Crossing Enemy Lines – The Growing Demand for Submersible Technology

***Abstract**: In several recent procurement specifications for submersible equipment, U.S. Special Operations Command (USSOCOM) has increased the operating depth requirement from the 1-10 meter range, to 20 meters (66 feet) [(1)]. While no specific reasons have been stated – at least not in unclassified sources – it may be reasonably assumed that this is in response to improved technology and wider deployment of underwater intrusion detection systems by our potential enemies. The requirement particularly affects equipment components that are directly exposed to water; not those that are contained in watertight enclosures themselves certified for operation at 20 meters depth or greater. This paper examines USSOCOM's emerging requirements for new and updated submersible equipment, with a focus on the factors that qualify such equipment for operation in combat environments. Specifically, it addresses the components most often considered the weakest link – namely, electrical cable connectors. Typically, significant changes in military equipment requirements such as this spawn innovation in the private sector. So the paper concludes by reviewing the types of equipment for which the 20-meter submersible capability may soon become standard.*

Underwater Intrusion

"One night in November 2003, beneath the moon-washed waters off Somalia's northern coast, a small, dark shadow slipped away from the attack submarine Dallas and headed toward the shore.

The smaller shape was a 21-foot-long submersible called a SEAL delivery vehicle.

Launched from a tubular dry deck shelter on the sub and designed to infiltrate Navy SEALs on covert or clandestine missions, the SDV carries its crew and passengers exposed to the water, breathing from their scuba gear or the vehicle's compressed air supply. Aboard were a handful of SEALs on a top-secret special reconnaissance mission into a country with which the U.S. was technically not at war.

The SEALs grounded the SDV on the ocean bottom and pushed away from it, taking with them the centerpiece of their mission, a specially disguised high-tech camera called a Cardinal device.

Unbeknownst to them, during the previous 24 hours, their mission had been the subject of Cabinet-level debate in Washington and had almost been canceled until President George W. Bush gave the go-ahead.

Now they were conducting what a special operations source with firsthand knowledge of the operation referred to as "a long swim through some of the most shark-infested waters in the world" toward the coastline

that loomed ominously ahead of them. The hard part was just beginning." (Excerpt from Navy Times, Oct 30, 2011 – The Secret War: How U.S. hunted al-Qaida in Africa, by Sean D. Naylor – reprinted with permission)

This was one of several such SEAL missions conducted around the Horn of Africa at that time. Their extraordinary training and meticulous planning – hallmarks of the Navy's SEAL teams – enabled them to carry out these daring intrusions without detection. Critical to their success was, and is, the reliability of their equipment. SEAL teams are trained to operate in extreme conditions, from blistering tropical heat to frigid arctic cold. The equipment they use must be equally capable of operation in conditions that would cause failure in almost any COTS (Commercial Off-The- Shelf) equipment.
In this era of counter-terrorism, the need for small teams of Special Operations warfighters is continually increasing. To stay a step ahead of the enemy, these forces must be equipped with the best and most durable equipment that today's technology can offer. Recognizing this, many recent USSOCOM Requests for Proposals for submersible equipment now require operational capability at a depth of 20 meters, a substantial increase from the 1 meter requirement prevailing as recently as five years ago. As we shall see later, this increased operating depth requirement implies other essential characteristics, such as the ability to withstand much greater surface pressure.

Evolution of the SDV

SEAL missions frequently involve infiltrating enemy lines through coastal waters, using their well-known SEAL Delivery Vehicles (SDVs). Unlike full-sized submarines, the SDV is a 'wet' submersible vehicle capable of carrying up to six SEALS (Figure 1). The occupants are seated in an open cockpit, wearing their diving gear and ready for immediate action upon arrival at their destination. While in the vehicle, they are able to breathe from either an on-board compressed air supply or from their own air tanks.

Figure 1. SEAL Delivery Vehicle Mark 8 Mod 1

The history of the SDV can be traced back to the Second World War, with *ad hoc* development by various naval units occurring on an 'as needed' basis, in the post-war years. The official SDV program however, was not launched until 1975. Since its inception, the vehicle has undergone numerous revisions, with the latest being the Mark 8 Mod 1. A key difference between it and its predecessor, the Mark 8 Mod 0, is the materials from which each is built. The earlier vehicle used an Aluminum alloy body while the Mod 1 is built with glass fiber reinforced plastic, making it less visible to radar and sonar detection systems. The importance of stealth characteristics was summed-up by Rear Admiral Edward Winters, former commander of Naval Special Warfare Command: "You're talking about an environment today where it's harder to sneak up on anybody's coast" – due to the widespread deployment by our foes of high-tech sensors both on land and at sea.

