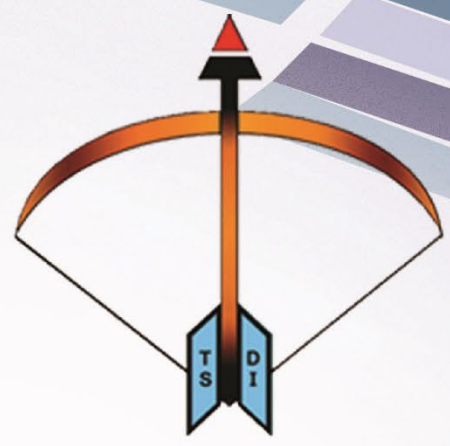




Temasek Defence Systems Institute

Modeling and Simulation-Based Assessment of Renewable Fuels for Unmanned Marine Vessels: A focus on Energy Density and Operational Effectiveness

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Background:

The Department of Navy (DON) is focusing on two critical strategies for future operations: addressing the urgent threat of climate change and developing unmanned systems to enhance national security in response to near-peer adversaries. The expected convergence of these two strategies cumulates in the emergence of a fleet of unmanned systems powered by alternative fuels.

Objective:

How can a capability be effectively developed, utilizing modeling and simulation, to assess the suitability of alternative fuels based on energy density for powering the Navy’s future fleet, ensuring operational feasibility and effectiveness in the context of future naval operations?

Key Findings:

Energy density is the most critical factor critical factor in evaluating the operational effectiveness of alternative fuels. The energy densities of alternative fuels reviewed in this thesis suggest they fall short of matching the operational effectiveness provided by diesel fuel. Therefore, attempts to achieve similar levels of operational effectiveness with alternative fuels are unlikely to succeed if their energy density remains insufficient, regardless of fleet size or infrastructure enhancements.

Potential Applications/Benefits:

This thesis offers military organizations a framework to assess the suitability of alternative fuels in meeting sustainability goals, enhancing strategic planning, and conducting cost-benefit analysis. For defense contractors, it provides insights into key fuel parameters, enabling informed decisions in product development and establishing baseline technical requirements to meet the operational needs of military clients.

MOE	Significant Factor		
	First Partition	Second Partition	Third Partition
SUSV Availability	Energy Density (≥ 1.839 kWh/L)	MUSV Engine Efficiency (≥ 0.128)	No of Fuel Pumps (≥ 3)
SUSV Average Mission Duration	Energy Density (≥ 5.959 kWh/L)	Energy Density (≥ 9.196 kWh/L)	SUSV Engine Efficiency (≥ 0.418)
MUSV Availability	Energy Density (≥ 4.487 kWh/L)	LUSV Engine Efficiency (≥ 0.356)	MUSV Engine Efficiency (≥ 0.130)
MUSV Average Mission Duration	Energy Density (≥ 2.133 kWh/L)	NA	NA
LUSV Availability	Energy Density (≥ 1.839 kWh/L)	Energy Density (≥ 5.076 kWh/L)	NA

