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ARTICLE

DE-RISKING SUBSEA SYSTEMS WITH LAND-BASED TESTING

Navies around the world are in the process of modernizing their submarine fleets, with some still operating designs launched in the 1970s. Since then, the electromagnetic environment of submarines has become significantly more complex, presenting challenges for designers looking to seamlessly integrate new electric power and propulsion technologies into first-in-class SSK boats. Full-scale land-based testing (FSLBT) is a method to de-risk systems before installation on platform, helping to cost-effectively prove interoperability ahead of sea trials.

Advanced systems, complex challenges

Increasing range, extending the submerged endurance, reducing the indiscretion ratio and lowering the signatures of SSK submarines are critical priorities for designers. Permanent magnet motors with high frequency variable speed drives, solid state power distribution and conversion architectures, advanced active batteries such as lithium ion, air independent propulsion systems and energy efficiency solutions are now favored technologies to achieve these aims. Likewise, variable speed controls and converters decouple equipment from the 60 Hz frequency, reducing signatures, underwater radiated noise and tonals for ultra-quiet running.

However, seamlessly integrating these technologies within a platform is challenging. As higher-performance power and propulsion systems become more complex, there is significant know-how required to understand system-level technology behaviors, interactions and risks. For example, stray capacitances and rotating earth faults are notoriously difficult to track down in these advanced architectures. With more equipment like power electronics running at different frequencies, assets may amplify each other, harmonics colluding to cause resonance. The low internal resistances of lithium-ion batteries can result in higher fault currents. In short, new technologies often present new challenges at a system integration level.

Add to this that the power and propulsion system will inevitably feature equipment from different suppliers - with off-the-shelf items often having little information available regarding electrical characteristics - and the integration challenge becomes even greater. Clearly, testing ahead of installation on platform is imperative for safeguarding project schedules, performance and budget. However, not all programs are equal.

Testing the limitations

Creating a simulation of the intended power and propulsion system can be a good starting point. However, developing a virtual model sophisticated enough to deliver meaningful results for specific factors is a major investment – so a trade-off must be considered between accuracy versus time and cost. Hardware in loop plugs real equipment into the simulation, allowing individual units or a simple system to be de-risked. This is not truly representative though, as load and source characteristics may differ operationally on-platform, with DC power system stability being a major challenge with more complex architecture.

Individual equipment lab testing focuses on de-risking at a product level which, while useful, often doesn't provide the system-scale perspective required by designers and integrators.



Fig.1 GE Vernova's Marine Power Test Facility (MPTF) offers a full-scale land-based testing (FSLBT) capability up to 20 MW.