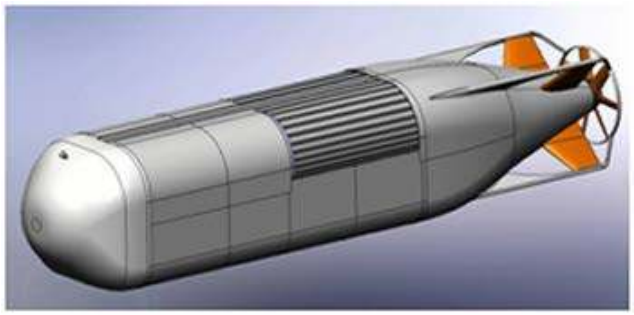

Figure 2. Possible concept drawing of SWCS[3]

In 2009, USSOCOM renewed its interest in underwater operational capabilities with the announcement of the Shallow Water Combat Submersible (SWCS) program, allocating an estimated budget of $530 million over a nine-year period [2]. The SWCS (Figure 2) is scheduled to go into service in 2017. It will replace the current SDV Mark 8 Mod 1.

Assessing operational characteristics of SEAL equipment

In addition to increasing the range from which the SEALs can initiate their missions, the SDV allows them to carry more equipment than they could otherwise take with them. The actual equipment they might utilize is classified, but some likely items include weapons and munitions, navigation and communications devices, surveillance equipment, battery-powered tools, positioning and measuring devices, and perhaps even medical instruments for search and rescue missions.

Along with introduction of the SWCS, USSOCOM has recently issued several broad technology RFQs for equipment that will have top-secret status. It is certainly reasonable to assume that a diverse range of 20-meter submersible devices would be included on their shopping list!

While some of this equipment may be entirely self-contained and watertight, it is likely that much of it will comprise multiple units interconnected via external low-voltage electrical cables, such as those used for data transfer. If these I/O cables themselves contain connectors, then those connectors must meet stringent performance standards to avoid being a dangerously weak link in the system.

In many commercial systems, cable connectors are the most significant points of failure, particularly over prolonged periods of time. Such single points of failure are unacceptable in the extreme conditions under which SEALs operate. At a depth of 20 meters, the ambient pressure is three times greater than the atmospheric pressure at sea-level. This means that submersible equipment, and in particular the seals that give the equipment its watertight property, must be designed to withstand the higher pressure over prolonged periods of submersion.

This is just one of the parameters by which the operational characteristics of submersible equipment can be measured. This and others, along with relevant standards, include:

- Water protection – International Protection rating IP68 (as defined in international standard IEC 60529). The '6' indicates a completely dustproof seal, while the '8' indicates waterproof at depths greater than 1 meter. No specific standards exist for greater depths.

- Temperature – Ocean temperatures decrease with depth, but the difference in temperature between the surface and 20 meters is not significant. More important is the actual location, since water temperatures can vary between -2°C in polar regions and +36°C in tropical regions.
- Corrosion resistance – The dissolved salts in sea water, primarily sodium chloride, have a corrosive effect on metals and rubber compounds over prolonged exposure. The ASTM G52 standard provides the procedure for evaluating corrosion resistance in sea water.
- Electromagnetic Interference shielding – Critical data passing through the shielded cable must be immune to external sources of Electromagnetic Interference (MIL-STD-464A). Conversely, the shielding must prevent signal transmission from the cable, since any such leakage might be detected by the enemy (MIL-STD-461F) [(4)].

When evaluating cable connectors specifically, other factors must also be considered. These include:

- Ease of physical mating and separation
- Maximum number of mating cycles without failure, and
- Diversity of electrical interface standards supported

As one might expect, there are numerous Military Specifications (MIL-SPECs) covering a wide range of electrical connectors [(5)], and there are several companies that offer connectors designed to meet these specifications. Smaller companies in the field focus on specific niche markets, producing a subset of the MIL-SPEC connectors. Larger companies offer comprehensive ranges of connectors, capable of meeting the majority of military equipment needs.

Figure 3. Example of 20-meter submersible connector from ODU

One company in particular, ODU, has focused on meeting these requirements for some of their submersible connectors capable of operating at the 20 meter depth discussed in this paper (Figure 3)[(6)]. The durability and reliability of ODU connectors are battlefield tested. According to the journal Defense Review, ODU right-angle connectors were used in the Atlantic Signal Dominator headsets worn by members of SEAL Team 6 during several of their top missions.

