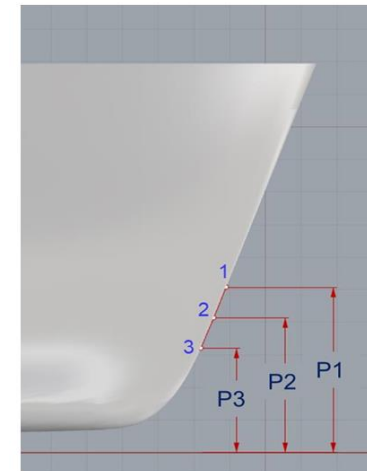
- What do we do?
- Positive collaboration and partnership with TMC
- Develop serial studies to allow design to continue
 - Mandate decision and “jumping off” points
 - Consensus on speed and sea state (guardrails)
 - Speed range 4 to 10 kts (contract maximum)
 - Sea States SS0, SS2 to SS4 (contract maximum)
 - Weigh cost and schedule benefits
 - How many data points?
 - Which one matters the most?

Phase ?		Sea State			
		0	2	3	4
Speed (kts)	4	?	?	?	?
	6	?	?	?	?
	8	?	?	?	?
	10	?	?	?	?

The Solution

Phase 1 CFD Analysis Contract Hull Form

- Goal – Validate the results of the Spring 2024 Bubble Sweepdown CFD analysis
- Rationale – Independent validation to support further action
- Result – Spring 2025 CFD analysis was validated
- Conducted by BSHC
 - Full-load and Mid-voyage without service life allowance @ 8, 10, and 12 knots at full load w/o SLA.
 - Varying pitch +/- four (4) degrees in 1 degree increments
 - + bow down, - bow up
 - Ship model fixed in pitch and heave
 - SHALLO© (Hamburg Ship Model Basin product) used for the simulations

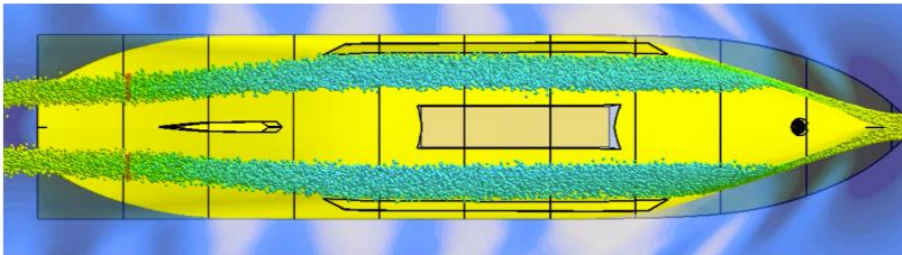
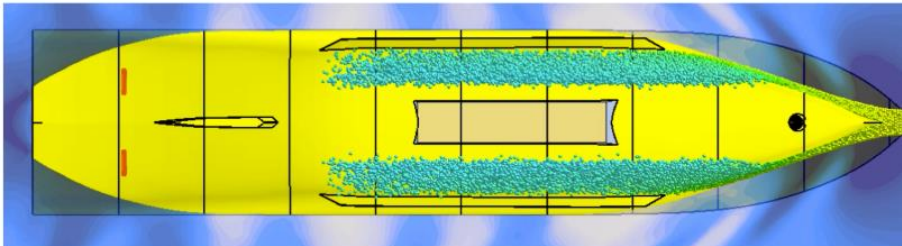
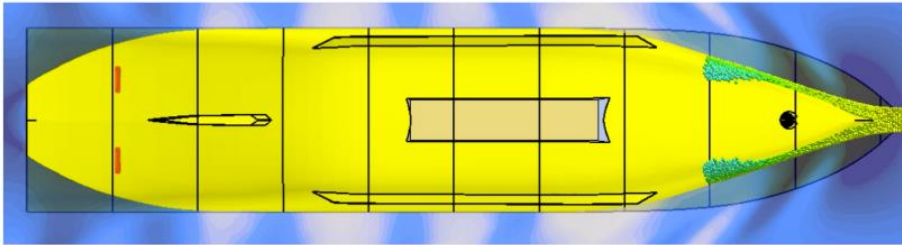


Initiation points

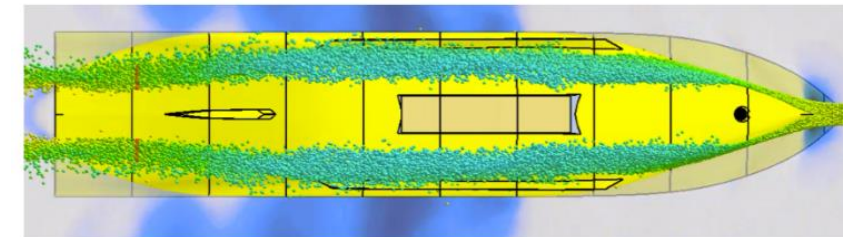
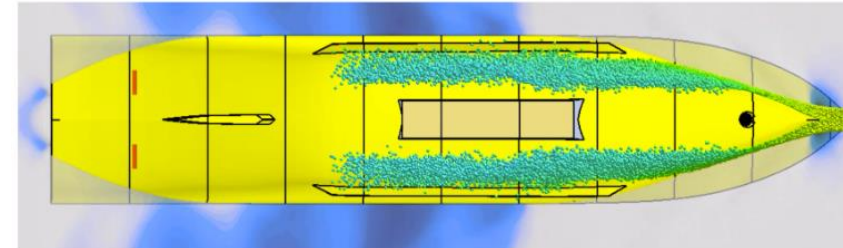
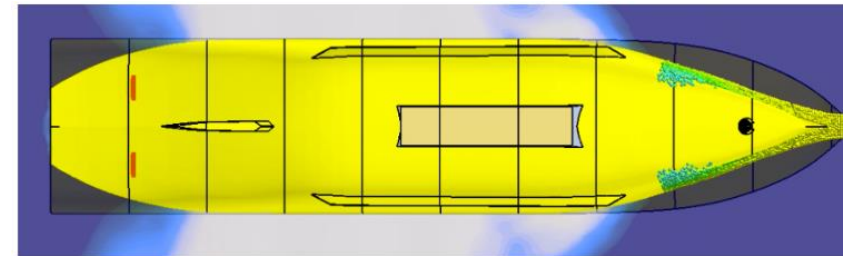
The Solution