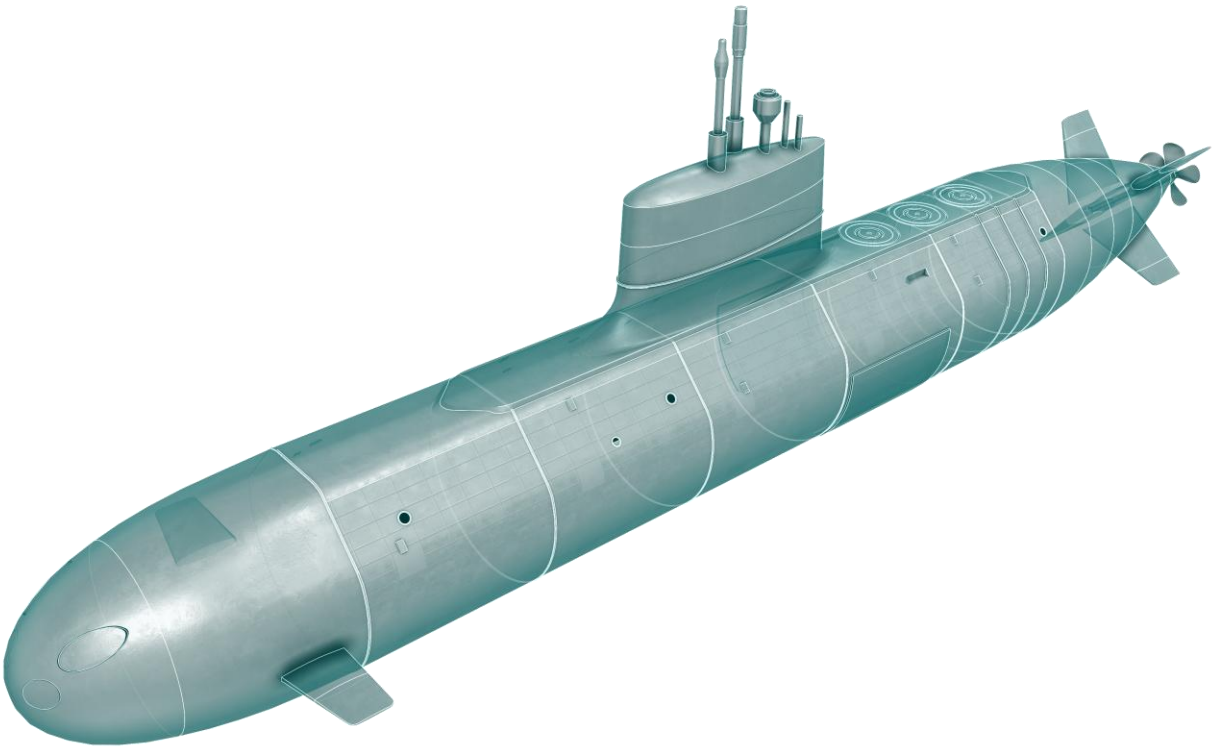


Fig.2 Effectively integrating multiple technologically advanced systems featuring equipment from different suppliers on SSK submarines (see above) is a challenge.

A lab-scale system test offers a better overview but is more suited to proof-of-concept rather than assessing a scaled-up, platform-ready system. Of further concern, it will not raise larger issues such as effects on quality of power supply, which can create a false sense of security.

Testing on platform provides the highest confidence that a power and propulsion system will function as intended, but as history has repeatedly shown, encountering serious issues at this stage can entail significant delays and costs. For submarines, this is compounded by the fact that cutting a hole in the pressure hull to access or remove equipment is not a practical option.

Ultimately, FSLBT offers the highest level of risk mitigation before testing on platform. By conducting integrated systems testing at a megawatt level on land, designers and integrators can help to eliminate surprises ahead of sea trials. Building early in this way also drives out broader integration risks that sometimes are not considered until later in a program, where the impact of change and applying lessons learnt can be costly. These may include safety, installation and commissioning, operability and maintenance processes, as well as deeper technical risks. The Marine Power Test Facility (MPTF) operated by GE Vernova's Power Conversion & Storage business demonstrates this approach.

System level testing and derisking

A unique, privately-owned test facility in the UK, for over 25 years the MPTF has provided full-scale electric power and propulsion testing for naval and commercial vessels. Along with subsea platforms, the facility has de-risked Queen Elizabeth-class aircraft carriers, Zumwalt-class destroyers, Type 26 frigates, Tide-class tankers, Thaon di Revel-class patrol vessels, Type 45 destroyers and more.

The site offers a wide range of testing capabilities. A 20MW programmable 'dynamic propellor' load can simulate different sea states and maneuvers. Integration of prime movers in a dedicated engine facility, prime mover dynamic emulators, ultra-capacitors and high-power supplies for battery emulation helps to verify a wide range of power system configurations. Controllable load banks and advanced dynamic load emulators simulate loads, while water-cooling systems and environmental conditions replicate the effects of limited cooling capacity or operations in high temperatures at a whole system level. A mix of proven architecture and a flexible backbone of controls, software, data acquisition systems and electromagnetic compatibility equipment is tailored to suit the needs of each platform and test program. Even cable types and lengths are often matched to the specifications of the intended platform, relative to the risks being addressed.

This representative testing can accurately identify problems regarding power quality, resonances, harmonics, volts to ground, common mode effects, earthing issues, control system behavior and faults well ahead of equipment being installed on platform. Therefore, integration and interoperability issues can be addressed before sea trials, greatly reducing the risk of additional costs and overruns.

First-class testing for first-in-class

As new classes of submarine leave the design phase, facilities such as GE Vernova's MPTF provide engineers, integrators and navies with testing optimized to prove the performance of complex electric power and propulsion systems. This allows new technologies to be inserted into platforms with less risk, supporting the latest innovations in SSK design, all while helping to safeguard the delivery of strategically important fleet modernization programs.

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