Next Generation Space Defense

MilsatMagazine

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Cover image: United Launch Alliance's Delta IV Heavy rocket carrying the NROL-82 mission for the National Reconnaissance Office lifts off from Space Launch Complex-6 at Vandenberg Air Force Base in California.
Image Source: United Launch Alliance

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Eutelsat Garners An Equity Stake In OneWeb

Eutelsat Communications **(Euronext Paris: ETL) has entered into an agreement with *OneWeb* for the subscription of a c.24% equity stake, becoming a leading shareholder of the company alongside the *UK Government* and *Bharti Global* — Eutelsat will invest $550 million in OneWeb, with closing expected in H2 2021 subject to regulatory authorizations.**

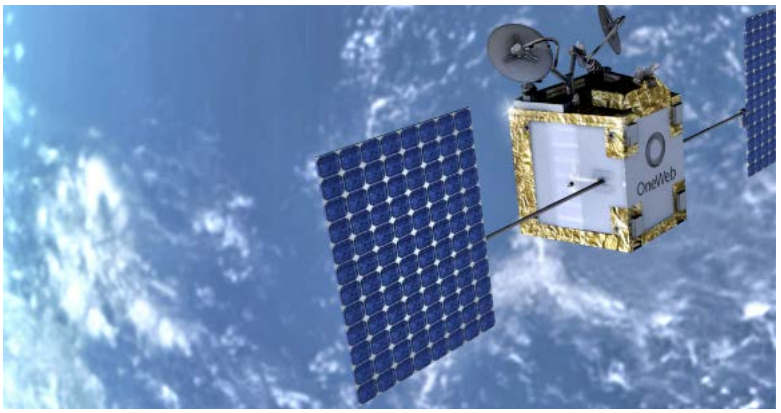
With much of its global network already deployed, the OneWeb constellation will operate 648 satellites in LEO offering low latency. This first generation of satellites will offer significant regional coverage by the end of 2021, reaching global coverage the following year.

OneWeb will be the first complete, non-geostationary constellation with truly global coverage, significantly ahead of competing projects. It will deliver 1.1 Tbps of capacity addressing the government, fixed data and mobility markets.

Plans include a second-generation constellation that will provide significant enhancements in terms of capacity, flexibility and economics. It anticipates annual revenues of circa $1 billion within three to five years following the full deployment of the constellation, with a partnership approach and profitable wholesale business model.

Eutelsat's investment leaves OneWeb almost fully funded and the company is well advanced in terms of securing its remaining funding needs this year. Eutelsat's investment will come with similar governance rights to the UK Government and Bharti, including board representation, where its position and expertise as one of the world's leading satellite operators will help to drive the success of the new constellation.

The investment will be 100% cash financed through Eutelsat's liquidity position of 1.9 billion euros as at end-March 2021[1] and the $507 million US C-Band auction proceeds, and will be accounted for under the equity method. It is consistent with Eutelsat's financial hurdle rates and does not alter its financial objectives, which are fully confirmed, including the medium-term net debt / EBITDA target of c.3x and a commitment to solicited Investment Grade credit ratings. Eutelsat's policy of a stable to progressive dividend is also reiterated.



Commenting on the agreement, **Rodolphe Belmer**, Eutelsat's Chief Executive Officer, said, "*We are excited to become a shareholder and partner in OneWeb in the run up to its commercial launch and to participate in the substantial opportunity represented by the non-geostationary segment within our industry. We are confident in OneWeb's right to win thanks to its earliness to market, priority spectrum rights and evolving, scalable technology. We look forward to working alongside the UK Government, Bharti and the other shareholders to open new opportunities and market access to ensure OneWeb maximizes its potential. OneWeb will become our main growth engine outside our broadcast and broadband applications, as we continue to maximize cash-flow extraction from our highly profitable heritage business and grow our fixed broadband vertical leveraging our geostationary assets.*"