Phase 1 CFD Analysis Contract Hull Form

8 kts, SS0 middle point



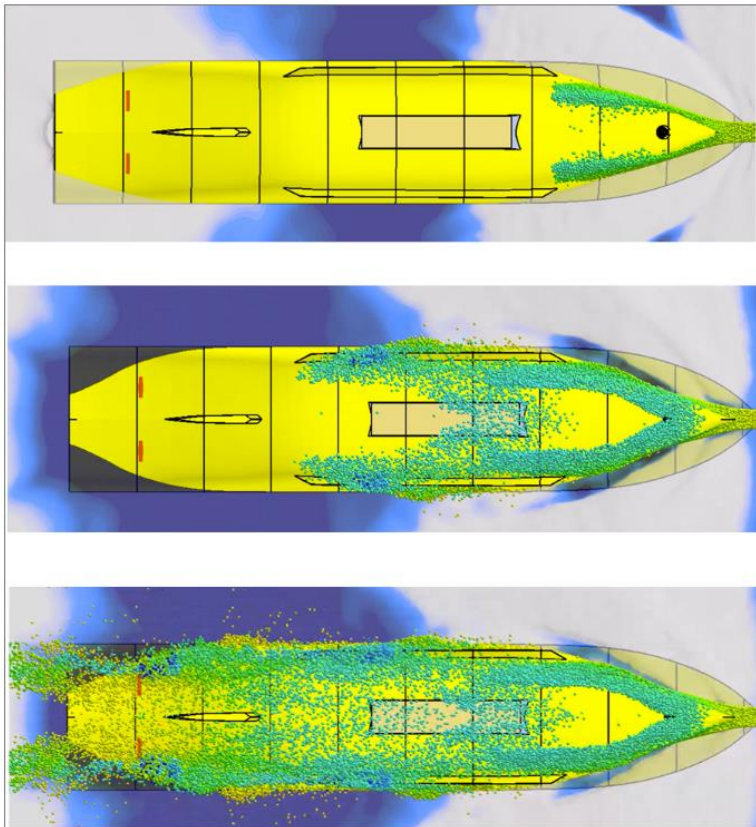
8 kts, SS2 middle point



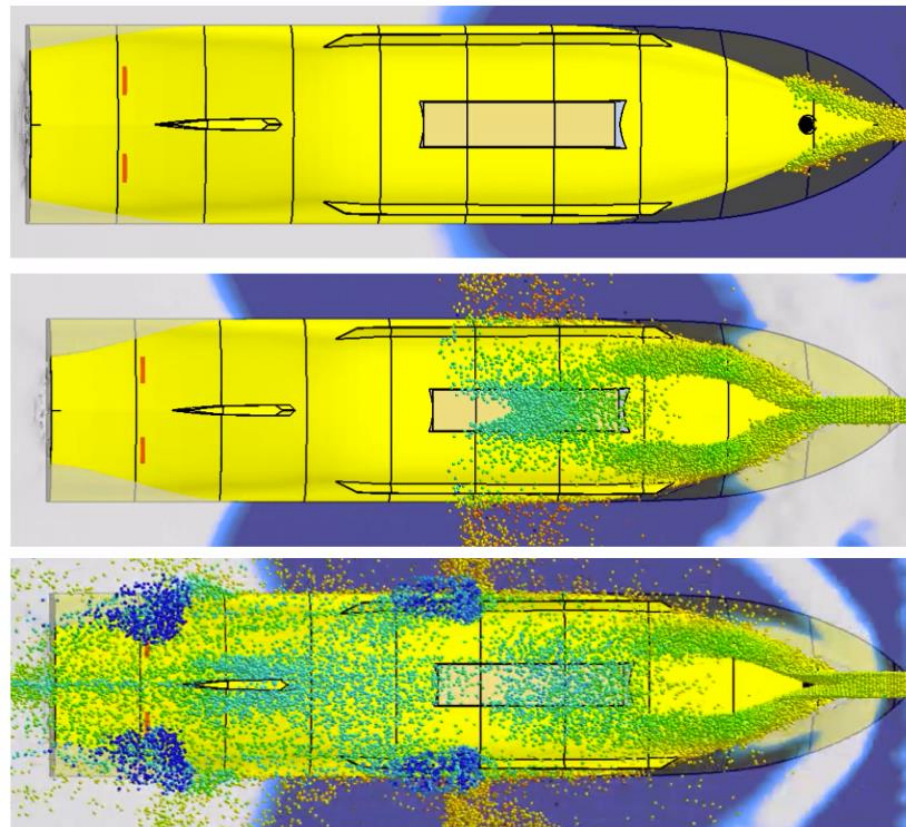
The Solution

Phase 1 CFD Analysis Contract Hull Form

8 kts, SS3 middle point



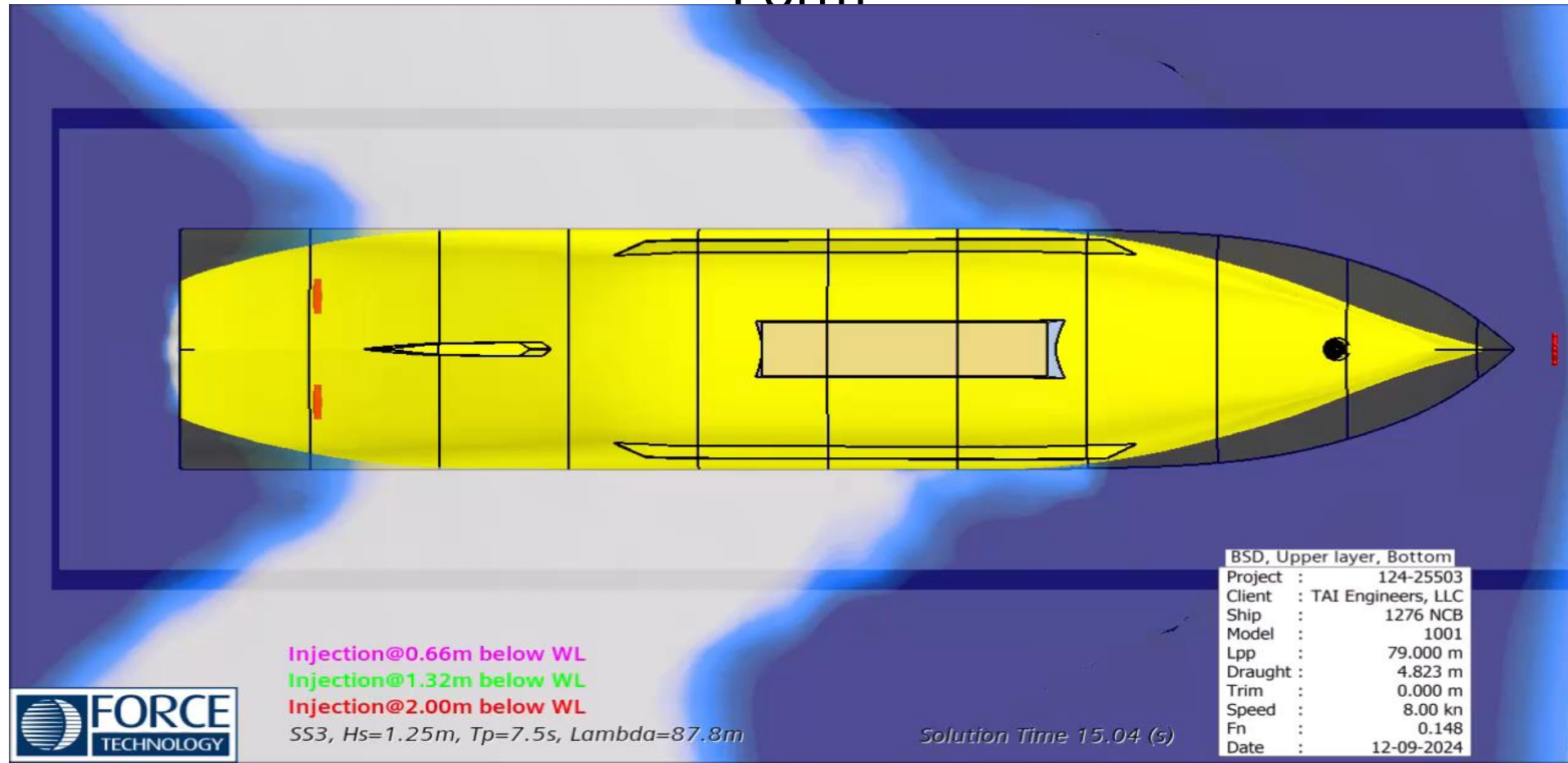
8 kts, SS4 middle point



Uh oh...

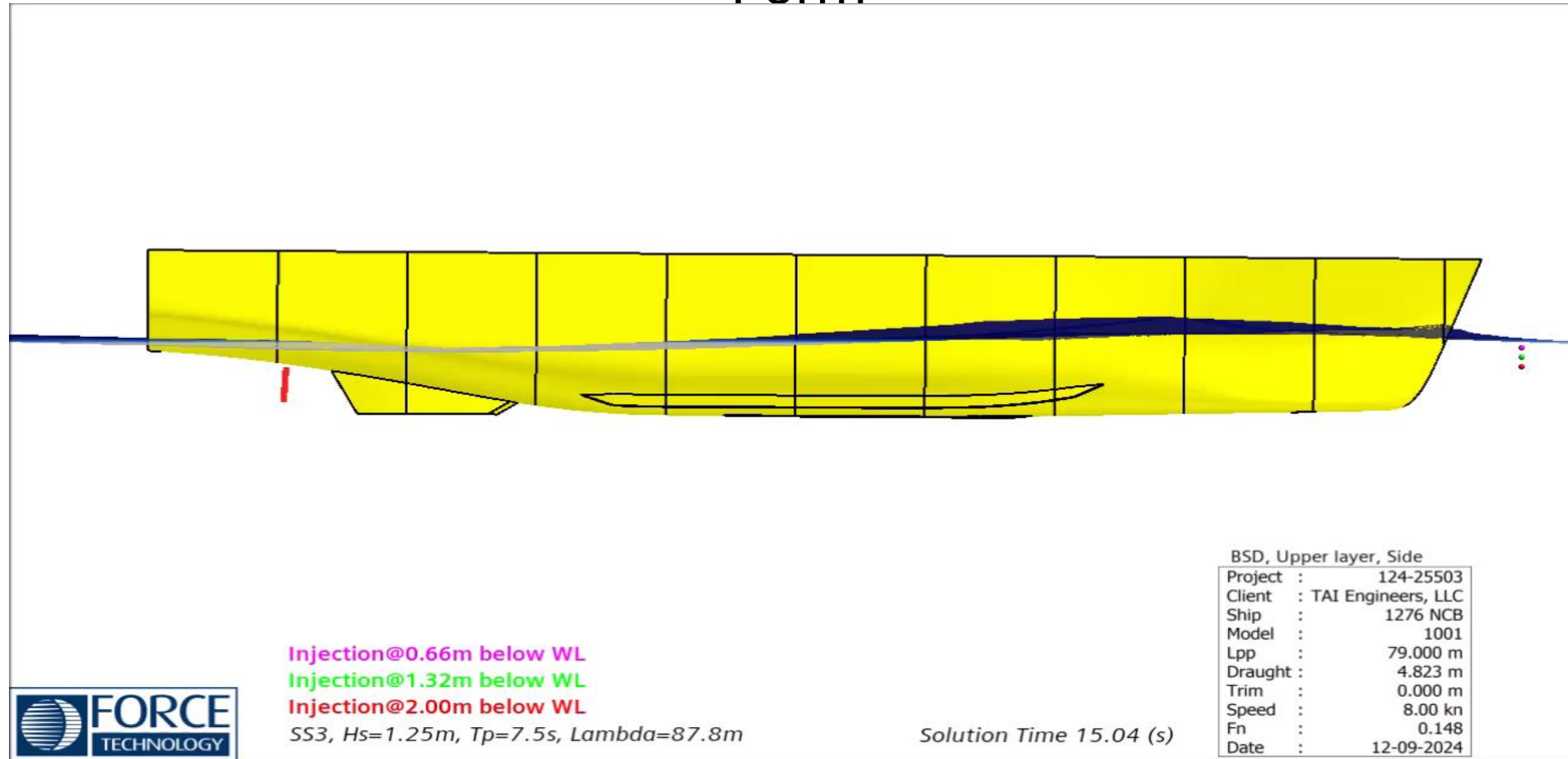
The Solution

Phase 1 CFD Analysis Contract Hull Form



The Solution

Phase 1 CFD Analysis Contract Hull Form





The Solution

Phase 1 CFD Analysis Contract Hull Form



- The question on your mind...
 - Why is the transducer area close to midship?
- The answer...

Initiation points

The Solution

Phase 1 CFD Analysis Contract Hull Form

		Trim, deg								
		+4	+3	+2	+1	0	-1	-2	-3	-4
Speed	8 kn									
	10 kn									
	12 kn									

Full load

		Trim, deg								
		+4	+3	+2	+1	0	-1	-2	-3	-4
Speed	8 kn									
	10 kn									
	12 kn									

Mid voyage

- Red – P2 and P3 streamline crosses transducer area
- Yellow – P3 streamline crosses transducer area
- Green – All clear of the transducer area are trespassing TRA.
 - Ship model fixed in pitch and heave
 - SHALLO© (Hamburg Ship Model Basin product) used for the simulations



The Solution

Phase 2 CFD Analysis Blister vs Gondola



- Goal – Investigate through CFD analysis to determine effectiveness and potential impacts to ship performance
- Rationale – weigh different factors for “best” solution
- Result – Gondola selected
 - Best performance
 - Accept increased resistance and potential penalties to fuel economy and speed
- Conducted by Force (CFD)

The Solution

Phase 2 CFD Analysis Blister vs Gondola

- Baseline speed and sea states
- Select most “efficient” conditions

Mid-Voyage (Blister)				
knots	SS0	SS2	SS3	SS4
4				
6	X		X	X
8	X		X	X
10				

Mid-Voyage (Gondola)				
knots	SS0	SS2	SS3	SS4
4				
6	X		X	X
8	X		X	X
10				

- Initial design of the blister and gondola
 - Ensure all sensors fit
 - Optimize relative placement (if possible)