The Broader Market for Submersible Equipment

Although the Navy SEALS have a history spanning back to 1962, many of the missions they carry out today simply would not have been possible in past decades. The technologies essential to the equipment they use today, did not exist – digital cameras, GPS tracking, micro-miniature electronics and computers, lithium-ion batteries, nanotechnology, panoramic night-vision goggles, and many more.

Some of the modern electronic equipment carried by SEALS is self-contained, requiring no external cables and hence no exposed electrical connectors. However, in today's data-centric world, connectivity is fast becoming a pre-requisite. Night-vision goggles and a headset connected to a secure tactical radio could, for example, allow remote visual and audio monitoring of every move each SEAL makes, the data being transmitted in real-time to skilled navy personnel aboard the host submarine – a second set of eyes and ears to assist the SEAL if necessary. The same audio/visual data would also be recorded for use in future mission simulations and training exercises.

Currently, there are very few 20-meter submersible products available that would be suitable for such an application. Examples of those that do exist include the:

- Harris RF-5800M-HH Multiband Tactical Handheld Radio [(7)]
- HTMI AN/PAS-23 Mini Thermal Monocular [(8)]
- Atlantic Signal MH180-H-AA Tactical Headset [(9)]

The lack of such products opens the door for innovation. When new opportunities emerge as a result of military RFQ's, industry suppliers typically respond with a range of products that go beyond just a single model designed to meet the military requirement. There's a good reason for this: In the past, government procurement budgets often included funds for development of new types of products, as well as for the subsequent purchases, no matter how large or small the product. However, with today's economic climate and budget constraints, military RFQ's for smaller or less specialized items place the development costs back in the hands of would-be suppliers. In most cases, suppliers are not willing to take the risk of developing a new product at their own cost, knowing that they might not win the military business. By developing a range of products to meet both military and commercial needs, suppliers lower their risk exposure.

Communications and surveillance devices such as the three mentioned above are examples of products for which a 20-meter submersible capability is, or may soon be, required. Other potential categories of interest to the SEALS likely include handheld computing devices (tablets and pads), miniaturized cameras, short-range underwater drones, navigation and GPS devices, tools, medical devices and, of course, weaponry.

Conclusion

The equipment technology available for today's covert operations far exceeds that available to past generations of SEALS. Nonetheless, the basic challenges presented by their underwater environment remain. No matter how powerful the electronics nor how small the products are, they must still be adequately protected against the 3G water pressure in which they may be immersed for long periods of time. Solid casings made from materials such as carbon fiber, titanium or synthetic rubber compounds provide solutions for protecting complete devices, but the solutions available for protecting the cables required to interconnect the devices are more limited. Companies such as ODU are leading the way in providing cable connector solutions for the emerging 20-meter submersibility requirement.

References

(1) *Example from FedBizOpps.gov: Solicitation Number: H92244-14-T-0141 for 20 meter submersible headset*
https://www.fbo.gov/?s=opportunity&mode=form&id=d1462b37e4078b8521076e258b88b0d7&tab=core&_cview=0

(2) *Shallow Water Combat Submersible (SWCS)*
http://www.globalsecurity.org/military/systems/ship/swcs.htm

(3) *Covert Shores: "US Navy SEALs next generation SDV Mk XI (SWCS)", April 8, 2015, by H. I. Sutton*
http://www.hisutton.com/US Navy SEALs next generation SDV Mk.XI (SWCS).html

(4) *Electromagnetic Compatibility (EMC) Requirements for Military and Commercial Equipment*
http://www.dtic.mil/dtic/tr/fulltext/u2/a509335.pdf

(5) *U.S. Military connector specifications. (2015, January 10). In Wikipedia, The Free Encyclopedia. Retrieved 06:14, April 22, 2015, from http://en.wikipedia.org/w/index.php?title=U.S._Military_connector_specifications&oldid=641854875*

(6) *ODU Advanced Military Connectors*
http://www.odu-usa.com/products-solutions/push-pull-circular-connectors/odu-amc.html

(7) *Harris RF-5800M-HH Multiband Tactical Handheld Radio*
http://rf.harris.com/capabilities/tactical-radios-networking/rf-5800m-hh.asp

(8) *HTMI AN/PAS-23 Mini Thermal Monocular*
http://www.ir-city.com/buy/mini-thermal-monocular/

(9) *Atlantic Signal MH180-H-AA Tactical Headset*
http://www.defcon.com.au/partners/atlantic-signal/AmphibiousAssaultHeadsetBrochure_DT.pdf