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Diesel Submarine Support to SOF

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NPS NRP Executive Summary

AIP Diesel-Electric Submarine Support for Special Operation Forces

Period of Performance: 07/01/2019 – 09/30/2020

Report Date: 04/02/2021 | Project Number: NPS-19-N062-A

Naval Postgraduate School, Graduate School of Defense Management (GSDM)

NAVAL RESEARCH PROGRAM

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

AIP DIESEL-ELECTRIC SUBMARINE SUPPORT FOR SPECIAL OPERATION FORCES

EXECUTIVE SUMMARY

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Student Participation: No students participated in this research project.

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Project Summary

Covertly inserting special forces for clandestine operations is an essential capability for U.S. Special Operations Command (USSOCOM). Naval Special Warfare (NSW) currently has the Mk-8 Mod-1 Sea, Air and Land Forces (SEAL) Delivery Vehicle (SDV) and the Mk-11 SDV for these insertions. These are wet combat submersibles with limited depth and duration, which exposes their occupants to the sea elements. They also require a large host submarine to launch, with a dry deck shelter installed. The Navy fulfills this mission currently by using existing nuclear submarine, which are always tasked with a broad spectrum of essential missions. NSW is in the process of acquiring the Dry Combat Submersible (DCS) Block I, a surface-launched submersible platform with program costs projected around $350M. NSW is also interested in developing DCS Block II with much greater projected program costs. The logistics burden associated with combat submersibles is substantial since they are not meant to operate of long periods of time independently.

The US Navy's nuclear-powered submarines are the envy of many nations. While our submarine force is technologically advanced, it is also very expensive to maintain. Given the current budgetary constraints it is unlikely that the nuclear submarine fleet can be augmented to fulfill USSOCOM needs, and the diesel-powered subs could have a role in an important niche at a low cost. The limited availability of submarines to support Special Operations Force (SOF), the potential to save limited federal funds, and to improve capabilities through quiet, shallow-water nimble submarines, motivate this review of potential diesel-electric submarine contribution to undersea clandestine insertion.

A few allied nations operate modern diesel-electric submarines enhanced with air-independent propulsion (AIP) technologies. AIP diesel-electric submarine cost less to acquire and operate, and they can add an important capability while bolstering total undersea asset availability. They are typically less expensive and quieter than nuclear submarines, but with shorter endurance; in turn, allied fleets are good benchmarks to estimate the capabilities of modern non-nuclear submarines. In assessing the potential application of AIP technologies in support of SOF operations, we participated in the 2019 undersea warfare conference, interviewed USW subject matter experts, reviewed intelligence data on foreign made submarines, interviewed AIP submarine manufacturers in Germany and Sweden, and reviewed archival data and previous studies. While the preponderance of this study was classified, this Executive Summary provides an overview of our study. Stakeholders in the Special Forces community should consider reading the classified report available in the Defense Technical Information Center archives.

Keywords: U.S. Special Operations Forces (SOF), clandestine operations, diesel-electric submarines, air-independent propulsion (AIP), Naval Special Warfare Command (NSWC), Sea, Air and Land Forces (SEAL), thyssenkrupp Marine Systems (tkMS), Saab-Kochums

Background
Submarines constitute a significant advantage in stealth naval battles. However, the duration the earliest submarines could remain under water was limited by the amount of air available for the crew and for the internal combustion engine. To maximize their ability to operate under water, nuclear propulsion was developed in the United States. The USS Nautilus was commissioned in 1954, which marked the US Navy's inevitable switch to nuclear powered submarines. The last diesel-electric American submarine, the USS Bonefish, was commissioned in 1959 and the US Navy never looked back. The increase in endurance was dramatic: diesel electric submarines at the time had the endurance of less than 2 hours at 3 knots underwater. For the Nautilus and the nuclear submarines that followed, endurance was no longer a submarine limitation.

Although the US Navy moved away from diesel electric propulsion for submarines, other navies could not afford nuclear innovation, so diesel electric propulsion systems for submarines have continued to evolve in many ways. The basic diesel-electric system design includes one or more diesel generators used to charge electric batteries and an electric motor connected to the propeller shaft, powered by those batteries. In order to generate electricity, the diesel generator requires access to air (to burn the diesel) and an exhaust system. To get air, the submarines need to surface, which defeats the objective of operating undetected. When the batteries discharge, the submarine needs to snorkel or to come to the surface to operate the diesel generator that will recharge the battery. Considering the frequent cycle of charge-discharge the batteries, to remain undetected, diesel-electric submarines depend on the efficiency and capacity of the batteries installed. Therefore, this propulsion system presents two opportunities for improvement: the development of more efficient batteries and the development of an air-independent system to charge the batteries.