OneWeb Executive Chairman, **Sunil Bharti Mittal**, said, "*We are delighted to welcome Eutelsat into OneWeb family. As an open multi-national business, we are committed to serving the global needs of Governments, Businesses and Communities across the Globe. Together we are stronger, benefiting from the entrepreneurial energy of Bharti, extensive global outreach of UK and long-term expertise of the satellite industry at Eutelsat. OneWeb, with its innovatory approach, is poised to take a leading position in LEO broadband connectivity.*"

Neil Masterson, Chief Executive Officer of OneWeb added, "*As OneWeb accelerates the deployment of its fleet and engages in discussions with potential customers, we welcome the powerful support of Eutelsat during the next exciting phase of our journey together, benefiting both companies equally. Eutelsat is a great partner for OneWeb thanks to our high level of complementarity in terms of technology, assets, addressable markets, geographic reach and institutional relationships.*"

[1] €1.4 billion when restated for the upcoming € 500 million bond maturity

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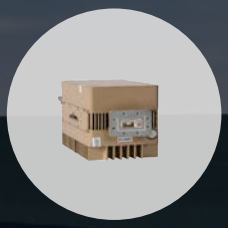
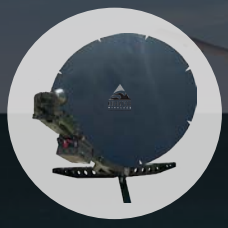


X-Band SSPAs/BUcs
GaN & GaAs configurations



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SATCOM Terminals

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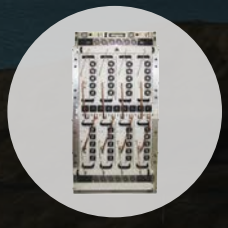

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ULA Powers NROL-82 To Orbit

Photo is courtesy of United Launch Alliance.

A *United Launch Alliance* Delta IV Heavy rocket lifts the NROL-82 mission from Vandenberg AFB in California.

This is the 143rd mission for United Launch Alliance and the company's 90th mission in support of U.S. national security and the 31st for the ***U.S. National Reconnaissance Office*** (NRO). This is the 386th Delta launch since 1960, the 13th Delta IV Heavy and the 9th Heavy for the NRO. NROL-82 is also the NRO's first launch from Vandenberg since January of 2019.

United Launch Alliance's Delta IV Heavy is a heavy-lift launch vehicle, the largest type of the Delta IV family and one of the world's most powerful rockets.

The Delta IV Heavy configuration is comprised of a common booster core (CBC), a cryogenic upper stage and a 5-meter-diameter payload fairing (PLF). The Delta IV Heavy employs two additional CBCs as liquid rocket boosters to augment the first-stage CBC. The Delta IV Heavy can lift 28,370 kg (62,540 lbs) to LEO and 14,210 kg (31,330 lbs) to GEO. This is an all liquid-fueled rocket, consisting of an upper stage, one main booster and two strap-on boosters.

The NRO's next launch is NROL-11, scheduled for later this quarter from NASA's Wallops Flight Facility, Virginia.

Engines supplied by ***Aerojet Rocketdyne*** provided the lifting power for the successful launch of a United Launch Alliance (ULA) Delta IV Heavy rocket carrying a classified U.S. National Reconnaissance Office (NRO) NROL-82 payload.

The Delta IV Heavy features three core stages in a side-by-side configuration, each powered by a single Aerojet Rocketdyne RS-68A engine generating 705,000 pounds of thrust at liftoff. The RS-68A, developed specifically for the Delta IV, is the world's most powerful hydrogen-fueled engine. The vehicle's second stage is powered by a single RL10B-2, hydrogen-fueled engine generating 24,750 pounds of thrust. The Delta IV Heavy's propulsion systems also feature pressurant tanks built by Aerojet Rocketdyne's ARDÉ subsidiary.