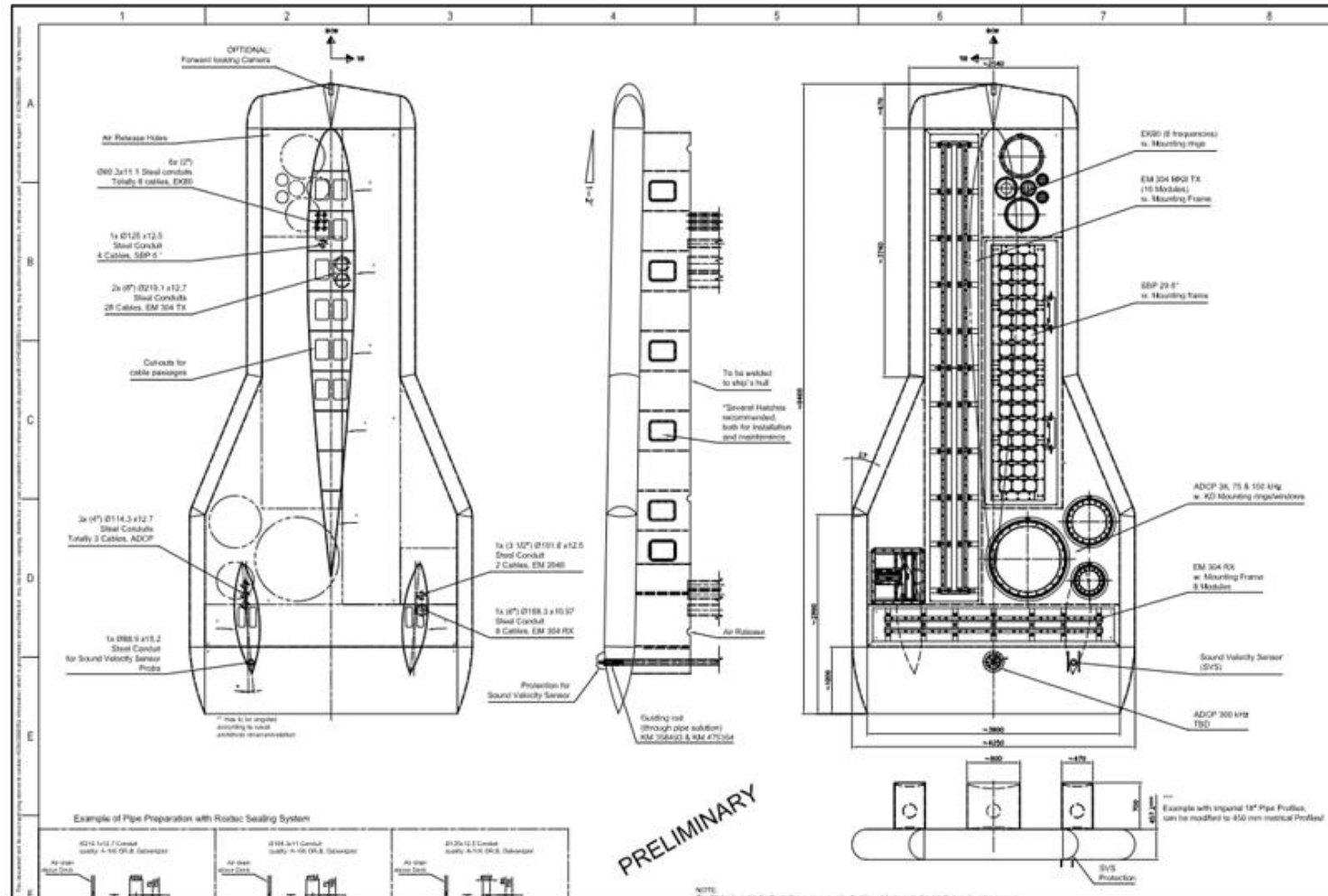
Bliste



The Solution

Phase 2 CFD Analysis Blister vs Gondola

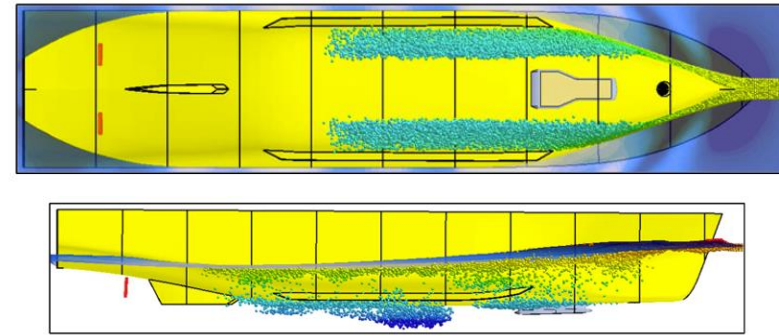
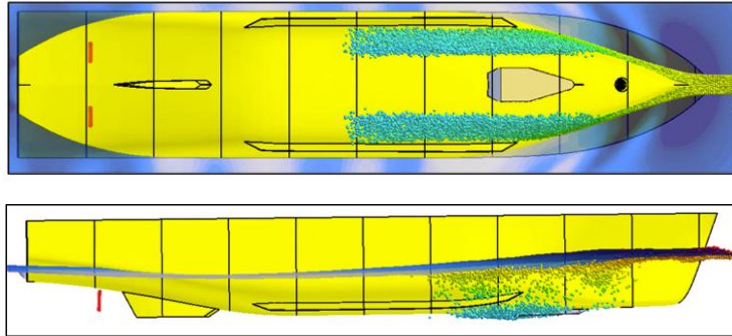
Gondola



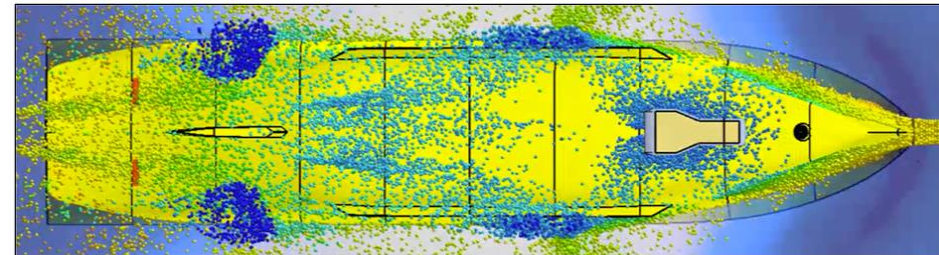
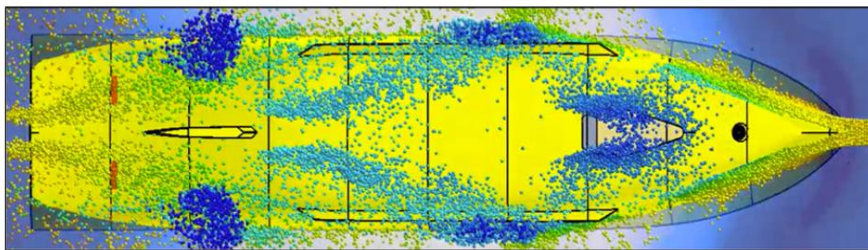
The Solution