We focus on the second opportunity, the use of air-independent propulsion, which defines any system to charge batteries where the submarine does not surface. The United States Navy uses nuclear power as the only air-independent solution for its submarines, but the leading AIP solutions in other navies include fuel cell, adopted by thyssenkrupp Marine Systems (tkMS) in Germany, and Stirling system, adopted by Saab-Kochums in Sweden: they are the backbone of AIP diesel-electric submarines. The endurance of the fuel cell is constrained by the amount of hydrogen in storage, and the endurance of the Stirling system is constrained by the amount of liquid oxygen it can carry. These technologies enable stealthy mobility for several days at low speed, which could facilitate clandestine operations in shallow waters.

Some commentators have addressed the possibility of the US Navy adopting this technology (Farley, 2018). Considering the limited availability of the aging Ohio-class cruise missile submarines – the host submarine of choice to launch SDVs – the SOF community would benefit from an evaluation of the capabilities that diesel-electric submarines could offer. In addition, diesel-electric submarines require less draft than nuclear submarines and have better maneuverability in coastal waters. Our study focused on the capabilities provided by the aforementioned submarines builders.

Findings and Conclusions

Our approach to this study focused on three aspects: (1) to understand Naval Special warfare (NSW) overall mission capability requirements, (2) to evaluate current capability gaps considering operational frequency and ability to execute them, and (3) to evaluate capabilities of existing AIP diesel-electric submarines and limitations for SOF use. In order to achieve that, we participated in the 2019 undersea warfare conference, we interviewed USW subject matter experts, reviewed intelligence data on foreign made submarines, interviewed AIP submarine manufacturers in Germany and Sweden, and reviewed archival data and previous studies. Detailed discussion of NSW operations appears in the classified report. Here, we overview the main AIP submarines used by allied navies. Worldwide, over 20 navies operate approximately 100 conventional submarines that were built using tkMS technology. Among them, 29 submarines incorporate AIP technology. For a few navies, notably those of Italy, South Korea and Turkey, the submarines are assembled locally using tkMS system components.

tkMS type 212A is the hull design with integrated air-independent system, which has been offered since late 1990's. Ten units are currently operated by the German and Italian navies. The boat is operated with a small crew of 28 sailors, as they incorporate fully automated Engineering Monitoring and Control System (EMCS) to ensure safe driving at all speeds and in all operating conditions, by controlling and monitoring 50 different sets of equipment and installations in the ship's operating system. In addition, tkMS submarines have the ability to dive 300+ meters (1000ft) and have an AIP endurance for several weeks submerged. The type 212A also has reduced signature (noise, magnetism, radar reflection, infrared) in addition to a water pressure torpedo expulsion system. This system provides two significant benefits: it allows release of the torpedoes in shallow water, and the torpedo engages its engine only after it is away from the submarine, which reduces the ability to identify the torpedo's source. The boat measures 57 meters (187 ft) with 1500 tons of displacement and the pressure hull is built with non-magnetic steel. The class 212A submarine may be fitted with a lightweight guided missile, the Interactive Defense and Attack System, a multi-purpose weapon system that enables the submerged cruising submarine to engage airborne, surface and coastal targets.

Likewise, Swedish shipyard Saab-Kochums is in its third generation of AIP diesel-electric submarines, the Blekinge class. They use a Stirling system to provide low power range and high energy density at patrol speeds. The battery provides sprint speed capability, the diesel engine generation system allows both rapid recharge at sea and during long range relocation while snorkeling. Although the AIP system mode provides low speed, it allows for lengthy submergence, only limited by the amount of liquid oxygen in storage. The heat generated in a Stirling engine is produced in a separate combustion chamber and transferred to the engine's working gas, operating in a completely closed system. The working gas forces the pistons in the engine to move, thus producing mechanical energy.

The Blekinge class modular design allows building submarines of different sizes and endurance using the same hull diameter. It includes three variants: the Pelagic (1500 tons), Oceanic (2000 tons) and Oceanic ER (up to 3500 tons). The Blekinge class underwent tests for Special Operations, optimized for ultra-silent operations. It is fitted with a flexible payload lock capable of holding overpressure, which enables prolonged decompression times without limiting dive depth. Kochums Blekinge submarines have the ability to dive 200+ meters (650 feet) with AIP endurance of 18+ days in patrol speed.

Recommendations for Further Research

To insert Special Forces operators within short distances from shore. air-independent propulsion (AIP) diesel-electric submarines provide the unique capability of operating undetected in shallow waters. This allows much greater proximity to the shore, reducing the time and distance that operators are exposed to the elements. Alternative capabilities available to US Special Operation Forces (SOF) require greater exposure potentially reducing the viability of some missions. Further study is necessary to evaluate the development of a community of Special Forces Submariners to support this weapon system.

References

Farley, Robert (2018, October 29). Question for the Navy: Is it time to build stealth 'AIP' submarines? *The National Interest* https://nationalinterest.org/blog/buzz/question-navy-it-time-build-stealth-aip-submarines-34557

Acronyms

AIP	air-independent propulsion
NSWC	Naval Special Warfare Command
SEAL	Sea, Air and Land Forces
tkMS	thyssenkrupp Marine Systems
USSOCOM	U.S. Special Operations Command
SOF	U.S. Special Operations Forces