QINETIQ

Hide and Seek:
In Space

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.

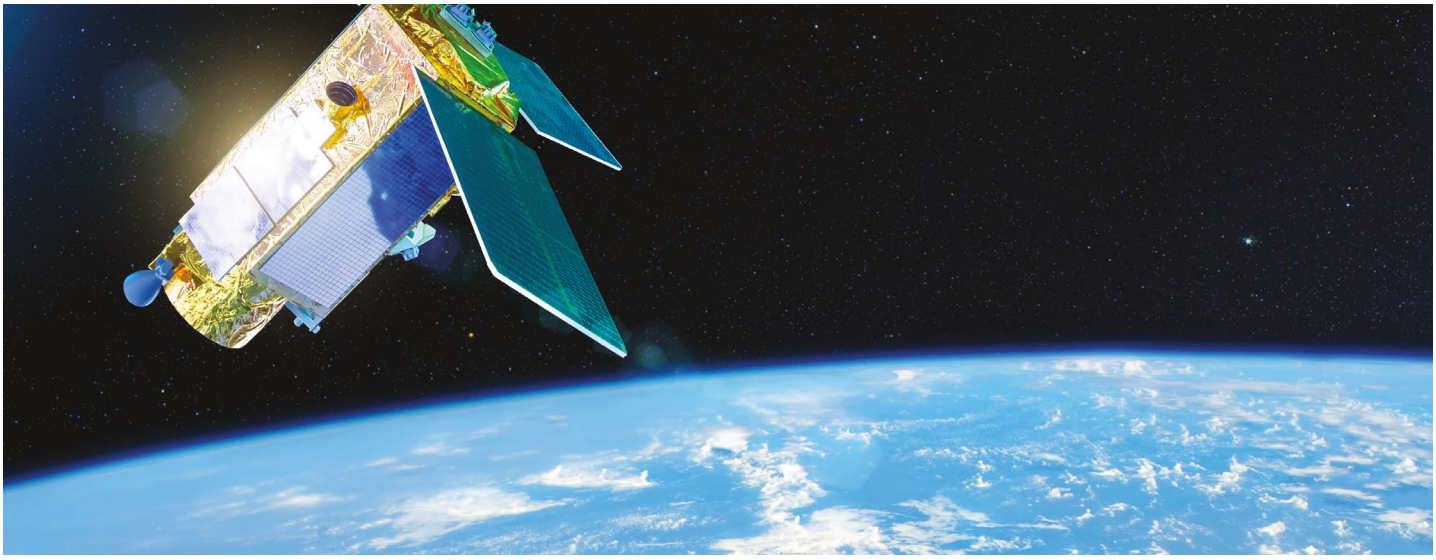
This age-old game of 'hide and seek' remains fundamentally the same, but the onset of the Information Age has altered its dynamics – multiplying the number of challenges and opportunities around detection. New technologies, open source intelligence, and advanced sensors provide more defence and security 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 underhanded grey zone conflict, and the ever-evolving race between sensors and stealth technology.

Space is the newest operational domain – indeed, NATO only declared it as such in 2019. Various treaties limit military activities in space – for example, prohibiting the stationing of weapons in orbit. That said, the vast majority of today's military operations would be impossible without space. It is, for example, needed for communications, position, navigation and timing (PNT), meteorology… and of course, intelligence, surveillance, target acquisition, and reconnaissance (ISTAR).



In the civil space, the past decade has seen a massive disruption and evolution in the market - largely driven by the falling costs of operation being brought about in the commercial sector. As satellites become smaller, cheaper and more numerous, the amount of coverage (and the kinds of coverage) increase.

This ever-growing plethora of low earth orbit (LEO) satellites is a game changer for sensing from space. Lower orbits allow for higher data resolutions, and the sheer number of satellites makes pervasive, 24/7 coverage possible.

In the 'NewSpace' era, seeking becomes easier, but hiding becomes harder.

You can run, but you can't hide

Hiding in earth's orbit is effectively impossible. Take, for example, the hobby of 'satellite spotting', in which members of the public equipped with nothing more than commercial off the shelf (COTS) optics spot satellites and track their movements. Those with a slightly larger budget need only enough upward-facing radar for consistent coverage.

As such, the only way to really hide an orbital asset is disguise it in a dual use – for example, a climate observation satellite with electro-optical sensors that doubles as an ISR platform. In fact, such applications are not uncommon today. But, once spotted (and identified), a satellite is vulnerable. Despite its altitude and speed, a range of anti-satellite weapons (ASAT) are capable of destroying it outright, or attacking its sensors and electronics, rendering it blind or useless.