Phase 2 CFD Analysis Blister vs Gondola

8kts,
SS0

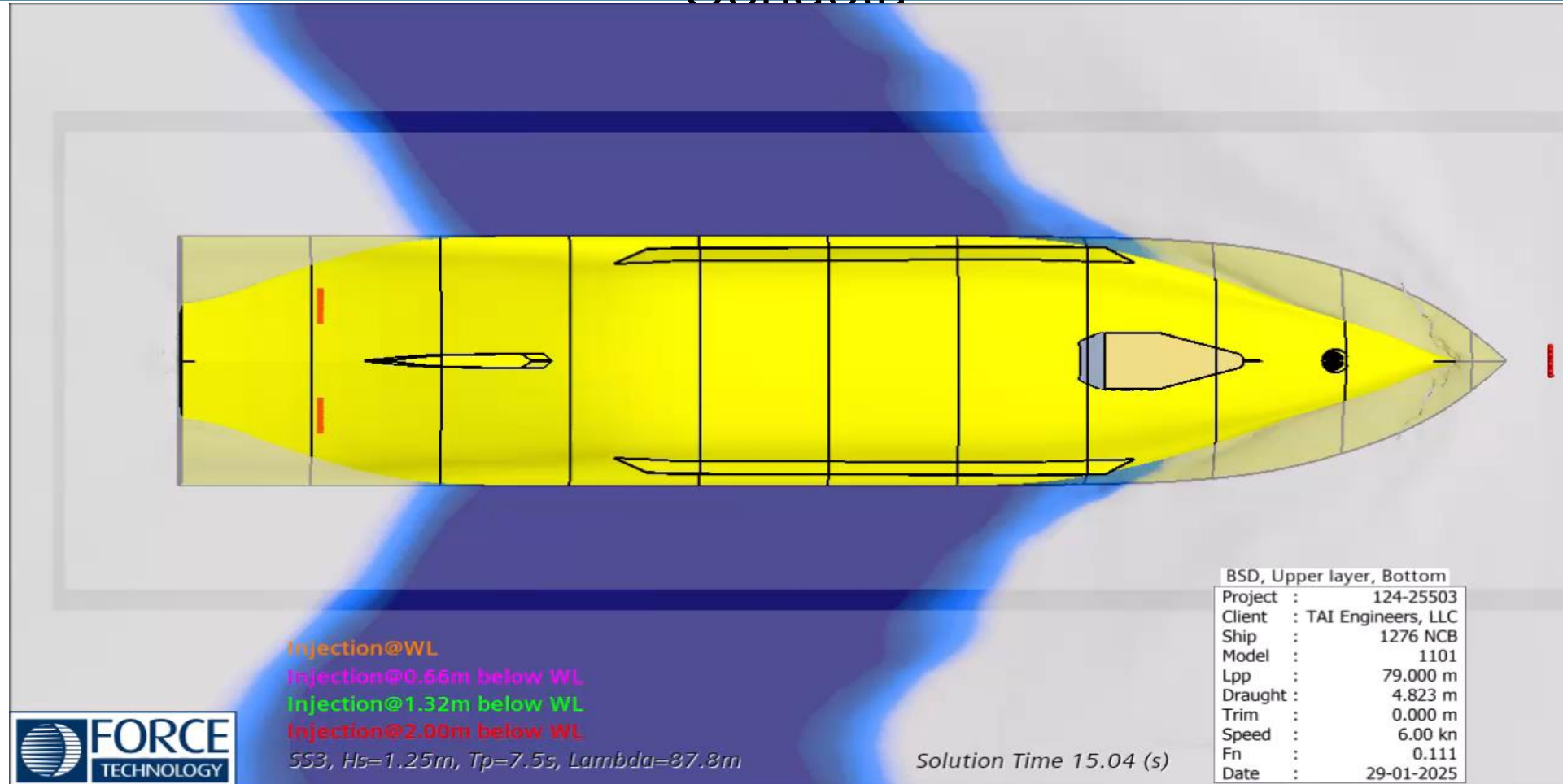


8kts,
SS4



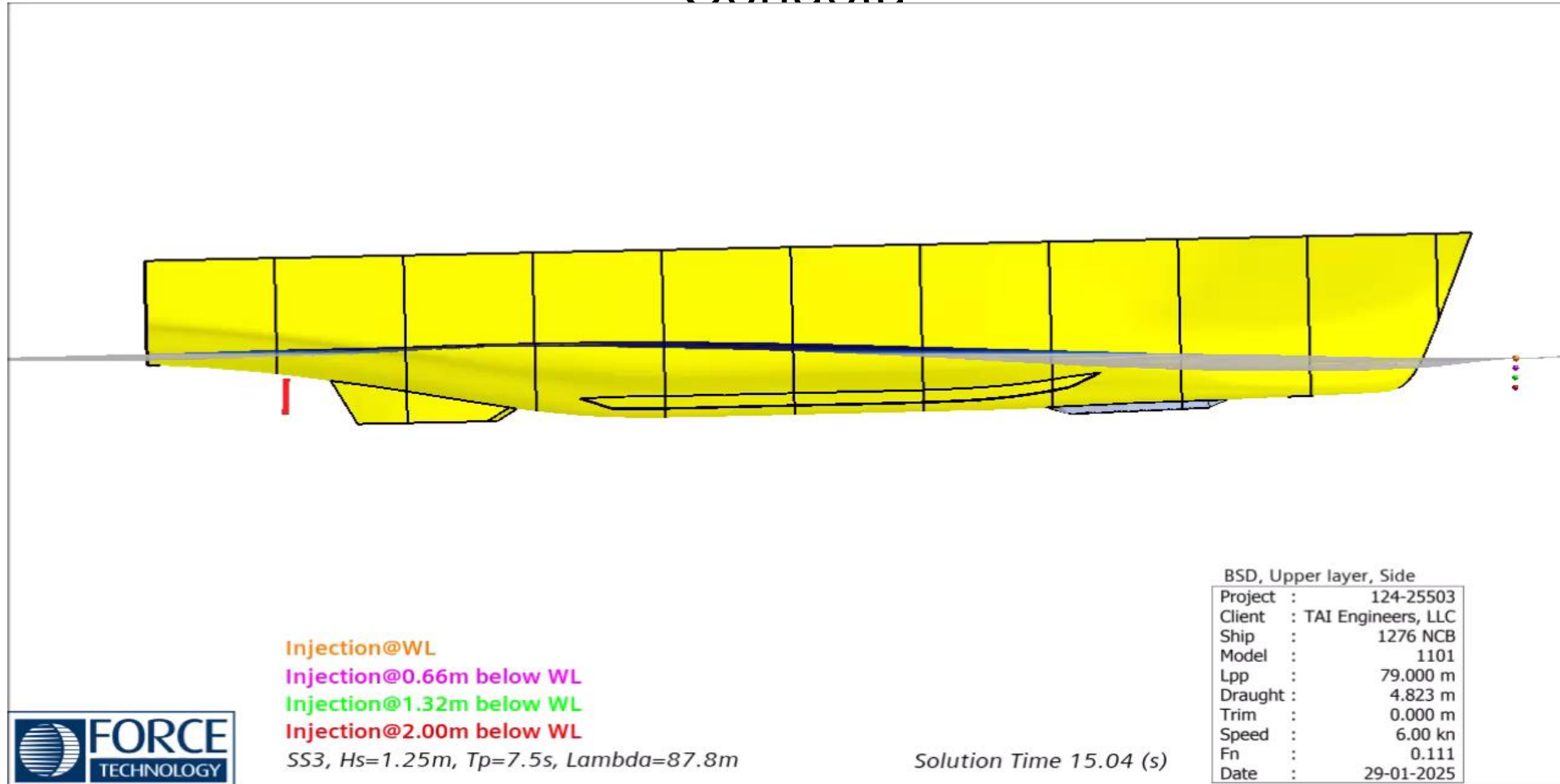
The Solution

Phase 2 CFD Analysis Blister vs Gondola



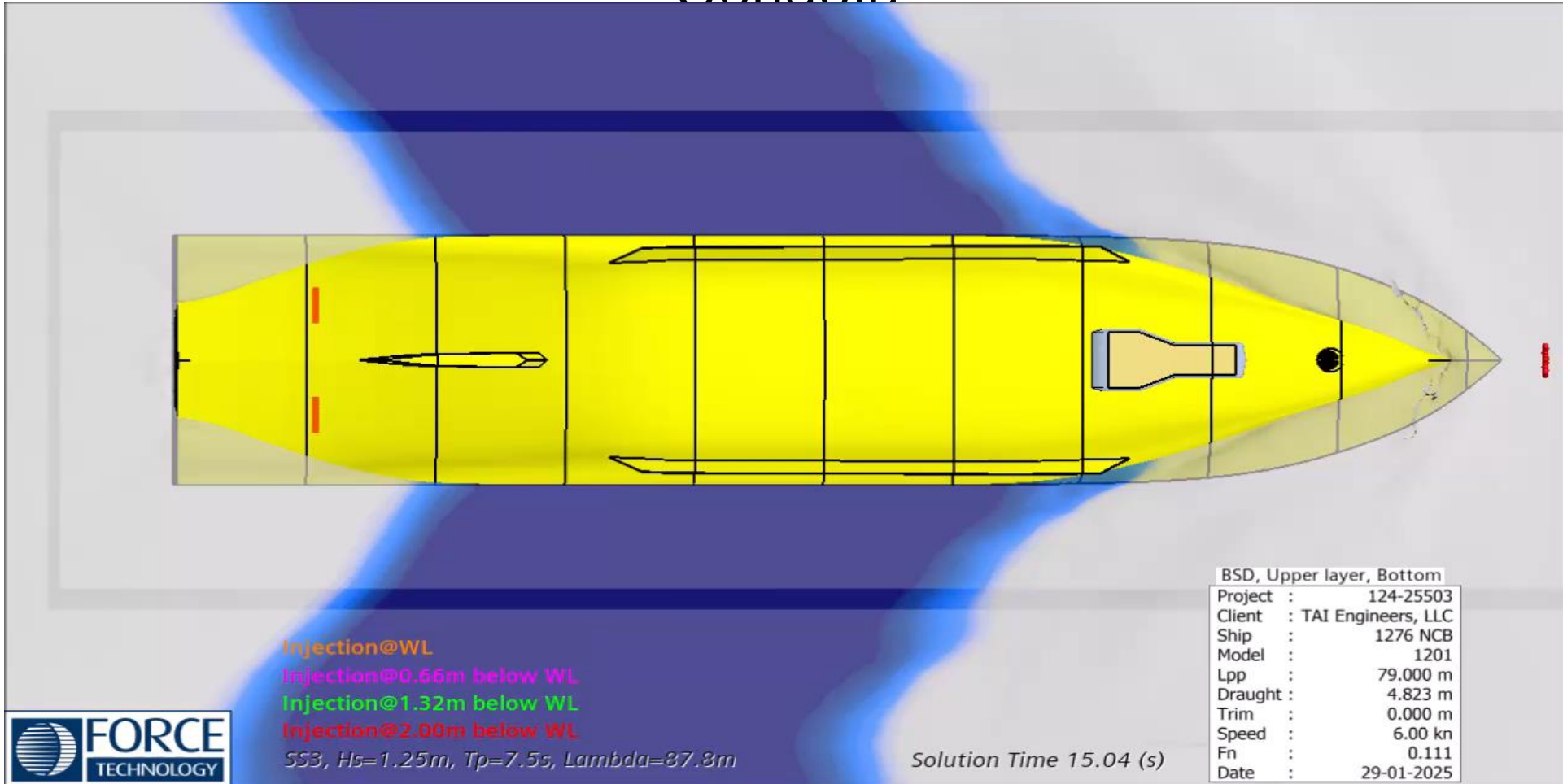
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Phase 2 CFD Analysis Blister vs Gondola