Eileen P. Drake, Aerojet Rocketdyne CEO and president, said, "*Our reliable, flight-proven RS-68 and RL10 engines have supported ULA's Delta IV Heavy missions since the rocket's first flight in 2004 and have continued with 100% mission success for nearly two decades.*"

"*The payload launched today is one of the most complex payloads our nation launches and it provides vital space capability*," said Col. **Robert Bongiovi**, director of SMC's Launch Enterprise. "*That's why we have to get it right the first time. The launch team performed flawlessly and I am so proud of the work they do to ensure 100 percent mission success.*"

ULA's next launch is the ***Space Based Infrared System*** (SBIRS) GEO Flight 5 mission for the U.S. Space Force from Cape Canaveral Space Force Station, Florida.

Northrop Grumman Corporation (NYSE: NOC) supported the successful launch of NROL-82) — the company's contributions to the ULA Delta IV heavy rocket include 11 key large composite structures including three thermal shields that house and protect the engines during flight; three centerbody structures that connect the *liquid oxygen* (*LOX*) and liquid hydrogen (LH2) tanks; the payload fairing that provides protection to the payload; the composite interstage on the center common booster core; the nose cones on the two strap-on boosters and one set of X-panel structures that connect the upper stage LOX tank with the upper stage hydrogen tank.

The large-scale composite structures measure four to five meters in diameter and range from one to 15 meters in length. Northrop Grumman produced them all using advanced hand layup, machining and inspection techniques at the company's manufacturing facility in Iuka, Mississippi.

Other Northrop Grumman products integrated on the ULA Delta IV heavy launch vehicle include four booster separation rocket motors for the launch vehicle manufactured at Northrop Grumman's Rocket City, West Virginia facility. The motors ignite when the two side-mounted common core stage burns are complete to assist booster separation from the center core.

Northrop Grumman also designed and produced the nozzles for the three Aerojet-Rocketdyne RS-68 engines, as well as the nozzles' innovative thermal protection material, and the propellant tank for the Delta IV upper stage roll control system at its Commerce, California facility.

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USSF / SMC Awards Raytheon Intelligence & Space GPS OCX 3F Contract

The *United States Space Force's Space and Missile Systems Center (SMC)* awarded a $228 million contract to *Raytheon Intelligence and Space* for the *Global Positioning System (GPS) Next Generation Operational Control System (OCX) Follow-On (OCX 3F)* on April 30.

The OCX 3F program is part of the GPS Enterprise Modernization effort. GPS is a satellite-based radio navigation system that provides accurate positioning, navigation, and timing (PNT) for military and civil users worldwide.

The GPS OCX Blocks 1 & 2 System, planned for delivery in 2022, will represent a major evolution in capabilities for the GPS enterprise. In addition to supporting the latest DoD standards and practices for cybersecurity, it also supports a number of advanced features over the legacy GPS Ground Segment.

These new features include an enhanced and expanded monitor station network for improved cybersecurity and improved anti-jam capability, enhanced operational capability to control the modernized military signals, support of GPS III boosted earth coverage Military code (M-code), and the monitoring of new Galileo-compatible and safety of life signals.

OCX 3F upgrades the OCX Blocks 1 & 2 system to use the enhanced capabilities of the new GPS IIIF space vehicles being developed by *Lockheed Martin*.

The OCX 3F program, in combination with the GPS IIIF space vehicle program, ensures PNT will continue to be available for future generations. Raytheon Intelligence and Space will perform the work in Aurora, Colorado, and delivery is expected in July 2025.

"*OCX is an adaptive architecture designed to evolve to combat emerging threats. OCX 3F is a great example of modifying the OCX Blocks 1 and 2 software baseline to launch and incorporate the GPS IIIF enhanced satellite capabilities. I look forward to continuing our relationship with Raytheon in delivering the United States Space Force GPS capabilities*," said **Barbara Baker**, SMC Production Corps Command and Control Systems Division's senior materiel leader.

"*The OCX 3F program office is looking forward to working with Raytheon on this new GPS ground control program. We are ready to take on any challenges and to work full bore to deliver the critical regional high-powered signals and GPS IIIF launch and control capabilities in support of joint warfighters*," said Lt. Col. **Grant Spear**, SMC OCX 3F materiel leader.

