



1. The AC traction motor can generate up to 6,000Nm of torque immediately for the propeller, and speed can be precisely controlled from 1rpm on the shaft up to maximum speed, providing unmatched response and control

2. Below deck arrangement on the Enhydra, Red and White Fleet's hybrid-electric passenger vessel

A powerful partnership

Maritime experts have shown that hybrid technology's use in marine applications is not only possible, but quickly becoming the future of the industry

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BAE Systems is partnering with leading operators, designers, and shipyards globally to deliver more-efficient and lower emission electric and hybrid-electric propulsion systems for the marine market. The latest project is the design and integration of the complete battery-electric hybrid system for a 700-capacity aluminum monohull passenger vessel for San Francisco's Red and White Fleet.

Currently in construction at All American Marine (AMM), based in Bellingham, Washington, is the soon to be christened M/V Enhydra, the 30ft (9.1m) molded beam vessel will be the first aluminum-hulled, lithium-ion battery-electric hybrid vessel under US Coast Guard Subchapter K passenger vessel regulations and the latest guidelines for structural fire protection.

BAE Systems will supply two HybriGen propulsion systems that include lithium-ion batteries, generators, power electronics, a control system and AC electric traction motors from its 2,000 system-strong production line.

Fully integrated by BAE Systems, the patented HybriGen provides the operator with a smart system that automatically delivers the exact amount of power to either the propellers or the ship's service loads (or both) from the most efficient source. It seamlessly shifts from all-electric to diesel-electric mode and back, based upon the power demand and the battery state of charge.

The HybriGen system uses all-electric battery operation when maneuvering at slower speeds and engages the variable-speed generators to augment the additional power demands of the traction motor when maneuvering at higher speeds.

Coupled directly with the propulsion shaft, each AC traction motor can generate

up to 6,000Nm of torque immediately for the propeller, and speed can be precisely controlled from 1rpm on the shaft up to maximum speed, providing unmatched response and control.

Each generator will mount to a variable-speed Cummins QSL9 diesel engine, developing 410hp at 2,100rpm. The generator mounts directly to the engine flywheel, extending the length of the engine by merely 6in (15cm) and additionally functioning as the starter.

Battery power will be incorporated from two 80kWh lithium-ion battery packs with Corvus Energy's next-generation Orca Energy batteries. Inherent in the Enhydra's design is the ability to expand the size of the batteries to reach complete zero-emissions operations in the future as charging infrastructure comes online. The battery system is able to meet any power demands of Enhydra while

the propulsion system provides a silent, emissions-free experience for recreational cruise experiences, like tours of the San Francisco Bay and the Golden Gate Bridge.

BAE Systems' propulsion technology has proved itself in nearly 10,000 systems operating across the globe in heavy-duty transit applications and in its acceptance by the US Coast Guard for use in inspected passenger vessels. Through two decades of hybrid- and all-electric propulsion experience, the many built-in failsafes and high level of redundancy are similarly in place in the company's marine installations, so that operators can be as confident in the system today and every day.

The Red and White Fleet chose BAE Systems' HybriGen system due to the on-road model's exponential advances in technology and user adaptation, which has provided an ideal bridge technology into marine

vessels. Enhydra can now move to all-electric mode while maintaining her geographic and range versatility.

All American Marine has seen that, now more than ever, customers are seeking new viable solutions that help reduce emissions, fuel consumption and operating costs.

Why it matters

Even with fuel prices hovering within the affordable range, vessel operators are looking for more efficient propulsion systems. Implementing hybrid technology is one of the best ways to achieve these goals without requiring substantial changes in infrastructure.

The Red and White Fleet has led the passenger vessel industry in repowering its fleet with EPA tiered engines well ahead of compliance dates, as well as researching and using alternative fuels such as natural gas and biodiesel.

BAE Systems' HybriGen system has lower engine operating hours than a conventional drive and requires less machinery, resulting in savings in both fuel consumption and maintenance costs. From this, the Red and White Fleet has furthered its environmental commitment while gaining an acceptable return on investment.

Furthermore, lithium-ion battery technology has exponentially improved in size, weight, energy density and safety factors.

By including plug-in charge capability, the Red and White Fleet anticipates further fuel and cost reductions by replacing onboard energy with renewable grid energy that is lower and more stably priced than diesel.

The Red and White Fleet has seen the electrification of transportation occurring rapidly, with real strides being made in the marine industry. With the Enhydra, Red and White Fleet has led the marine industry in the US toward further electrification using the proven, advanced technology of the HybriGen system. And now, BAE Systems and Red and White Fleet are proud to announce the next step in clean, marine technology with their latest project, the first zero-emission hydrogen fuel cell ferry in the world +



Images 2 and 3: Red and White Fleet

3. Guests on board Enhydra will be able to experience views of the bay and cityscape from each of the three decks