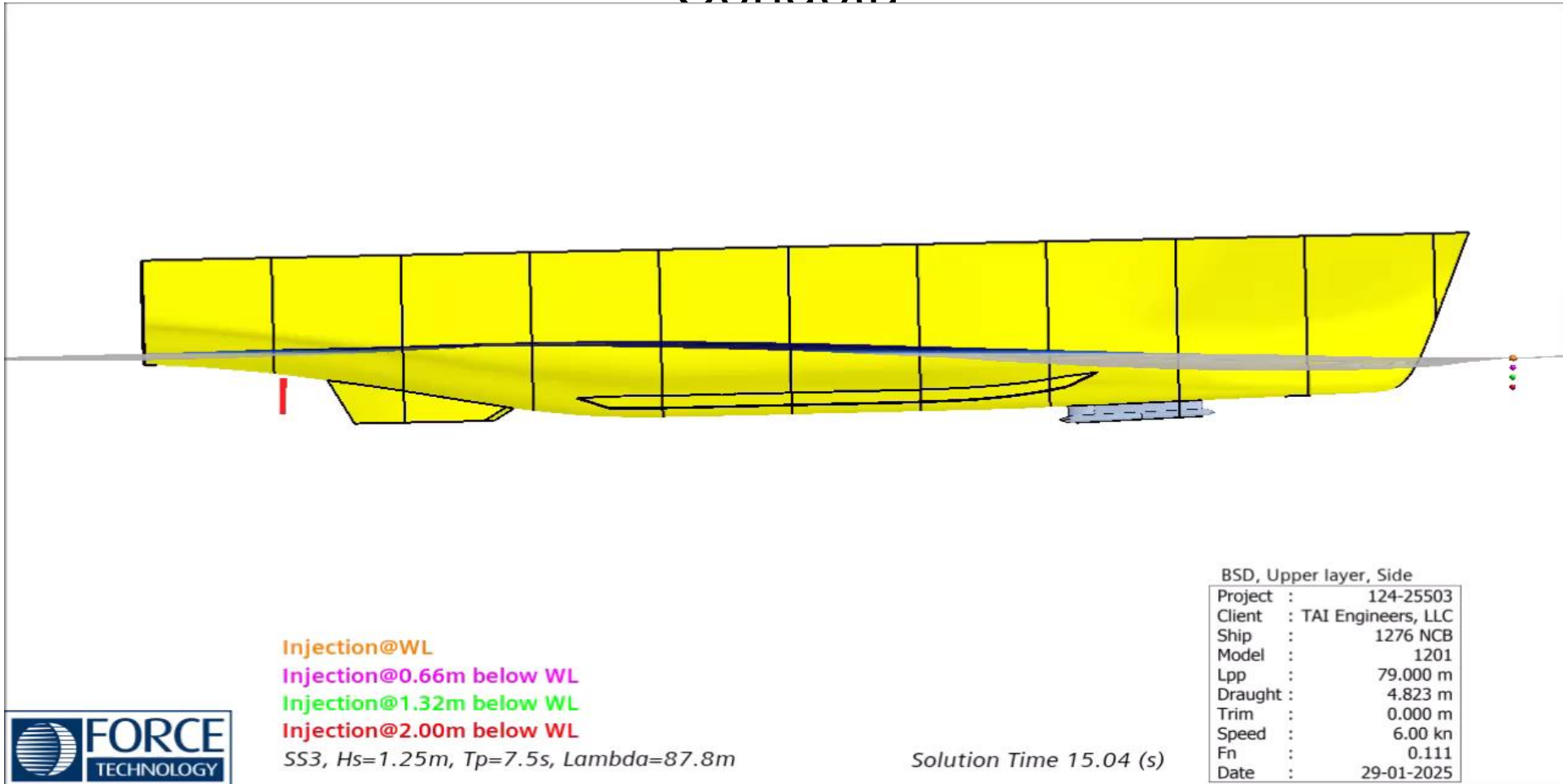
The Solution

Phase 2 CFD Analysis Blister vs Gondola



The Solution

Phase 2 CFD Analysis Blister vs Gondola





The Solution

Phase 3 CFD Analysis Refine Best Solution



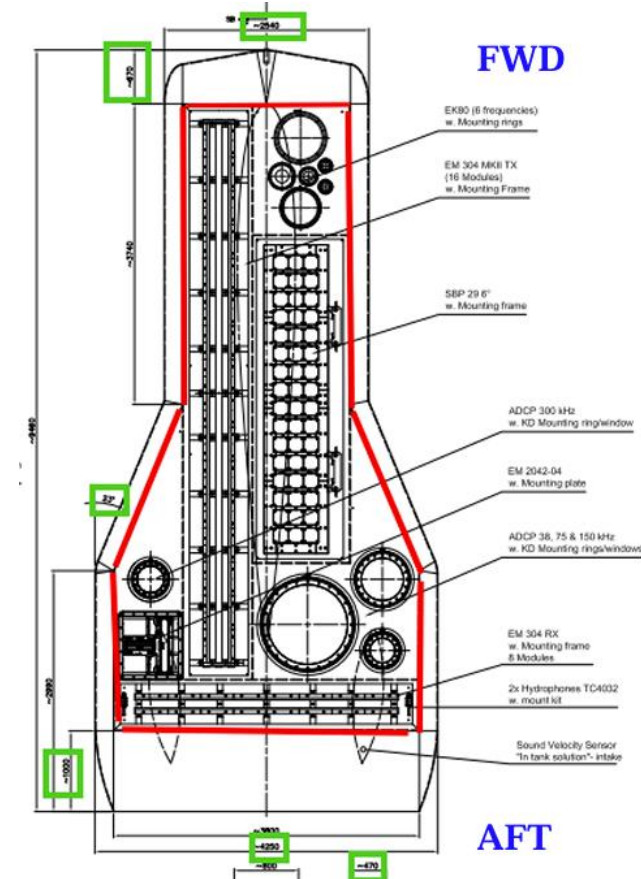
- Goal – Optimize the gondola design; hone the shape for the equipment; minimize propeller wake
- Rationale – Ensure the design can accommodate the sensor suite and reduce potential impacts on the propeller
- Results – Design successful resulting in minimal tweaks to the propeller



The Solution

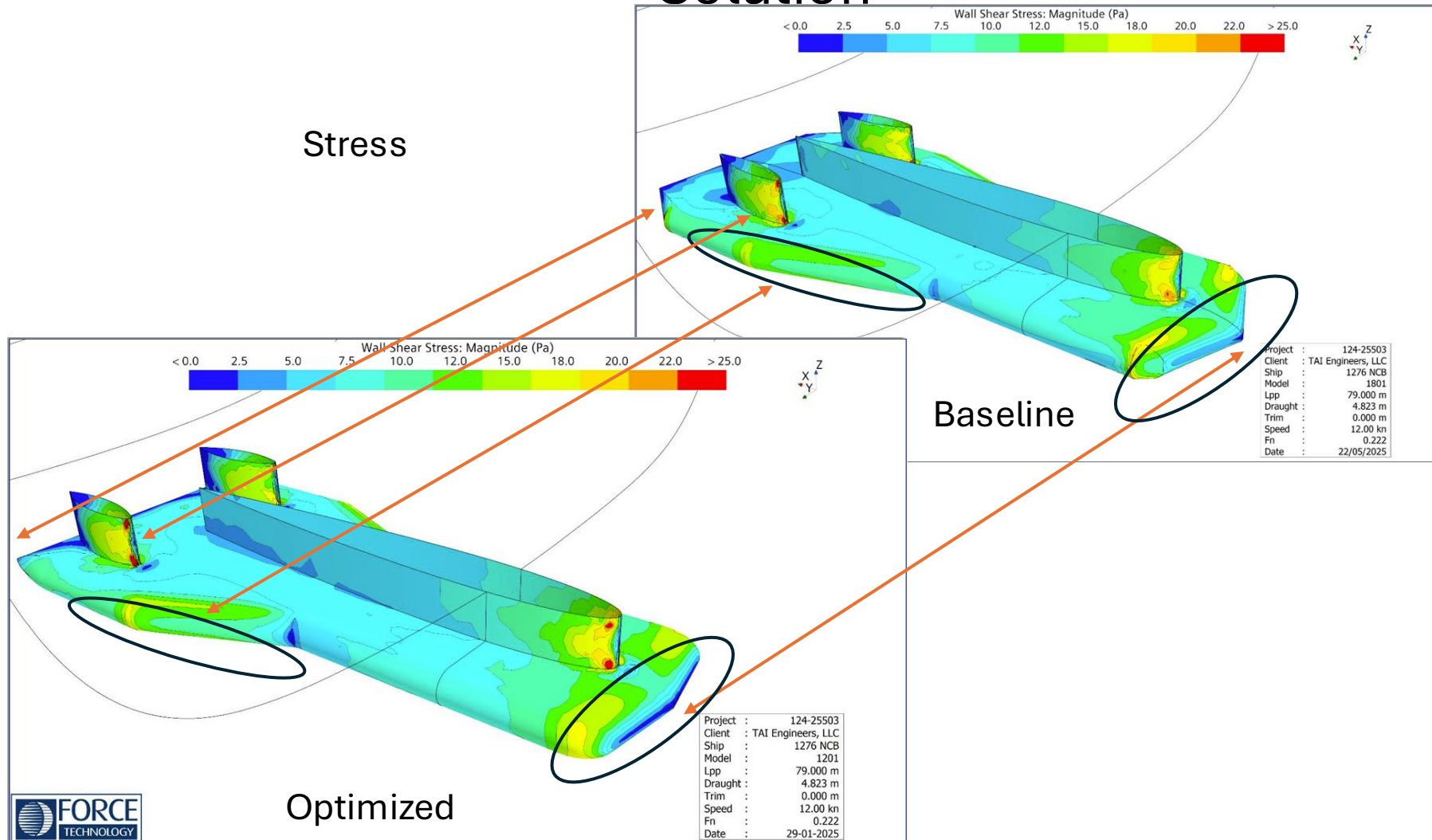
Phase 3 CFD Analysis Refine Best Solution

- Collaboration – TAI, FORCE, Kongsberg
- Areas of focus
 - Aft port/starboard struts; centerline strut contains conduit
 - All of the edges
- Early resistance calculations (Baseline to initial design)
 - +9.1% @ 8 knots
 - +7.6% @ 12 knots