Lockheed Martin Names New Senior Vice President of Government Affairs

***Lockheed Martin* (NYSE: LMT) has named Christian Marrone as the senior vice president of government affairs, succeeding Robert Rangel, who will retire later this year.**

Marrone, a current Lockheed Martin vice president of government affairs, has played an active role in many of the most critical issues facing the company. Prior to joining Lockheed Martin in 2019, he successfully served as a senior presidential appointee in both the Bush and Obama administrations in addition to his experience in state and local government and the private sector.

Marrone was chief of staff of the U.S. Department of Homeland Security for former Secretary Jeh Johnson and also held a number of senior positions within the U.S. Department of Defense, including special assistant to then-Secretary Robert Gates, and acting assistant secretary of Defense for Legislative Affairs.

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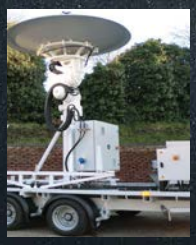

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Space & Component Technology

Space Flight Laboratory's NorSat-3 Maritime Smallsat Launched — Commissioning Underway For The Norwegian Space Agency

The *Norwegian Space Agency* has announced the successful launch of the NorSat-3 maritime tracking smallsat, built by *Space Flight Laboratory* (SFL) in Toronto, successfully launched on April 28, 2012, aboard *Arianespace's Vega Flight VV18* from the Guiana Space Center in French Guiana — this is the 17th SFL satellite launched within the past eight months.

NorSat-3 carries two instrument payloads. The primary device is an *Automatic Identification System* (*AIS*) receiver that acquires messages from civilian maritime vessels to provide information on ship locations and marine traffic.

The smallsat is also equipped with an experimental navigation radar detector developed by the ***Norwegian Defence Research Establishment*** (FFI) to augment the AIS receiver.

Combining a navigation radar detector and AIS receiver will potentially provide much better maritime awareness for the ***Norwegian Coastal Administration***, Armed Forces and other maritime authorities.

Detection of navigation radar from ships will provide the ability to verify the accuracy of received AIS messages and to detect vessels whose AIS messages have not been received.

SFL developed the 16.5 kg NorSat-3 smallsat on the company's space-proven, Next Generation, *Earth Monitoring and Observation* (*NEMO*) platform, under contract to the Norwegian Space Agency, with funding from the Norwegian Coastal Administration.

SFL also built the NorSat-1 and -2 maritime tracking smallsats now on-orbit and the firm is currently developing the ***NorSat-TD*** (*Technology Demonstrator*) satellite that is slated for launch in 2022.

SFL congratulates Norway on its leadership in space-based maritime traffic monitoring," said SFL Director Dr. **Robert E. Zee**. *"NorSat-3 was contacted shortly after launch and is healthy. Commissioning is underway."*

Virgin Orbit Selected By Brazilian Space Agency + Air Force For Orbital Launches

The *Brazilian Space Agency* (*Agência Espacial Brasileira; AEB*) and *Brazilian Air Force* (*Força Aérea Brasileira, FAB*) announced that *Virgin Orbit* has been selected to bring orbital launch capability to Brazil, a country which has never successfully completed a domestic launch to orbit.

Thanks to the unique mobility and small footprint of Virgin Orbit's air-launched system architecture, launches to a wide range of orbital inclinations could quickly become possible without the need for new permanent infrastructure, nor the expansion of existing facilities.

Launches would occur from the Alcântara Launch Center (*Centro de Lançamento de Alcântara, CLA*) on Brazil's northern coast, located just two degrees south of the equator. Virgin Orbit's LauncherOne system, which uses a customized 747 aircraft as its flying launch pad and fully reusable first stage, could conduct launches from the existing airbase at the site, flying hundreds of miles before releasing the rocket directly above the equator or at other locations optimized for each individual mission. The approach enables Alcântara to become one of the only continental spaceports in the world capable of reaching any orbital inclination.

Since construction of the facility began in 1982, Alcântara has hosted dozens of launches of uncrewed, suborbital sounding rockets — but the facility has not yet been used to reach orbit.