Conversely, hiding from space, although a little easier, is also difficult. The range (and number) of sensors that currently orbit the earth is growing. When combined with aerial sensor platforms, such as uncrewed aerial vehicles (UAVs) and high altitude platforms (HAPs), the situational awareness picture enabled by space is becoming detailed, and more pervasive.

Space offers remarkable opportunities for sensing, but being one of the most inhospitable of domains, is not without its challenges. The first challenge is to actually get the platform itself into orbit. Although costs are falling, this is still expensive. Then there are the sensors themselves. For a sensor to operate in space, it needs to be able to do things that terrestrial ones can't – demands for robustness, power and miniaturisation make the design and development of such systems particularly expensive.

In the maritime domain, ships used to be able to hide themselves from detection by turning off their radar transmissions – but no longer. Sensitivity and total coverage area have increased dramatically. In fact, there's a case to be made that there is nowhere, really, left on the earth's surface to hide. For example, certain LIDAR sensors can see through the densest of surface cover.

On the other side of the equation, adversaries are also developing better sensors, which makes it harder to remain undetected. For example, many of China's commercial satellites possess powerful electro-optical sensors, and in line with China's military-civil fusion policy, are designated for dual military-commercial use. In April 2020, Iran launched 'Noor', its first military satellite. Tehran has released no information about the satellite's purpose or designs, so it's not known if Noor is capable of surveillance – but the launch sets a precedent for the Iranian military exploitation of space.

'Revisit' or 'refresh' time describes the period in between satellites being able to cover an area. This means that consistent real-time coverage is not yet a reality, but, as the number of surveillance satellites grow, the amount of time taken between passing satellites decreases – driving down revisit time. The eventual endgame is a multispectral, global coverage network with no revisit time.

As such, the only real places left to hide are underground – or underwater. And, with the development of gravimetry and magnetometry, these domains may, one day, no longer be quite so opaque...

3 opportunities for space sensing

#1: Space situational awareness (SSA)

According to spacefoundation.org, SSA

'refers to keeping track of objects in orbit and predicting where they will be at any given time.'

As more and more satellites are launched into earth's orbit, there's a growing threat of collision, and, as such, a growing need to keep track of them all. It also probably goes without saying that keeping an eye on adversary satellites is a growing concern.

There's also a growing need to monitor the growing amount of space debris that could damage or destroy these valuable orbital assets. Tracking both satellites and debris (which is substantial, and growing) presents a significant challenge.

#2: NewSpace / Private industry

There are numerous commercial satellite constellations providing sensor data that was previously restricted to sovereign nations.

Examples abound, including Unseen Labs ('satellite-borne radio-frequency electronic and signal intelligence'), Horizon Tech ('signals intelligence and space-based maritime domain awareness'), and Hawkeye ('space-based RF analytics').

Of particular interest is synthetic aperture radar (SAR), which provides a number of advantages that active sensors (e.g. conventional radar) and passive sensors (e.g. electro optical systems) can't. This includes the ability to penetrate atmospheric conditions such as smoke and clouds, and to collect images at night. A number of commercial providers, like ICEYE (who launched the first commercial SAR satellite) and Capella Space, have already made significant progress.

In many cases, these innovative companies will make the data available to those with pockets deep enough to afford it. Indeed, wealthy buyers, purchasing access to multiple commercial feeds, could assemble an astounding situational awareness picture - without ever having to launch a satellite of their own.

There are many such commercial providers, and, considering the speed of growth in NewSpace, there will likely be more over time.

#3: Missile tracking

As part of the US 2019 Missile Defense Review (MDR), experts determined that the US' existing earth and space-based sensor architecture was not up to the task of detecting hypersonic threats. Hypersonic weapons are those that travel at speeds of more than five times the speed of sound (Mach 5).

As such, the US Space Development Agency (SDA) is currently planning the development of a missile tracking satellite layer – this consists of hundreds of low earth orbit (LEO) satellites, designed to keep a mechanical eye on hypersonic and ballistic missiles. The HBTSS (Hypersonic and Ballistic Tracking Space Sensor) will be located within this layer, and equipped with a mix of wide and medium aperture sensors, better suited to spotting and tracking rapidly-moving objects.

A dedicated space sensor network would allow us to maintain continuous coverage of hypersonic vehicles, even if they were able to avoid radar fences and other terrestrial sensor networks.

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