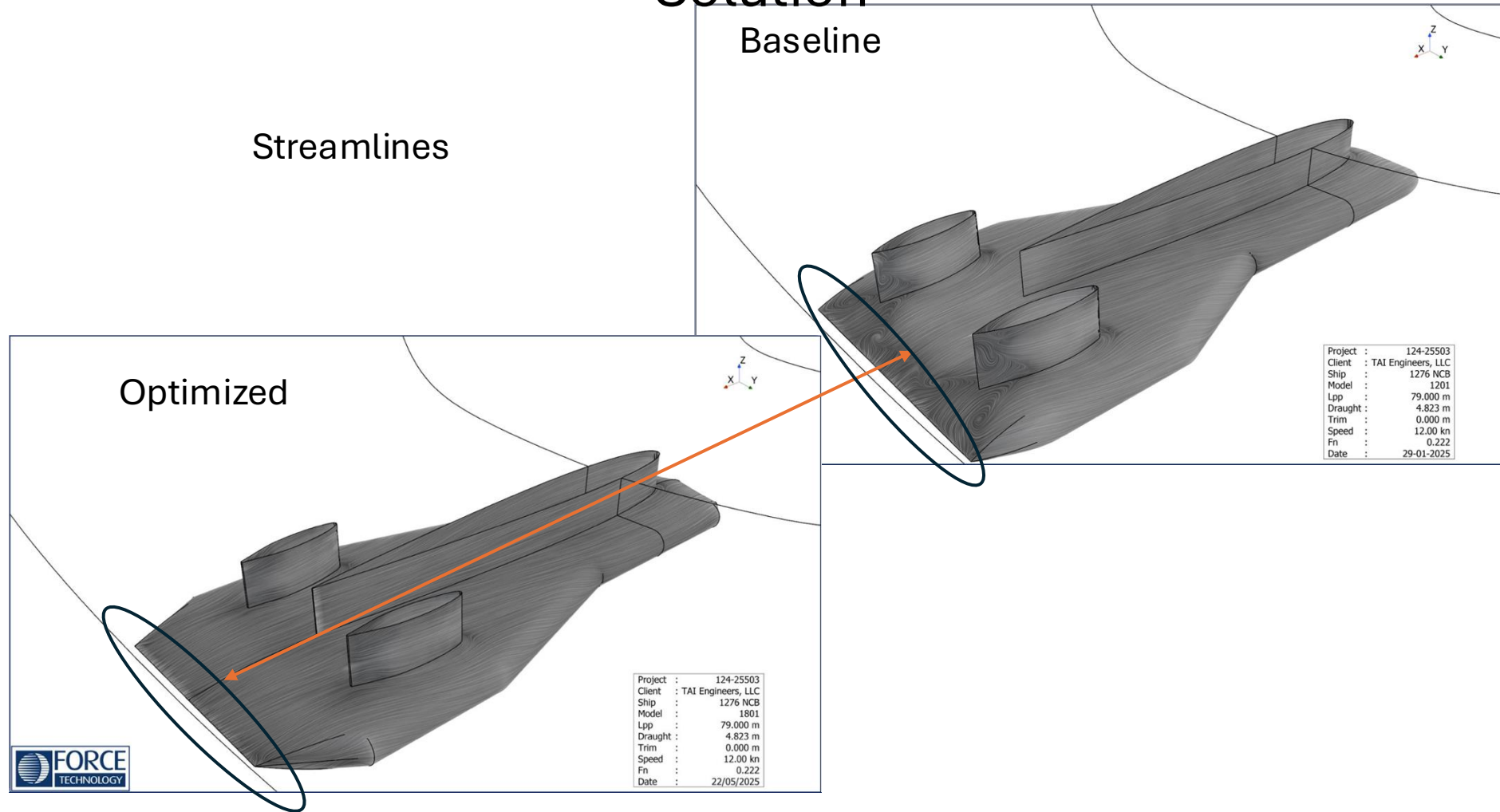
The Solution

Phase 3 CFD Analysis Refine Best Solution



The Solution

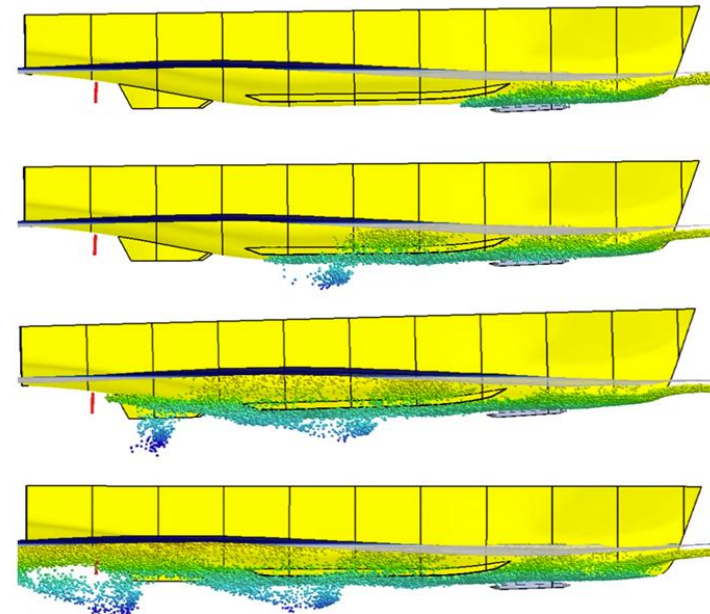
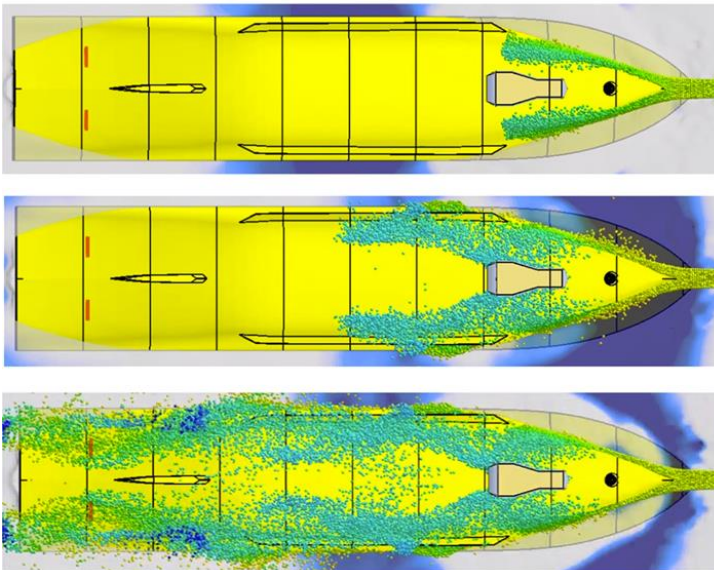
Phase 3 CFD Analysis Refine Best Solution



The Solution

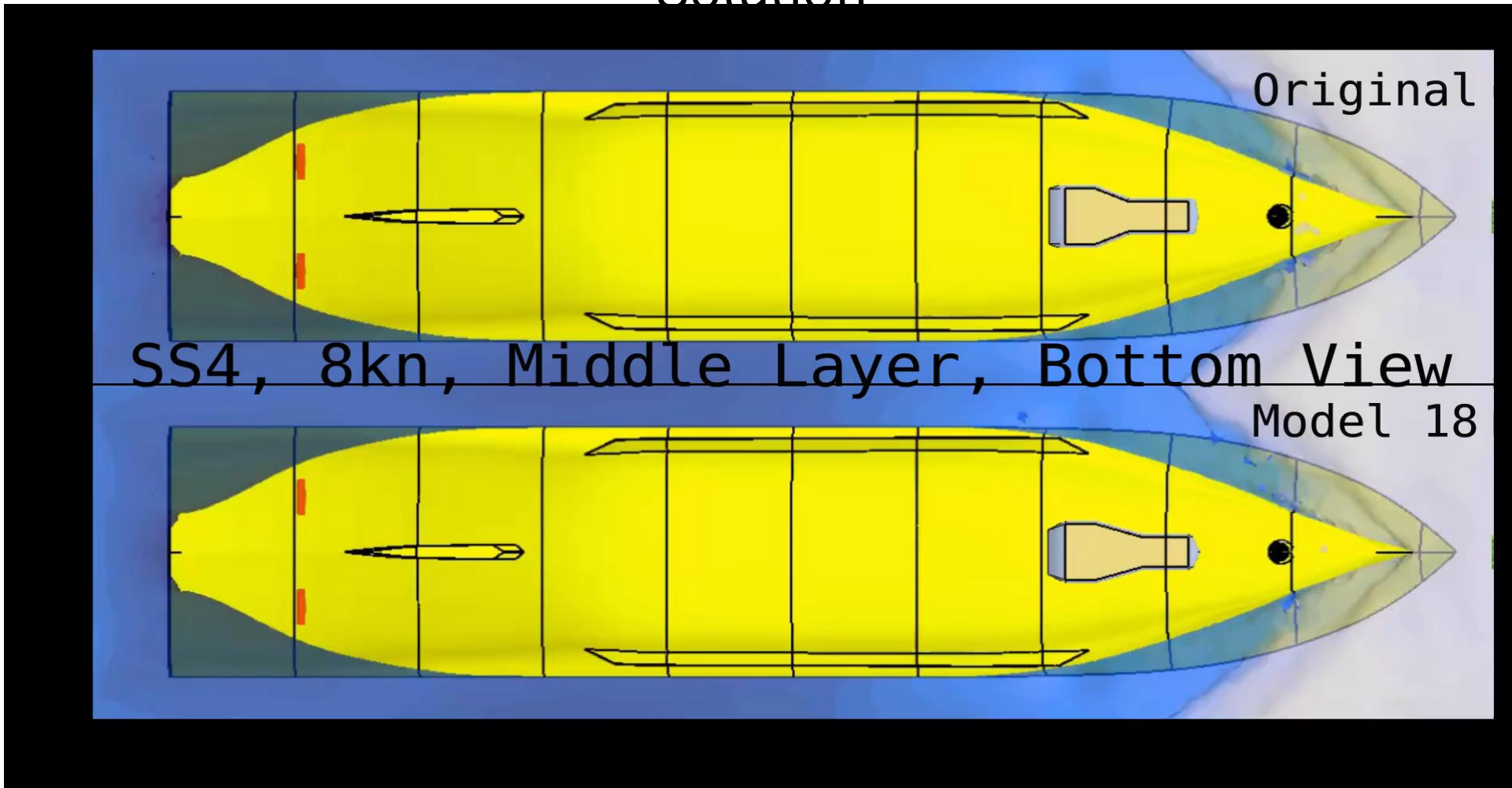
Phase 3 CFD Analysis Refine Best Solution

- Resistance initial vs optimized
 - 9.1% → 7.8% = 1.3% reduction
 - Reduce wake
- CFD to validate optimization did not impact BSD
- 8 knots, SS3