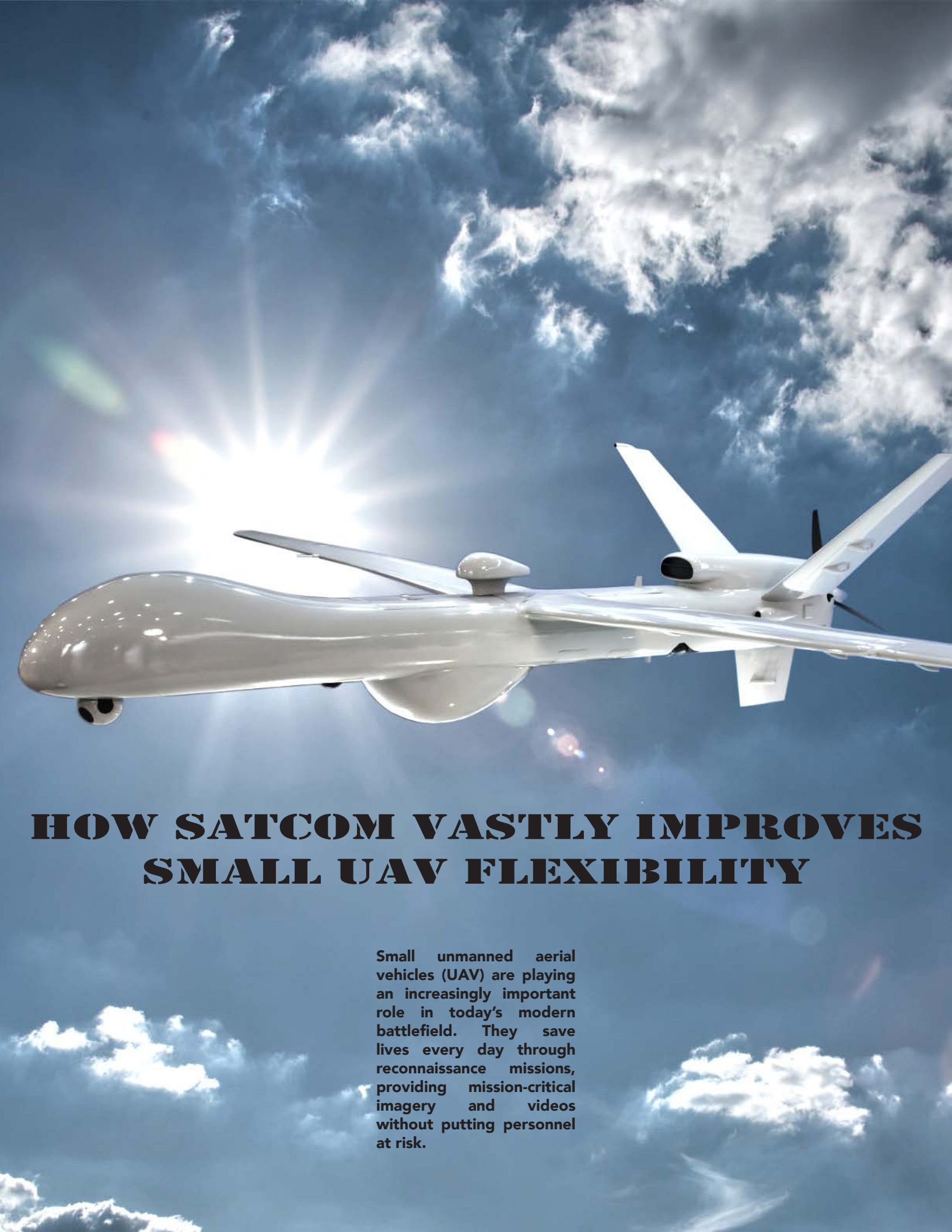
By bringing that long-sought capability to Alcântara, Virgin Orbit, AEB, and FAB will create an important new capability for the region while delivering on the promised economic value of the site for the local *quilombo* communities.

