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View from above

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Military satellite networks are an increasingly vital component for a range of activities, from location-tracking to communications. However, in the 'New Space' era, it is becoming cheaper and easier than ever before to launch satellites, presenting opportunities to nations and companies who may not previously have been involved in the sector. *Gerrard Cowan* reports

The military satellite market is wide and complex, with products aimed at a growing range of applications. Within this industry, the major companies are pursuing opportunities in a host of areas - from observation to communications - while smaller, newer entrants eye their own potential openings.

Perhaps most notably, satellites are now embedded in the infrastructure of military communications; this is likewise an area of high importance for the industry. For example, Boeing Government Satellite Systems is the primary contractor for the Wideband Global SATCOM (WGS) system, which provides wideband communications for the US Department of Defense (DoD) and allied nations in X- and Ka-band. The company has pointed to investments in phased array antennas and digital signal processing, which has been combined with innovations in the commercial satellite market to produce "a flexible WGS system". Eight Boeing-built WGS satellites are currently in orbit, with another planned for launch in March and a tenth in 2018. WGS also has a number of international partners, including Australia, Canada, Denmark, Luxembourg, the Netherlands, and New Zealand.

The company believes that there will be changes to the WGS system in the future in response to increased requirements for protected tactical wideband communications. There will be modifications to the ground infrastructure, in order to make use of the protected tactical waveform, while its functions will be separated into smaller, mission-specific systems to support resilience and flexibility and generate cost savings.

Satellite communications are also a major area of focus for Airbus Defence & Space (DS). Most notably, the European company is responsible for the UK Ministry of Defence's (MoD's) Skynet satellite communications system, which is based on a network of eight satellites: four older-generation Skynet 4 systems and four of the new Skynet 5 platforms. Additionally, it is working with the European Space Agency on the development of the SpaceDataHighway, which comprises two geostationary satellites and is designed to relay information and data extremely quickly between different assets. The main use initially will be for observation satellites, said David Chegnion, head of strategic business development in Airbus' Secure Communications business, although it will eventually represent "the next generation of high-bandwidth and secure communications", he said, transmitting information and data between unmanned aerial vehicles (UAVs), aircraft, and satellites.

The SpaceDataHighway uses laser communications, Chegnion said; the company envisions this as a major area of development, looking forward.

"We are strong believers in laser communications ... we believe that will be a revolution in the satcom [satellite communications] domain."

Looking to market trends, Chegnion said that data rates have been growing and there are an increasing number of mobile devices on the market. Customers are looking for a seamless experience and have high resilience and security demands, which are "critical in an environment that is more and more contested and congested ... the future is clearly about seamless and virtual interworking of different networked technologies", connecting any space, whether it be mobile, satellite, or maritime. The increase in mobile requirements is leading to smaller antennas, high bandwidth, high-throughput satellites (HTS), and laser communications.

There is also increased threat in the military satellite arena, said Paul Millington, head of the UK and US sides of Airbus DS's Secure Communications business. A network comprises the core geostationary military satellites, which are highly protected against jamming threats, he said; Skynet 5 "has an unprecedented jamming performance ... it's very difficult to defeat or blind Skynet 5". However, the broader network comprises many different 'bearers' of data, which range from satellites like Skynet 5 to a radio tactical network on the field. It is therefore important to ensure that every part of this network is resilient to attack and jamming.

Connecting the battlespace and passing information effectively around is becoming an increasing area of focus, said Patrick Wood, CEO of Surrey Satellite Technology Ltd (SSTL), an Airbus-owned manufacturer of small satellite systems. In this picture, satellites are one of a number of different elements of a broader communications network.

"There's a lot more discussion about ad hoc networks where low-earth orbit satellites may join a communications network, they may join up and communicate with maritime patrol aircraft, UAVs, or HAPS [high-altitude pseudo-satellites]," he said. "So there's a really exciting period of investigating new potential architectures."

Wood also highlighted the potential for new technologies, once again underlining the potential of laser communications, "where people can envisage architectures where the connection from a low-earth orbit satellite back up to a geo is via very high-speed laser communications", which are hard to intercept, have a low probability of detection, a low probability of interception, and a low probability of being interfered with.

In today's battlefield it is actually difficult not to use satellite communications, said Jean-Claude Schmitt, vice-president of network and infrastructure systems at Thales. This is especially the case for larger militaries, he said, and is driven by a number of factors, such as the vast distances involved in modern operations and the need to have communications between the headquarters and the battlefield, which can often be long distances apart. The satellite network "is the heart of the network in the battlefield", he said.

Schmitt placed a particular emphasis on the threat from jamming, which is a very real issue in satellite communications. Even from an asymmetric perspective it is relatively cheap and easy for opponents such as terrorists to build a jammer.

"So imagine what big nations are capable of in that field," he added. "Jamming is something armies are no longer afraid to talk about."

