Hide and Seek:

At Sea

Warfare has always been about signatures: finding your enemy's, and controlling yours. Whether that be a visual signature, heat signature, radar signature, or another kind – if you can't find the enemy, you can't defeat them. And if you can't hide, you may, in turn, be seen and defeated.

This age-old game of 'hide and seek' remains fundamentally the same, but the onset of the Information Age has altered its dynamics – multiplying the number of challenges and opportunities around detection. New technologies, open source intelligence, and advanced sensors provide more defence and security information than ever before.

Detailed information is pieced together from networks of sensors stationed in multiple locations and operating on different parts of the EM spectrum – resulting in improved situational awareness. Better processing hardware coupled with improved AI algorithms can fuse raw data and analyse it to ultimately create actionable intelligence.

On the other side of the equation - materials science drives the development of systems that are almost entirely resistant to radar and infrared detection, and even ones that can even disguise themselves, chameleon-like, against their visual backdrop. Advances in passive sensing allow craft to detect enemies with greater accuracy, all without giving their positions away.

On the macro scale there is growing global instability, more sophisticated adversaries and an increasingly noisy electromagnetic backdrop. Hide and seek now happens on more fronts and in more ways than ever before – playing out in grey zone conflict, and the ever-evolving race between sensors and stealth technology.

The ability to network assets over the globe and ever-increasing satellite surveillance is creating near-real-time situational awareness of everything on and above the water. As a result, the last place to hide may be under the waves. Over a century ago, hiding and seeking at sea took a major turn after the advent of submarine warfare. In the ensuing decades, the nuclear-armed SSBN submarine has been a first choice for deterrence – a capability of colossal power that is effectively impossible to find.

Under an ocean is a good place to remain unseen. Not only is it vast, it's also noisy.

There is the biological noise (or 'biologics') created by creatures like shrimp, dolphins and whales. There is wind noise; surface disturbance created by the breakage of waves and air bubbles, along with low-frequency turbulence from tides and waves, and the sounds of breaking ice. And, of course, there is a range of man-made sounds – from fishing trawlers to oil drilling, communications between ships and sonar navigation. Sound propagation varies, depending on factors like salinity, temperature, and water density - creating quiet channels to hide.

All of this is ideal for those trying to avoid detection. And remaining undetected on the surface is more difficult, but not impossible. There's a difference between being detected and being classified. A warship may pass through a busy shipping strait, be spotted by a satellite, but never classified as a military vessel.

This is not new, but is more of a concern in the increasing grey zone of conflict that simmers just below the open threshold of war. Such uncertainty has been exploited to great affect by China's armed fishing militia – officially called the People's Armed Forces Maritime Militia (PAFMM). Though they certainly resemble fishing ships, they do things that fishing ships don't – such as lingering for weeks in a single, strategic spot in order to harass or block an adversary - not something that a 'real' fishing ship could afford to do. Their actions, repeated over decades has stripped away any plausible deniability as to the purpose of the boats, but it does lead to questions around the use (and abuse) of signatures in future grey zone conflict.

Now let's contrast a low-tech problem with a high-tech one. As with the land and air domains, the maritime space is seeing a move towards smaller, uncrewed systems. This necessitates a need for smaller, more capable sensors – especially in uncrewed underwater vehicles (UUVs). The underwater domain presents particular challenges – viewing conditions that become darker and murkier as depth increases, and the complex noise and clutter of the ocean environment.

Seeking at sea

Hydroacoustics and acoustic surveillance

Perhaps the most common example of sensing in the maritime space to date is acoustic sensing, in the form of sonar. It has been a mainstay of the maritime domain for over a century, but the technology continues to develop and new applications become viable on an ongoing basis.

Underwater acoustic sensor networks (UASNs) are growing in importance, seeing civil uses like ocean observation, climate monitoring, underwater device maintenance, the study of marine life and pollution detection. But they can also be used for strategic purposes.

For example, China has been installing acoustic sensors into the Mariana Trench, no mean feat considering the enormous water pressure to be found nearly seven miles below the ocean's surface. These sensors provide China with sensory capability near US-held Guam.

Elsewhere (and as first covered in QinetiQ TechWatch 6), researchers from the Massachusetts Institute of Technology (MIT) have developed an underwater positioning system powered by sound, which they have dubbed the 'Underwater Backscatter Localization' (UBL) system.

MIT describe UBL as a 'battery-free pinpointing system'. Instead of emitting an acoustic signal (and recording its reflections), UBL modulates signals reflected from its environment. It achieves this by using piezoelectric materials that generate an electric charge under mechanical stress; sound waves are one source of such stress.

Whilst using sound as its power source, the reflected, modulated signals provide researchers with positioning information – and at net-zero energy - making it incredibly stealthy. When fully developed, the team envisages that the system could become a key tool for marine conservationists, climate scientists, and the U.S Navy.

Quantum-enhanced detection

Electro optical (EO) sensing has never been the first choice in the maritime domain – but advances in imaging technology may make it more viable in the coming years. The challenges of the deep require more sensitive, more robust and more energy-efficient EO sensors. Such sensors will provide greater resolutions in a broader range of frequency domains – not only to navigate, but also to find enemies amidst a cluttered environment.

New quantum-enhanced imaging technologies offer the possibility of clearer visual feeds under the depths – seeing through cloudy and murky environments – and at distances that have never previously been achieved.

In 'The quantum age: technological opportunities', the Government Office for Science defines two broad types of quantum imaging technology:

1. Devices that measure single photons, such as a single photon avalanche detector (SPAD). A camera based on arrays of SPADs can detect single photons efficiently with short exposure times.
2. Systems that use quantum effects to get around limitations in detecting light.

Quantum imaging provides many potential promising applications. Quantum cameras, for example, can produce sharper images than non-quantum cameras – reducing noise below what once seemed to be a fundamental limit. SPAD-based devices can exploit photon timing to see in 3D, look around corners, and image at wavelengths that normal cameras can't.

Other forms of quantum-enabled sensing are also relevant here. For example, quantum gravimetry – which uses the quantum interference of matter waves to measure the local value of gravitational acceleration. This, one day, could be used to detect the minuscule variations in gravity created by a ship or submersible. Quantum magnetometry, which is used to detect magnetic fields, could be put to similar uses.

Software defined multifunction systems

Space is often at a premium on smaller underwater platforms, necessitating more efficient space usage. One way this could be addressed is through multiple use, software-defined systems that fit a diverse set of sensors into a single form factor. These for example, could combine communications, electronic warfare (EW) capabilities and multiple sensor types into one package.

Examples already abound in nature. For example, humans and other biological systems integrate a range of different sensory inputs without so much as a second thought. Part of the challenge is in developing a single software package that could integrate data coming from a range of different sensors.

One promising example is SDML (software-defined multifunction LIDAR); a payload that combines a variety of real-time light detection and ranging (LIDAR), intelligence, surveillance and reconnaissance (ISR) collection capabilities, and an optical data link within the same sensor. SDML could see air, ground, naval and space-based use.

Social media as a sensor

Our last example is probably the most unconventional. Monitoring the movements and intentions of adversary submarines has always been a difficult SIGINT problem, but social media may prove to be unlikely aid. In fact, social media is, arguably, one of the worst things to have ever happened to operational security.

For one example, the 'stalking' of publicly available Facebook profiles (for example, of a ship's crew, and the crew's family) has been used to determine the date of embarkation and, sometimes, details of the ship's intended destination. That old phrase, first coined in World War 2, 'loose lips sink ships' still holds true.

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