All of the equipment required for Virgin Orbit to conduct a launch to orbit is fully transportable, from the ground vehicles that prepare the rocket for flight to the rocket and aircraft itself — meaning that the team can securely transport the entire system in, conduct a launch campaign, and return to one of the company's other facilities without requiring any further construction beyond the airbase.

LauncherOne's first flight from the facility would transform Alcântara into the second orbital-class spaceport in all of South America, and only the fifth in the entire Southern Hemisphere.

Since the start of his term, the President of AEB, Carlos Moura, has stated that making the Alcântara Launch Center a reference for space activities in Brazil and in the world is at the center of the priorities of the Brazilian space program. "*Alcântara is one of the most ideal places in the world for launching rockets. It is close to the equator, which increases the launcher's payload capacity, and allows a wide range of azimuths for launches, with access to all orbits. When we put the Center into operation, we will overcome a historic challenge for the program, which means a commitment to Brazil and the world community towards ever greater achievements for humanity*."

"*The people of Brazil have been patiently and diligently working towards orbital launch for many years now, and it will be a tremendous honor to help make that vision a domestic reality*," said **Dan Hart,** the CEO of Virgin Orbit. "*Space launch will bring a key capability to the nation and to the space community, while helping address the long-standing needs of the local community. There's really no better place on the planet*



HOW SATCOM VASTLY IMPROVES SMALL UAV FLEXIBILITY

Small unmanned aerial vehicles (UAV) are playing an increasingly important role in today's modern battlefield. They save lives every day through reconnaissance missions, providing mission-critical imagery and videos without putting personnel at risk.

Technological improvements allow small UAVs to stay aloft for up to 20 hours and electrical motors offer the potential to get close to targets in stealth modes, but *line of sight* (LOS) communication limitations hamper their effectiveness.

The result of this technological limitation cannot be overstated. Due to the curvature of the Earth, LOS communication restricts missions to less than 100 miles, by forcing UAVs to fly at a higher altitude.

However, this increase in distance between the UAV and its targets impacts image resolution and video quality. Without the required high-quality imagery to provide positive identification (PID) and the range to prove chain of custody, to take actionable steps.

The Height-Distance Relationship in LOS Communication

To better understand the limitations of LOS communications, it's instructive to see the relationship between distance and height. As shown in the table, a UAV can get as low as 328.10 feet above the ground as long as the distance between the UAV and its ground station antenna is 22.19 miles.

The further away the base station is from the battlefield, the higher the UAV needs to fly. Looking at the base of the chart, where the base station is nearly 100 miles away from the target zone — the UAV needs to fly at an altitude of more than 6,500 feet, well over a mile above the target.

Unfortunately, at that distance, the intelligence being received from the UAV often lacks details and definition. This requires larger and more expensive sensors to be carried by larger UAVs with increased visual and audible detectability.

Mountainous regions can further complicate LOS communication, as the topography of the land interferes with the required line of sight between the ground station and the UAV.

As these missions are frequently actionable in hostile territory, moving the ground stations and UAV pilots closer to the target isn't a viable option.

LOS Radio Frequency Jamming

Line-of-sight missions are vulnerable to technological disruptions, as well. Traditional LOS communication occurs on the C-, S-, and L-bands. However, enemy combatants can easily block or jam these bands with high power directional emitters. As a result, even missions that have a nearby ground station may be disrupted, possibly leading to a loss of the UAV.

Limitation of Programmed UAV Missions

To overcome the challenges presented by LOS communications, some operational units have turned to programmed missions. While programming a course and a mission for a UAV enables the device to fly at a lower altitude, thereby allowing it to gather higher-quality intelligence, it introduces significant limitations.

Programmed missions disable any real-time capabilities that a UAV offers. The UAV flies its mission, but it doesn't send back any data until it has returned within range of the ground station and the UAV pilot at the base is unable to make any changes to the flight path, once the UAV leaves for its mission.

