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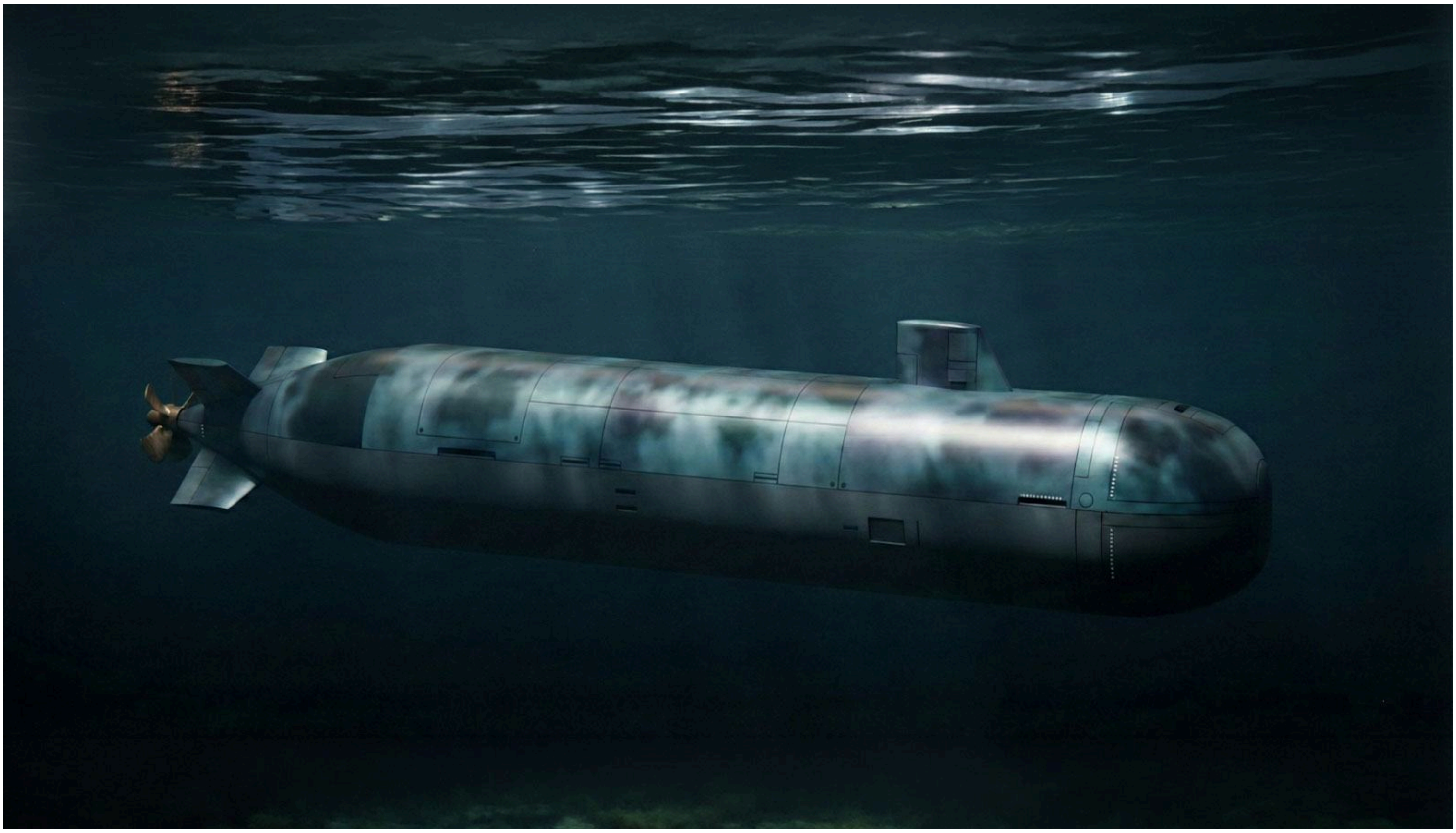
SHIFT-Submarine

# AI for Rapid, Physics-Based Hydrodynamic Optimization

PROBLEM

Maritime defense contractors are under pressure to efficiently design and deliver modern submarines and next-generation Unmanned Underwater Vehicles (UUVs). This means balancing hydrodynamic performance with packaging constraints.

Traditional CFD simulation is slow and costly, limiting design space exploration and making CFD specialists a bottleneck. Instead Physics AI enables non-experts to directly explore hydrodynamic efficiency and performance, freeing up CFD engineers for in-depth analysis.



SOLUTION

**Shrink days of simulation to minutes of AI optimization.**

SHIFT-Submarine is a Physics AI model for submarine hydrodynamics to provide physics-based performance predictions in seconds. It allows engineering teams to rapidly evaluate thousands of design candidates — unlocking high-performance geometries that traditional workflows miss.