Thales' solution for the jamming threat is Nexium SAT, which comprises a portfolio of land, naval, and air terminals. It implements a number of security mechanisms at the transmission, network, and service levels, including multilevel data encryption and advanced network protection. Nexium SAT incorporates Thales' System 21 product, which uses frequency hopping to bolster security.

Navigation is another major area of focus for a range of companies. Boeing, for example, delivered its 50th GPS satellite to the US Air Force in March 2016, and has built more than two-thirds of the GPS satellites that have entered service since 1978. The US company believes that in the future there will be further advances in the satellites as they receive more modern technologies; for example, flexible digital-navigation payloads will provide advantages over the current GPS analogue systems. Additionally, there will be increased flexibility, thanks to hosted payloads that can be attached to a satellite to provide an additional capability at relatively low cost.

SSTL has also been involved in navigation systems, notably through Europe's Galileo programme. Broader navigation networks will benefit from the diversity provided by multiple systems, said Wood.

"In the military domain, navigation is about diversity: it's about the fact that there is the GPS system, there's the Galileo system, and the terminals on the ground will have the ability to look at multiple satellite navigation systems," he said. "So the resilience of these systems will improve significantly with the use of multiple satellite navigation systems."

Israel Aerospace Industries (IAI) is mainly focused on the observation side, said Opher Doron, general manager of the company's space division. The company's satellites provide very-high resolution images down to the 30-í50 cm range.

Observation satellites have improved across the board in recent years, Doron said.

"Avionics are getting better, the cameras are getting better, the downlinks are getting better, everything's improving all the time," he said, with today's systems only slightly heavier than the 300 kg systems of a few years ago, but capable of providing far better resolution, much more quickly.

The next step in technology is a move to provide better data rates, resolution, and avionics. There is a growth in demand for very-high resolution imagery, Doran explained, with a number of requests for proposals released with such requirements recently. This is connected to a broader change in military requirements, he noted.

"It's not enough to look for tanks any more, or planes, or ships. You need to look at the pick-up trucks, you need to look at civilian areas to see where suspicious things are happening," he said. "Many of the conflicts nowadays all over the world are not between armies. They are where the other side is trying to blend into the territory and look like the civilian population."

Raytheon has a number of focuses in the satellite arena. Its IIS division focuses on "the brains of the satellites" through the ground command and control side, as well as receiving, processing, analysing, and disseminating data, said Jane Chappell, vice-president of Global Intelligence Systems. Raytheon IIS conducts strategic satellite-based mission planning and data processing for the US DoD, among a number of other customers.

Chappell said that the ways in which data is analysed and manipulated have evolved in a number of ways. The key is to be able to pool together data from the wide variety of networked sources, from satellites to high-altitude platforms and UAVs.

"It's all around the analytics: what you can do from an analytics side, so that the raw data that's coming out of the system is converted into actionable information that answers a question, and how you can automate the analytics for speed and accuracy of decisions," she explained. "There are so many sources of data today, whether that's coming from a satellite, whether that's coming from open source, or coming from a UAV. You want to really be able to look across all of that data."

Ultimately, satellites are a means to an end, she said. "At the end of the day it's all about the data, and it's about the intelligence that you can get out of the data to quickly make critical decisions. It's the need to know something versus to have something. You want to learn more, versus just get the image."

Manufacturing of key components and subsystems forms a crucial focus for many firms. For example, BAE Systems' Space Systems' (S2's) product line develops and manufactures space subsystems and components using digital, infrared, optical, radio frequency (RF), and ground processing and visualisation technologies, said Ricardo Gonzalez, director of S2. Its products are used in applications for a range of customers, including the DoD. For example, it makes the infrared sensor chip assemblies for the Space-Based Infrared System (SBIRS), which uses infrared sensors to spot missile launches by detecting hot plumes. Additionally, the company produces single-board computer products based on its RAD750 and RAD6000 microprocessors, which are used on a number of satellite systems with defence applications such as the Advanced Extremely High Frequency (AEHF) system.

While there is a need for more advanced technologies, driven by a demand for system integration, there is also a requirement for standardisation from many customers looking to reduce the costs and risks associated with custom solutions.

Gonzalez highlighted an increased emphasis on the need for resiliency. There are a number of risks to space missions, such as anti-satellite weapons and space debris, and it is crucial that systems are built to be tough

enough to stand up against such threats. Therefore, the robustness of the technologies is critical, in terms of both withstanding the space radiation environment over potentially long periods of time, but also in terms of being protected against destruction or damage.

The most drastic change in recent years concerns the fast-changing nature of the threats, Gonzalez said.

"For anyone watching the news recently, it is evident that space is no longer a sanctuary. Today, dangers exist in all domains - air, land, sea - and space is the new battleground."