While the intelligence gathered should be of high quality, by the time a platoon is ready to take action, the data may be hours old and, therefore, irrelevant.

Paramount Need for Better Communications

Clearly, military units require a new solution to overcome the limitations that are inherent in a LOS communications system. While SATCOM has been an option for larger, more expensive UAVs, class 3 UAVs are often perceived as being non-compatible with SATCOM solutions.

SATCOM solutions would be ideal for small UAVs. Rather than ensuring that there is always a direct line of sight between the ground base and the UAV, the ground control station would connect through a satellite and communicate directly with the unit. This communication architecture would allow UAVs to embark on low-altitude missions that would be limited only by the platform's range.

SATCOM would further protect UAV pilots, keeping them far from the front lines of the battlefield. Rather than staying close enough to maintain line-of-sight with their UAV, they could sit thousands of miles away, in a safe location, and pilot the UAV from a control room.

Additionally, intelligence would be gathered in real-time, enabling UAV pilots to dynamically retask as missions evolve. The real time dissemination of intelligence to dismounted troops can make all the difference to keeping personnel safe and enable success on the battlefield. The satellite communications would also be shielded from interference in the C-, S-, and L-bands, as it uses the more secure Ka- or Ku-bands.

To date, however, the size of the SATCOM terminals has prevented the adoption of SATCOM communications with class 3 UAVs that weigh between 100 to 220 lbs. At that size, the additional weight from SATCOM terminals would impact the drag and endurance of UAVs of this size. Without significant ***size weight and power (SWaP)*** in the airborne satellite antenna, SATCOM would still have remained a fantasy for class 3 UAV operators.

Get SAT Places SATCOM Within Reach

Get SAT has developed a small SATCOM terminal that offers range extension to large class 2 and class 3 UAVs, range that was previously only available to very large airborne platforms.

Get SAT's patented ***InterFLAT*** panel antenna, a miniaturized, interlaced antenna that combines both receive and transmit elements on one panel as well as fast-tracking technologies, thereby delivering game changing capabilities to tactical UAVs.

This industry leading, integrated, highly efficient SATCOM terminal has been designed to maximum performance in demanding airborne environments.

Get SAT units operate with both GEO and MEO satellite constellations. This ensures efficient bandwidth use and is optimal for low-altitude missions, on land and at sea.

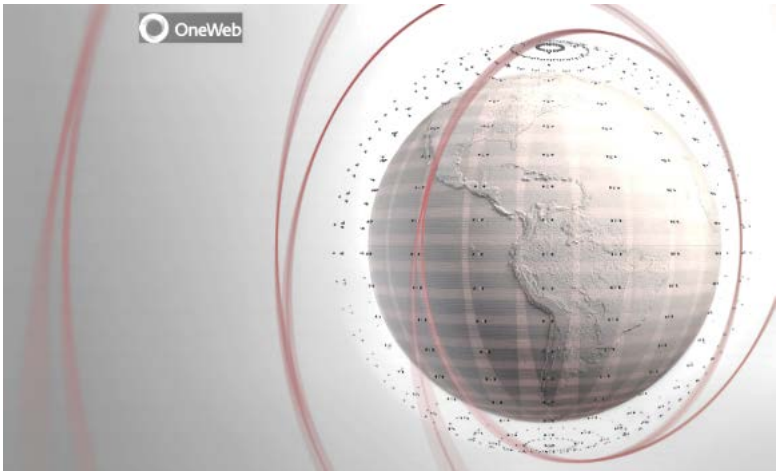
The units use a single LRU, making the antenna easier to integrate and maintain. Additionally, seamless data transfer over satellite links is fully supported.