The value lies in using the inference model to perform an optimization loop. Treating the AI as the performance evaluator, analysts can rapidly explore the twenty-three geometric parameters defining the design space. This optimization framework queries the AI model thousands of times in minutes (a process that would take days with traditional CFD) — allowing for exceptional speed in achieving objectives, such as minimizing drag force, while maximizing volume.

The parameters are then used to automatically regenerate the best design, fundamentally accelerating early-stage design by quickly converging on optimal, constraint-respecting geometry.

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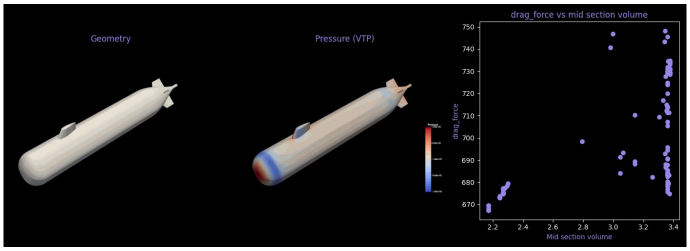
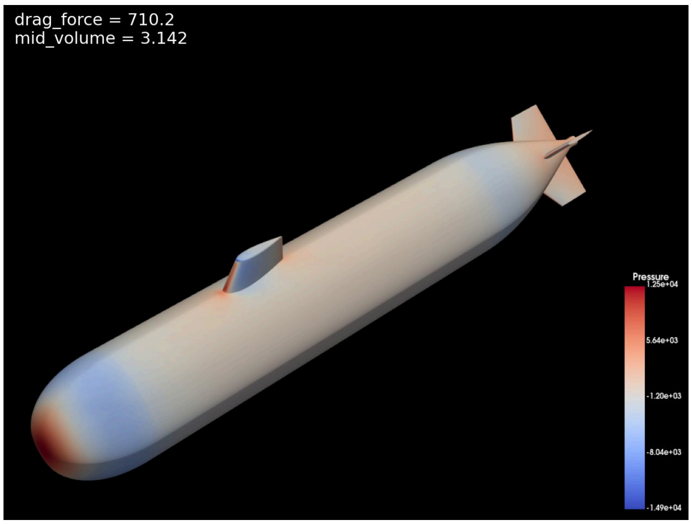
RESULTS

**AI optimized design reduces drag by 5% and increases volume by 7%.**

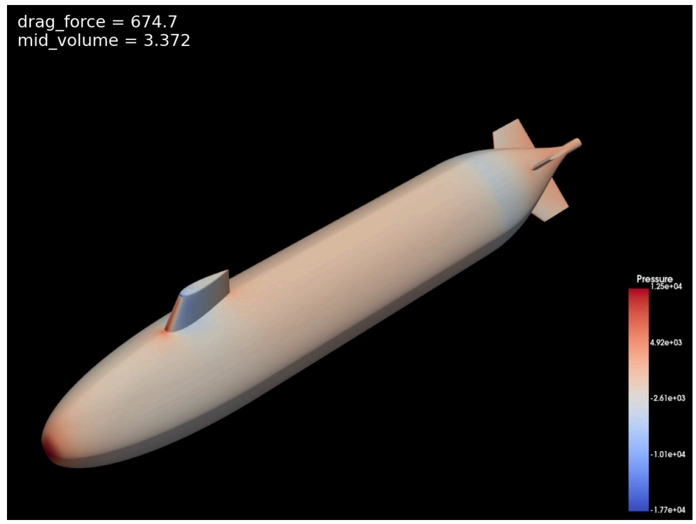



| Dataset | Drag Force (N) | Volume (m3) |
|---|---|---|
| Original | 710.2 | 3.142 |
| Optimized | 674.7 | 3.372 |
| % Improvement | 5% | 7% |

**Baseline design**




**Optimized design**

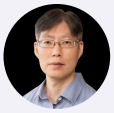



WHAT THE MODEL LEARNED

**AI model excels at predicting horse-shoe vortices off the sail.**

The SHIFT-Submarine model demonstrated that it learned meaningful physics by accurately predicting both wall shear stress (WSS) and complex flow structures. Specifically, it successfully captured basic hydrodynamic features like the high-pressure region at the front stagnation point and the lower pressure near the hull's aft taper. More importantly, the inference model excels at predicting the horse-shoe vortices off the sail and their interaction with the downstream wake, a highly complex flow feature critical to pressure distribution, drag, and downstream efficiency.

“Physics AI is the next level of complexity in AI, and Northrop Grumman is bringing this technology to our design engineers to dramatically speed up hardware development.”



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**Try the submarine prediction demo:**

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