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No. 013/2013 dated 24 January 2013

Submarine Trends in Asia Pacific: Air-Independent Propulsion A Game Changer?

By Michael Raska

Synopsis

The contending strategic realities of the Asia-Pacific region compel states to adopt innovations of their rivals. This is the case for new classes of conventional submarine designs, which incorporate an array of innovative technologies in order to maximise their survivability and lethality in diverse maritime operations.

Commentary

WHILE EUROPE and North America remain key submarine markets, China's ongoing military modernisation coupled with contending international relations in the Asia-Pacific will increasingly drive submarine procurement in the region over the next decade. In 2011, the total submarine market in Asia-Pacific is estimated at US\$4.4 billion, and for the next decade, submarine expenditures are projected to US\$46 billion.

With changing strategic realities, Asian navies aim to become increasingly flexible, and capable of varying mission profiles: from countering traditional coastal defence missions to protecting sea lanes and communication lines. Simultaneously, submarines are increasingly valuable strategic resource for both electronic and signal intelligence. To enhance the varying operational capabilities, increase submerged endurance and stealth, installing viable Air-independent propulsion systems is thus becoming a strategic necessity.

Advantages of AIP systems

Designed to enhance the performance of modern conventional (diesel-electric) submarines AIP is a key emerging technology that essentially provides a "closed cycle" operation through a low-power electrical source supplementing the battery, which may extend the submarine's underwater endurance up to two weeks or more.

AIP systems close the endurance gap between nuclear and conventional submarines, and mitigate increasing risks of detection caused by advanced anti-submarine warfare technologies - from modern electro-optical systems and surface radars to magnetic sensors, active and passive sonars, and airborne surveillance radars. Advanced AIP technologies thus promise significant operational advantages and tactical flexibility.

In theory, there are four primary AIP designs currently available: (1) closed-cycle diesel engines; (2) closed-cycle steam turbines; (3) Stirling-cycle heat engines with external combustion, and (4) hydrogen-oxygen fuel

cells. Each provides a different solution with particular advantages as well as limitations in relation to performance, safety, and cost factors.

Since the early years of the Cold War, while major naval powers shifted to nuclear propulsion, smaller navies - particularly in Europe (Germany, Sweden, Spain, Italy and France) continued to develop and rely on conventional diesel-electric submarine fleets, given their lower cost and operational relevance for coastal defence. Traditionally, however, these submarines were highly vulnerable to various types of sensors - acoustic, visual, thermal and air - particularly when running on engines.

AIP systems in Asian navies

On the other hand, when running on batteries, these submarines became very quiet and difficult to detect, yet their battery capacity, discharge rate, and indiscretion rate (the ratio of diesel running time to total running time) substantially limited their underwater endurance. To overcome these baseline limitations, naval innovation in propulsion technologies over the past two decades has shifted toward AIP systems.

There is a variance, however, in the procurement of AIP systems in select Asian navies. For example, the only AIP steam-turbine system currently available is the French "MESMA" (Module d'Énergie Sous-Marine Autonome) module, operational on Pakistan Navy's two Agosta 90-B class submarines.

Swedish-Kockum designed Stirling AIP technology is installed on Singapore Navy's two Archer-class submarines, and Japan's new Soryu-class submarines. The Chinese PLA Navy's Type 041 Yuan and Type 043 Qing class submarines are also reportedly using Stirling technology. Meanwhile, the Republic of Korea Navy has ordered nine Type 214 submarines with German HDW AIP fuel cell technologies. Three first batch models of the new Son Won-II class had entered service since 2007, and six second batch models will enter service from 2012.

Limitations and constraints

Notwithstanding the diverse AIP technologies, the overall effectiveness of each system will depend on how well it is integrated with other critical systems that ensure optimal submarine functions: power systems, sensors systems, safety systems, navigation systems, command, control, and communication systems, weapons systems, and climate control systems. In this context, any critical failure of an AIP during a combat mission or contested areas will mitigate survivability factors as well as tactical options.

Indeed, each AIP system design comes with an array of technological limitations, vulnerabilities, and risks, particularly in submerged operations – from the specific acoustic signatures produced by select AIP systems in specific operating regimes, to technical vulnerabilities in storing oxidizer/fuel, as well as their maintenance regime. At the same time, new anti-submarine warfare sensor technologies may provide viable AIP countermeasures.

Ultimately, AIP-related technological innovation and breakthroughs may not guarantee operational success – strategy, operational concepts, tactical development, leadership, training, and morale will continue to play as important role as emerging technologies and their operational capabilities.

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