DDG FLT IIA ENDURANCE RANGE CONVERSION PROJECT

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DDG FLT IIA class ships have been completing essential missions for the US Navy since 2000. This class of ship has a current endurance range of about 4500 NM. The objective for this conversion project was to determine the feasibility of extending this range by approximately 60 percent, while keeping the maximum speed above 26 knots, and maintaining all other mission capabilities. With the DDG as the limiting factor in a strike group's endurance range, this improvement will greatly enhance the strike group's mission capability. Additionally, DDGs that are independent deployers will be able to remain in essential operational areas while also traveling greater distances prior to refueling.

The baseline ship used in this project is the U.S. Navy's DDG FLT IIA hull design. We were able to obtain the ASSET match model that has been previously validated by Naval Surface Warfare Center, Carderock Division (NSWCCD) and used this model as a reliable starting point for the conversion project. Throughout the conversion project the design team briefly explored the concepts of adding additional fuel tanks, propeller modification, engine conversion and reducing endurance speed to increase the endurance range. We considered the feasibility of each and ultimately decided that an engine conversion in addition to reducing the endurance speed to 16 knots was the best way to achieve this objective.

Various engine configurations and specific engines were considered in an in-depth evaluation of the tradespace. Rather than solely looking at the endurance range calculations, the design team concurrently analyzed the mission profile range, by referring to a studied time-speed profile of DDG FLT IIA class ships. The ship operates at speeds less than 10 knots for the majority of its underway time, so a Combined Diesel and Gas Turbine (CODOG) engine configuration consisting of a high-speed diesel engine (HSDE) and gas turbine engine allowed for more fuel-efficient loading conditions at these lower speeds, while still being able to reach the required maximum speed. The baseline ship consisted of four LM2500-30 gas turbine engines, so we decided to keep two of the baseline engines and replace the two inboard GTM modules with HSDEs. We researched many HSDEs to find the right combination of power, weight, and size. The selected CODOG arrangement features an LM2500-30 gas turbine and a Rolls Royce MTU 20V4000M93 HSDE for each shaft.

An extensive analysis of this configuration was completed; to include arrangements, weight changes, fuel efficiency and range calculations at both endurance speed and across the time-speed profile, and risks associated with the conversion. The MTU engines are smaller in all dimensions, and therefore there were no potential problems with equipment spacing. Together, they result in a net increase of 40 tons. The weight was added roughly centerline and low on the ship, which reduced KG by 0.03 meters, increased draft by .02 meters, and increased GM by .03 meters, which is all within an allowable range. Additional propulsion plant foundations and new resilient mounts are needed for the heavier and louder diesel engines. The main reduction gear (MRG) increased in size by approximately 5%. Backed by the advice of our project sponsors, it was determined that both the intake/exhaust systems, and necessary lube oil systems could be re-purposed from the original GTM to support the new HSDE. Below are the detailed drawings of one of the modified engine rooms.

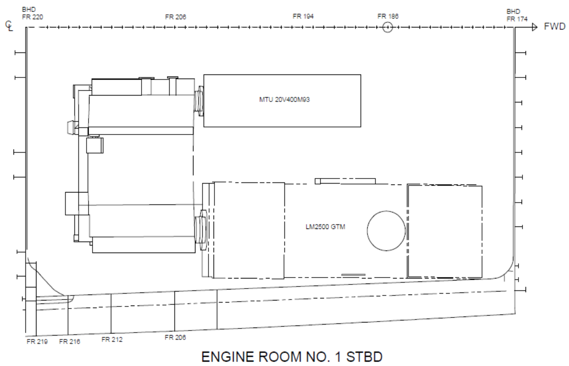

Figure 1. Engine Room #1 STBD

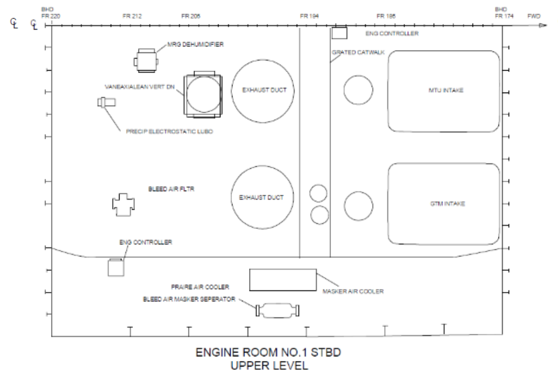

Figure 2. Engine Room #1 STBD Upper

The DDG's total resistance, required brake horsepower, and specific fuel consumption were used to calculate the endurance range at each speed. We recorded this endurance range at 16 knots and observed an increase of 3,500 NM compared to baseline. Endurance ranges were calculated for both split plant and trail shaft operations, with a 15% added resistance included when in trail shaft. To also provide mission profile range, the time at each speed was weighted based on the DDG time-speed profile. With the CODOG conversion, the endurance range of the DDG FLTIIA at 16 kts is 8000 NM, an increase of 75%, and the mission range increased by 2100 NM. The maximum speed dropped from greater than 30 knots to 28 knots, but still exceeds the resource sponsors requirement of 26 knots.

	Baseline	CODOG	Change
Endurance Range (NM)	4500 @ 20 kts (7000 @ 16 kts)	8000 @ 16 kts	+3500 (+1000)
Mission Range (NM)	5900	8000	+2100
Max Speed (kts)	>30	28	-2
Displacement (MT)	9400	9440	+40
Propulsion Weight (MT)	840	870	+30
KG (M)	7.57	7.54	-.03
GM (M)	1.28	1.31	+.03
Draft (M)	6.66	6.68	+.02

Table 1. Comparison of baseline to modified configuration characteristics

After an in-depth analysis, the design team concluded that a conversion of the ship's propulsion plant is an effective and feasible solution to the objective of increasing the range of the DDG FLT IIA. The team recommends a CODOG engine arrangement featuring one LM2500-30 GTM and one MTU 20V4000M93 HSDE per shaft. Risks associated with this conversion include CODOG reduction gear installation and operation, enhanced structural support and sound mounts for the diesels, and compatibility issues with existing auxiliary equipment.