Table 1. Summary of Partition Tree Analysis Results

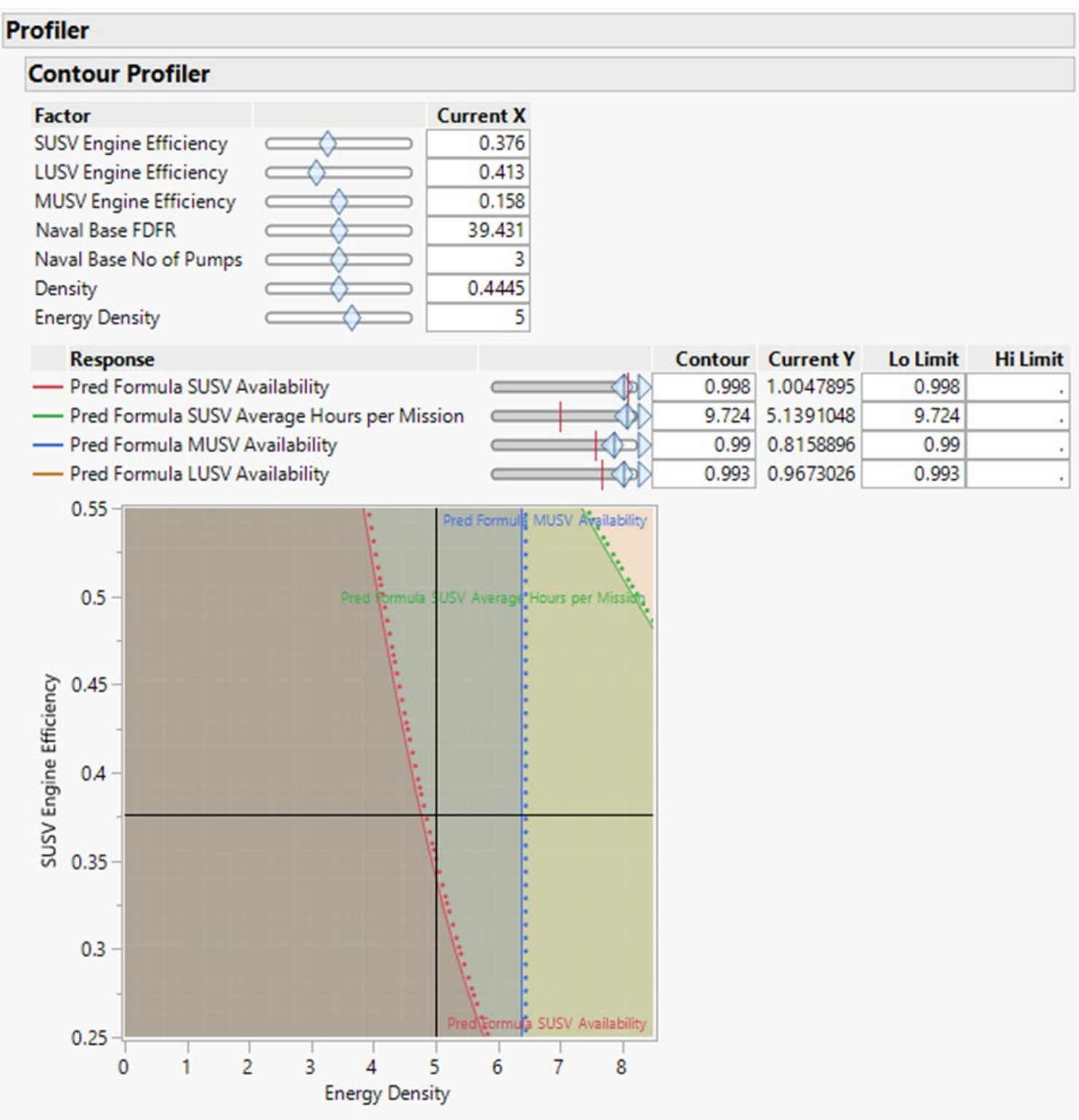


Figure 2. Combined Contour Plot with Median Input Parameters

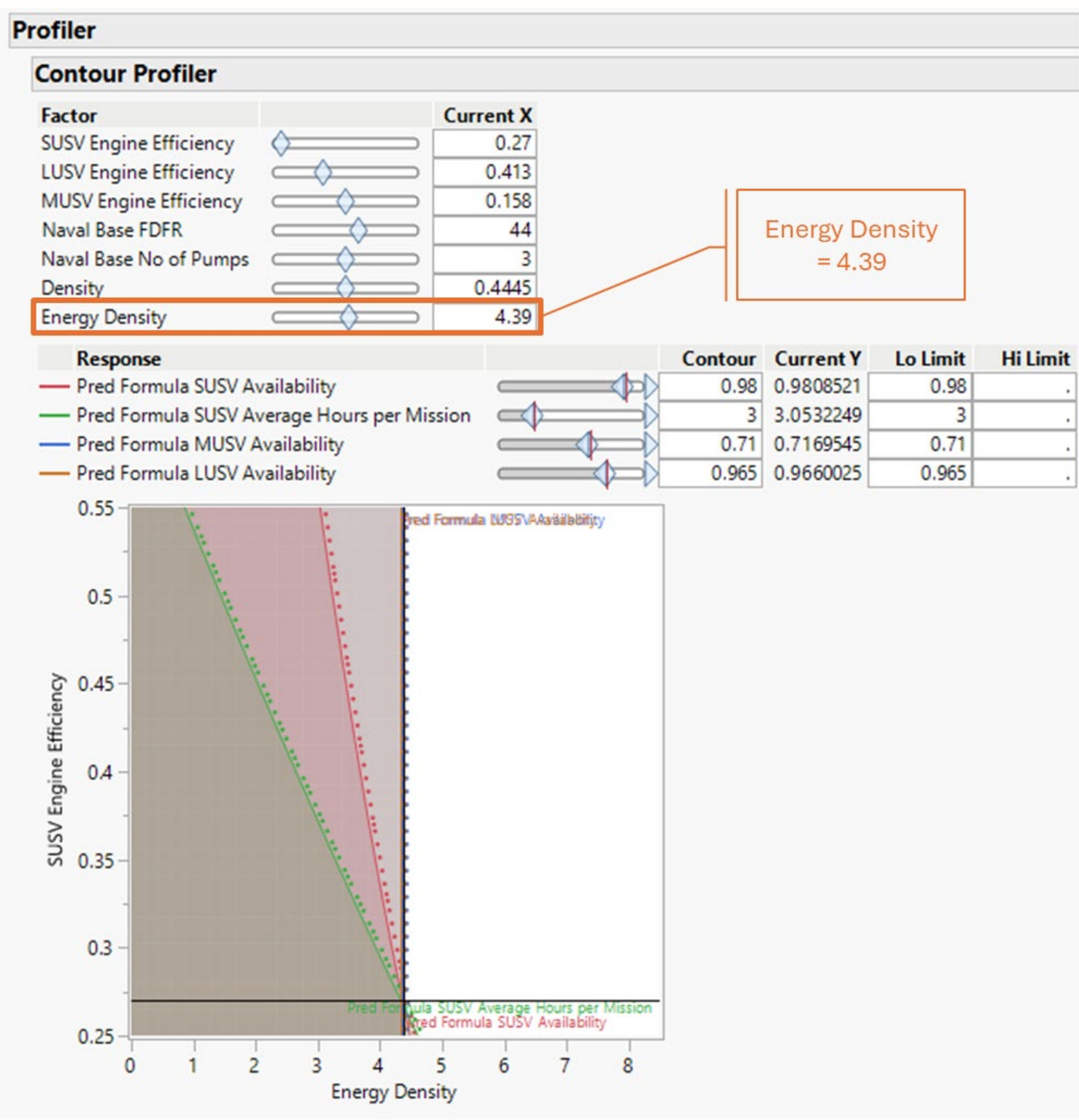


Figure 3. Contour Plot with Energy Density at 4.39 kWh/L

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