Threats in the space realm are rarely considered, Gonzalez said, when compared with cyber-security breaches or ground hostilities. Adversaries can send assets into space to block GPS signals, for example. There are numerous other threats, too, he said, such as radiation. Against such a backdrop, there is a need for "new satellite architectures and adaptive satellite electronics that can be easily tailored to the evolving threats".

Gonzalez said that there are advantages to developing constellations of multiple smaller satellites, rather than relying on a single, larger system: a process he referred to as 'disaggregating' space capabilities onto multiple platforms. The odds of a mission's success are increased, he said, because the number and diversity of potential targets increases.

While the United States has more satellites in space than any other nation, there is ample evidence of other countries working to close the gap and neutralise the advantage, he said. US government investments in space system defence and counter capabilities are being driven by increasing acts of foreign space hostility, creating a high demand for technologies that enhance indications and warnings, space situational awareness and protection, and battle management command and control.

"Having the ability to catalog and analyse this type of information from the ground and using sensors and advanced processing capabilities on board our satellites is essential," Gonzalez said.

From a US perspective, the country produces and relies on a large quantity and variety of data from its space assets, Gonzalez noted, and runs the risk of cyber attacks, spying, eavesdropping, or network degradation. It is possible that these networks could be overtaken or flooded with extraneous data that could impede the country's ability to communicate using space-based technology.

"Clearly, space resiliency is equally important to the ground and control centres that fly our satellites," he added. "These are just a few examples of what drives the need for our systems to become more resilient, disaggregated, and operationally integrated in order to bring the intelligence community and DoD together to provide greater protection of our space assets."

The space market is rapidly evolving, with a number of smaller and newer entrants eyeing opportunities in a phenomenon known as 'New Space'. There has been a general trend over the past 30 years to slowly privatise and commercialise a lot of the space operation, said John Serafini, CEO of Hawkeye 360, a company that was founded in late 2015 and is planning to launch a constellation of small satellites.

These satellites will have a number of different focuses, primarily on the signals side. The uses include collecting and selling RF data and detecting RF interference for satcom providers. In the long term, Hawkeye sees the military market as a potential target, particularly in the maritime domain awareness space: tracking signals of ships and building profiles of ships "that don't want to be found", he explained.

"I think certainly our capabilities in and around maritime domain awareness are particularly important for navies, to provide additional domain understanding of their environments," he said, adding that the product is more likely to be targeted at other governmental organisations in its initial stages, as "there is a long heritage of the US government and other governments providing [military] signals capacity and detection organically themselves".

Looking forward, Gonzalez said that protection of satellites will be critical, given their role in US national security and in people's everyday lives. Therefore, technology has to advance to stay ahead of the rapidly changing threat environment. This meant "the need for increased onboard processing capability and re-programmability will be a vital component of future systems", he said. BAE sees strong growth in the area of radiation-hardened components, which enable higher levels of onboard processing and software reconfigurability. Additionally, "highly integrated processors and reconfigurable computing modules are essential building blocks that are required for current and future demands of the evolving space market", Gonzalez added.

The space environment has changed vastly when compared with a decade ago and there is now a need for new, space-based capabilities to protect satellites, Gonzalez said. Many of the technologies currently used to protect military aircraft can be employed to safeguard satellites, he added.

Wood pointed to two areas of major interest in the future: the development of 5G technology, which will "bring the space and terrestrial infrastructure closer together", as well as the further development of laser communications, which will be fruitful not just for telecommunications, but also for retrieving optical and radar data quickly.

"The terminals today are very large, they're very expensive. We know that there are a number of companies that are going to produce smaller, lighter, cheaper, more agile, products in the very near future, and that will really open up the architecture that people can use," he said.

COMMENT

The space sector is a critical element of modern military thinking. As it becomes increasingly accessible to a wider range of participants, the opportunities and challenges seem likely to multiply, for both MoD and the industry.

Communication is perhaps the most obvious area of utility for satellites, with modern forces dependent upon the technologies in many ways. There are a number of avenues in which this could evolve looking forward, with many in the sector pointing to laser communications as a potentially fruitful area for future development. Likewise, there is expected to be an increase in mobile devices, which could bring challenges around security.

The security aspect is a broad concern, firstly in relation to the assets themselves, but also - and arguably just as importantly - to the data that the satellite might be transmitting. Jamming and cyber threats are important considerations.

Still, there have been major advances in recent years, most notably on the technology side: from the resolution provided by observation satellites to the anti-jamming systems used to protect the transmission of data. This progress looks set to continue, alongside an emphasis on robustness and resiliency to protect against a host of dangers, from radiation to the actions of adversaries.

The industry itself has seen massive changes in recent years, with a host of new, smaller companies entering the market. The costs of building and launching satellites have decreased substantially, providing greater accessibility for companies and government organisations around the world. The military market may be a more challenging prospect for these companies than the broader, commercial world; still, it will be interesting to observe their progress, both in terms of the equipment they manufacture and the use they make of data.