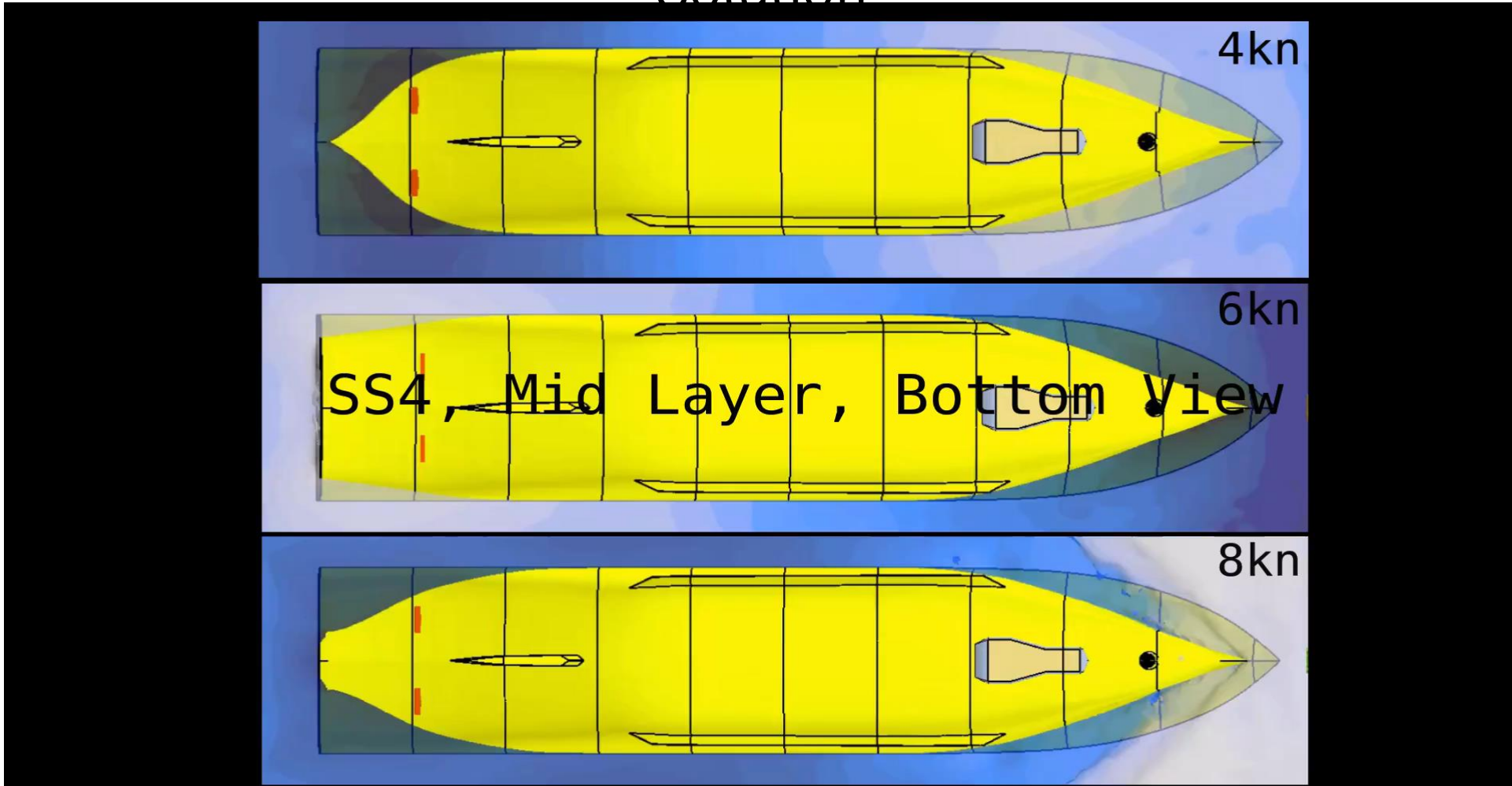
The Solution

Phase 3 CFD Analysis Refine Best Solution



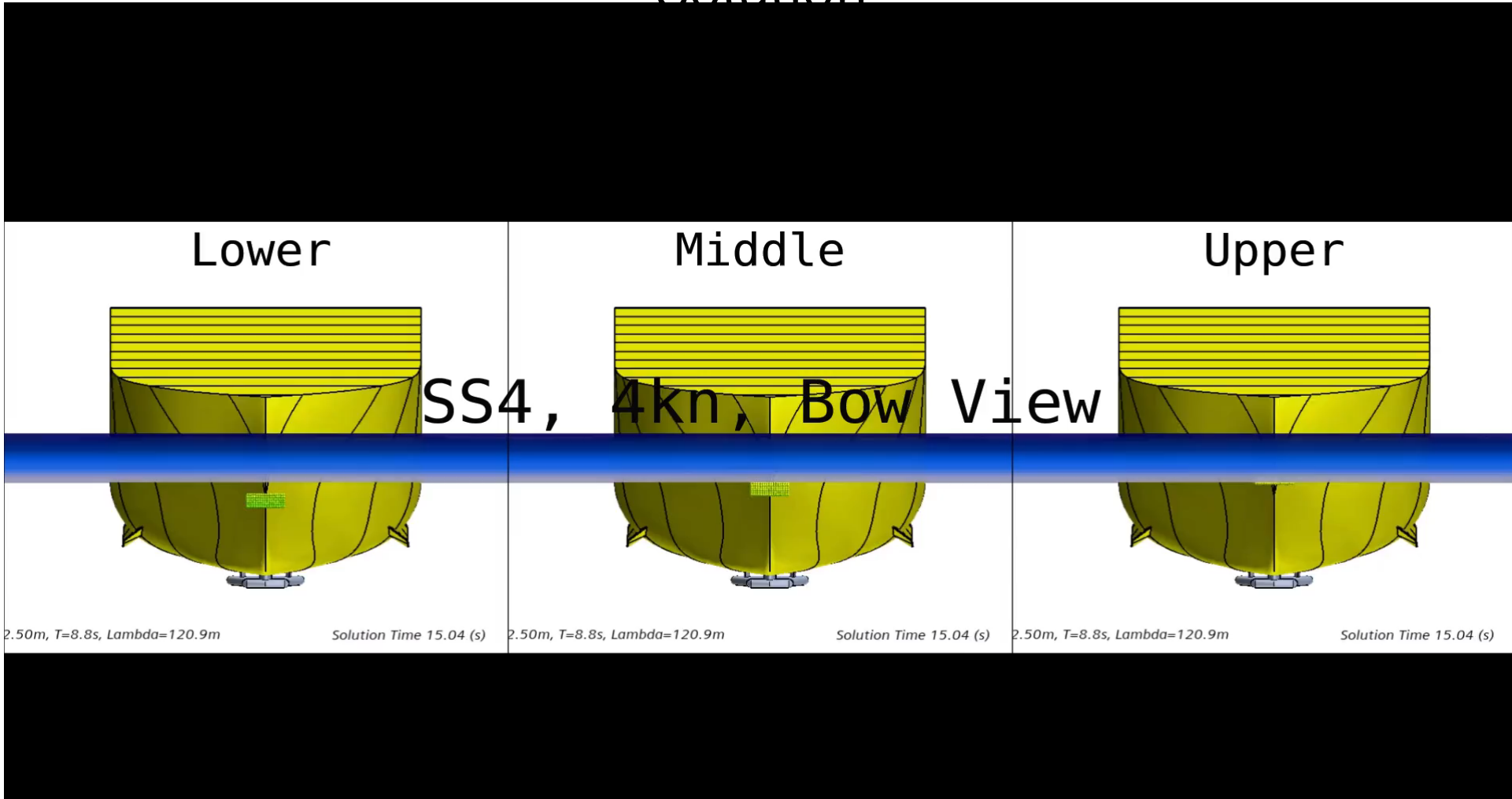
The Solution

Phase 3 CFD Analysis Refine Best Solution



The Solution

Phase 3 CFD Analysis Refine Best Solution





The Solution

Phase 4 Model Tank Testing

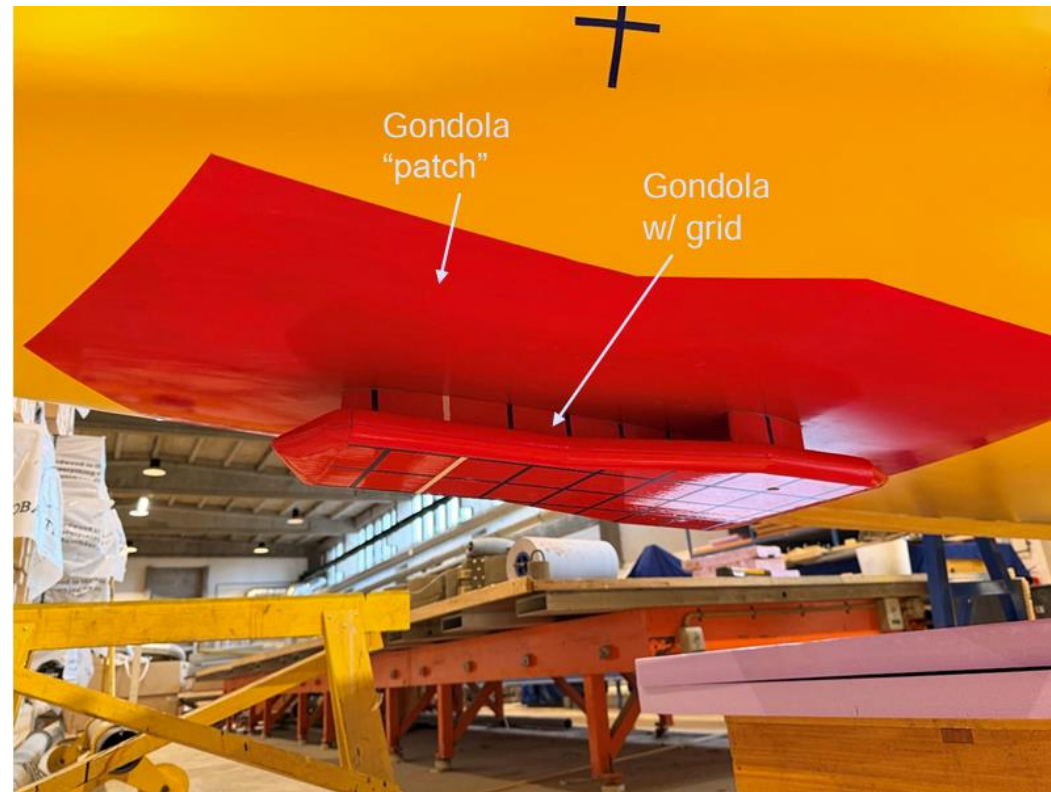


- Goal – Validate CFD on the optimized gondola design
- Rationale – Ensure data correlation before proceeding on additional engineering and contract modification.
- Results – Model testing validated the Phase 3 CFD analysis
- Conducted in FORCE Technology, Copenhagen, Denmark

The Solution

Phase 4 Model Tank Testing

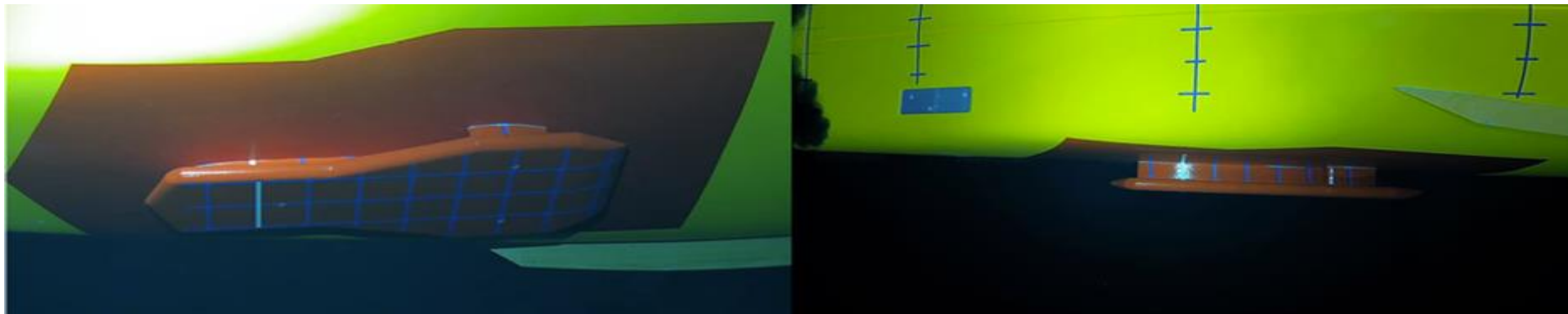
- Gondola with color contrast



The Solution

Phase 4 Model Tank Testing

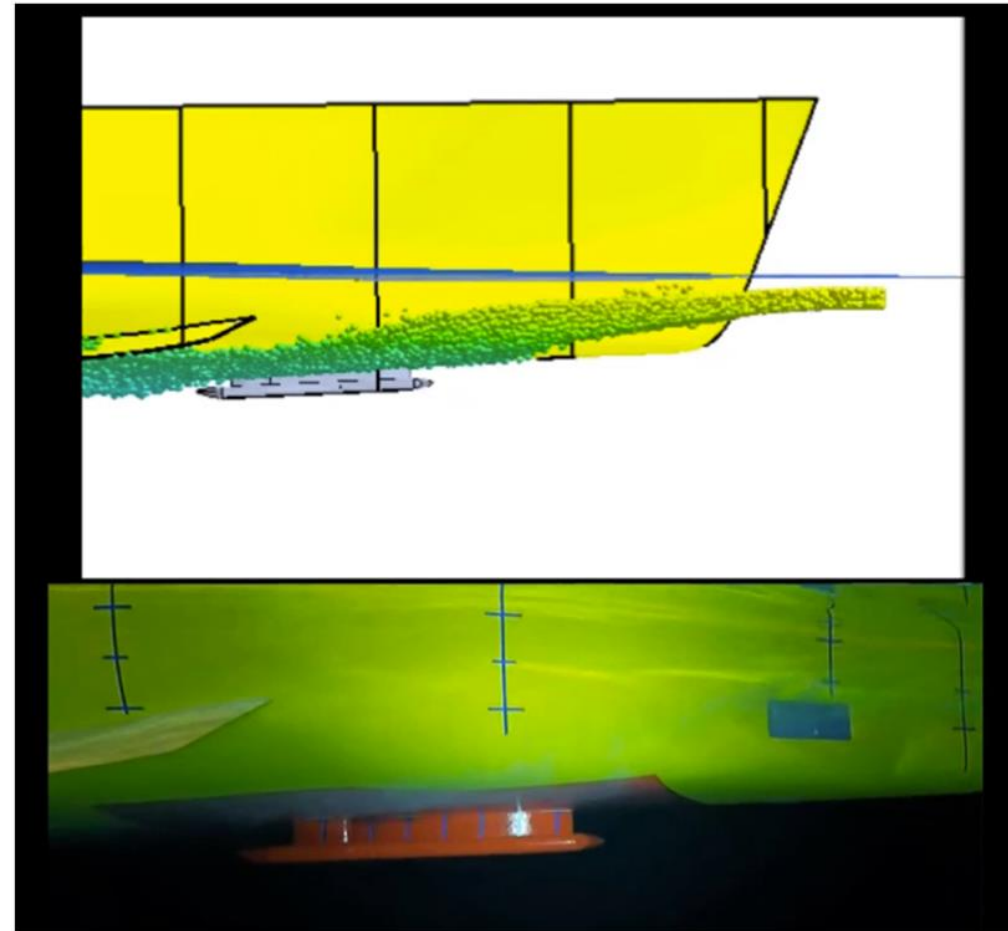
- Matched cases with P2 and P3
- Camera set up to show port and underside view
- Considerations
 - Time to reach speed
 - Validate wave height
 - Dye color vs the color of the model
 - Tested several dye colors; green selected



The Solution

Phase 4 Model Tank Testing

- 20 runs made
 - SS0 – 4, 6, 8, 10x3 kts
 - SS2 – 6x3, 8x2 kts
 - SS3 – 6x2, 8x2 kts
 - SS4 – 4x5 kts
- Correlation
 - CFD vs model testing
 - Validated the CFD models are accurate



The Solution

Phase 4 Model Tank Testing



The Solution

Phase 4 Model Tank Testing



The Solution

Phase 4 Model Tank Testing



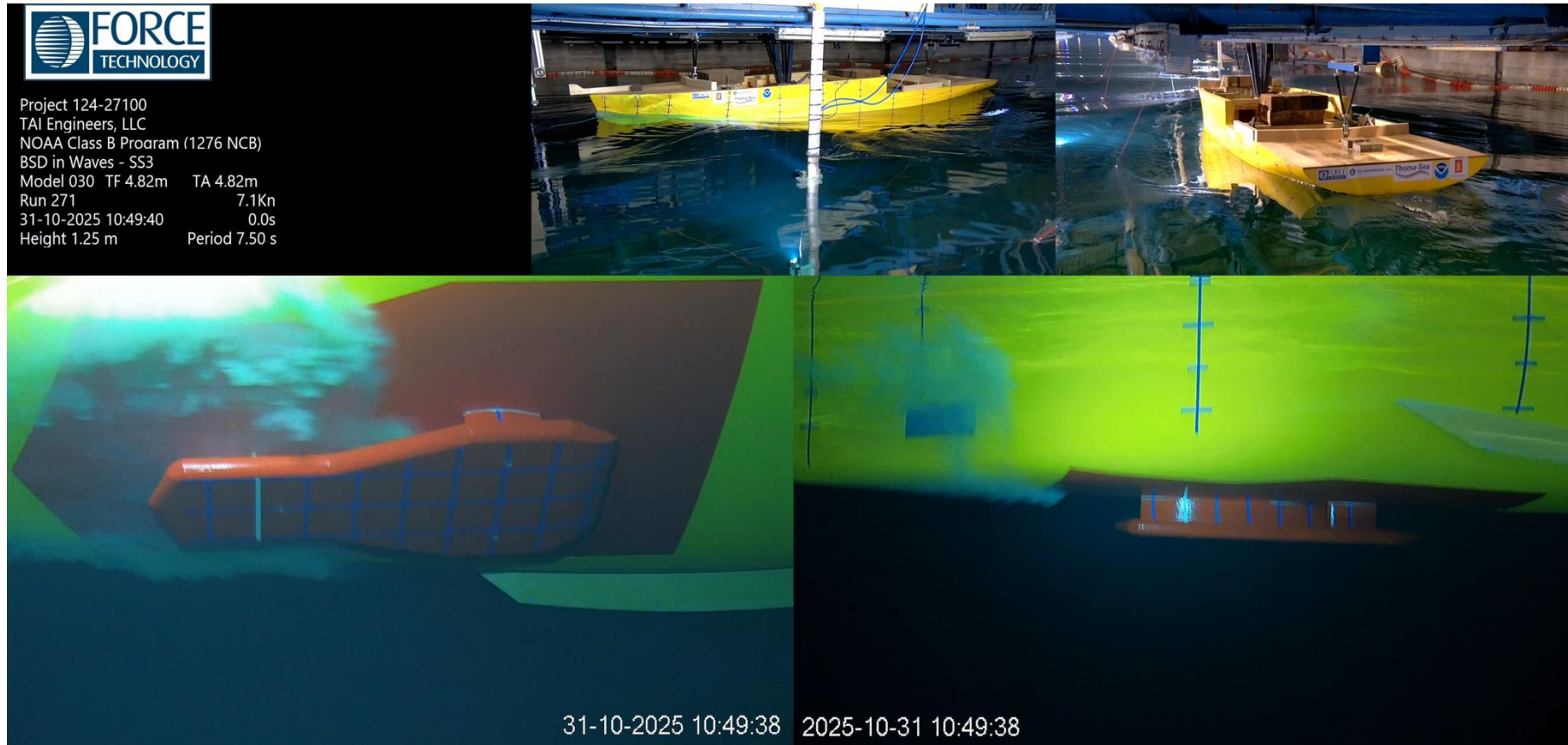
The Solution

Phase 4 Model Tank Testing



The Solution

Phase 4 Model Tank Testing



The Solution

Phase 4 Model Tank Testing

- SS3, 6 knots
 - Team observed potential streamlines in way of gondola





The Solution

Phase 5 Open Water Test/Cavitation



- Goal (initial) – Conduct on the gondola solution for other ship design impacts
- Goal (revised) – Additional propeller runs
- Rationale – Additional assurance that other impacts are accounted
- Results – Model testing validated the propeller avoids cavitation at max survey speed of 10 kts
- Conducted at HSVA

The Solution

Phase 5 Open Water Test/Cavitation

- Short set back
 - Pretest data showed variance in the propellers
 - Cause: malfunction in electrical connection.
 - Reconditioned and retested



The Solution

Phase 5 Open Water Test/Cavitation



The Solution

Phase 5 Open Water Test/Cavitation



Without strobe



With strobe

The Solution

Phase 5 Open Water Test/Cavitation



- Engineering to forward compartments
 - Auxiliary Machinery Room (AMR)
 - Transducer Room...gone
 - Stairwells, passageways etc
- Change to the build sequence
 - Midship → Forward to Midship ← Aft
- Disruption to the progress of the 3D modeling
- TMC worked diligently with NOAA to mitigate further impacts to cost and schedule

Lessons Learned

- Single phase acquisition
 - What did we gain or lose?
- Hull form versus contractor design versus parent design
- Use of advanced simulations
- Importance of simulating sea states for model testing
- Interesting phenomenon – hull form with gondola achieve better performance by going **faster**



Thank you, FEMME!