For years military establishments have had to work around the limitations that have been inherent in small UAVs that are highly reliant on LOS communications. Now, with Get SAT, these smaller UAVs can be used for advanced missions without sacrificing the intelligence quality being gathered.

getsat.com

Hughes + OneWeb Receive AFRL Award To Demo Arctic LEO SATCOM TacComms Services

Hughes Network Systems, LLC (HUGHES) and OneWeb have been selected by the U.S. Air Force Research Lab (AFRL) to demonstrate managed LEO SATCOM services to connect the Arctic region to sites around the globe. Hughes is to provide systems integration expertise and to demonstrated managed LEO SATCOM services for tactical communications



Under the agreement, Hughes will test and implement these end-to-end services on the OneWeb system between selected U.S. Northern Command (NORTHCOM) locations, a first step in harnessing the power of LEO satellites for high-speed, low-latency broadband access in the Arctic.

"This opportunity reinforces the relationship between Hughes a*nd the U.S. Air Force to ensure resilient, flexible SATCOM networks for tactical, multi-domain operations," said Rick Lober, vice president and general manager of the Defense and Intelligence Systems Division at Hughes. "We look forward to partnering with OneWeb to bring LEO innovation into the military SATCOM enterprise, especially in the strategic Arctic region where connectivity has been limited—until now.*"

The OneWeb gateway (*image above*) in Svalbard, Norway, capable of 10,000 hand-offs per second, is one of the gateways developed by Hughes that will orchestrate handover and tracking of gigabits of data for NORTHCOM. Photo is courtesy of OneWeb/Kongsberg Satellite Services (KSAT).

"*The OneWeb constellation has been designed to enable low-latency broadband access across the globe, allowing connectivity in previously unreached areas—a capability that is ideal for tactical, multi-domain operations in the Polar region and beyond,"* said **Dylan Browne**, Head of Government Services with OneWeb. "*Working together with Hughes, we will bridge the gap* i*n connectivity for NORTHCOM with an interoperable and secure solution*."

As the prime contractor on the project, Hughes will lead adaptation, integration, testing and ongoing management of this service demonstration with OneWeb and Intellian, who are developing user terminals for use on the OneWeb network.

Designed for ease of installation, the new Intellian terminals will use next-generation technology to provide a cost-effective system to access the low-latency, high bandwidth connectivity offered by OneWeb.

(*Intellian won a US$73 million contract with OneWeb in March of this year to develop and supply affordable compact user terminals. These easily-installed antennas will use next-generation technology to provide high bandwidth, low latency connectivity to OneWeb's global satellite service, delivering to multiple markets including enterprise and government services.*)

Under a separate agreement with OneWeb, Hughes is engineering and producing the gateway equipment and user terminal core module, making the company a logical choice for enabling high-speed, low-latency services above the 50th parallel North, an area that has been difficult to connect with other types of satellite services.

The DoD contract is part of the U.S. Air Force's Defense Experimentation Using the Commercial Space Internet (DEUCSI) program.

OneWeb's network was designed for global coverage and is uniquely capable in its ability to deliver much-needed connectivity services to the Arctic. With 182 satellites launched to date and regular 2021 launches planned and on-track, OneWeb will be able to deliver coverage to the 50th parallel North and above by the end of 2021, bridging a long-standing connectivity gap and building secure communications capability in an underserved region.

Loft Orbital Contracted By AFWERX and USSF / SMC For NextGen Onboard Edge Processor

Loft Orbital has been awarded a Phase II Small Business Innovation Research (SBIR) contract by AFWERX and sponsored by the U.S. Space Force (USSF) Space and Missile Systems Center's (SMC) Portfolio Architect office.

The contract will provide funding to support Loft Orbital's development of a high-performance, reprogrammable onboard edge computing environment and associated applications. This will address a major government and commercial operator need for large constellations of satellites to execute autonomous decision-making and mission tasks.

Under this contract, Loft Orbital will develop its next-generation onboard processor to support customer and third party "*massless payloads*" onboard.

This onboard processor will function as a "brain" on Loft Orbital spacecraft, providing an environment to host applications for sensor data processing, mission autonomy, satellite self-protection, or any other application requiring advanced computing at the edge.

Other potential applications of the edge processor include payload and telemetry data processing, as well as the ingestion of other space assets' data through intersatellite links.

This space edge processor allows individual satellites to act as computing nodes within a mesh-connected network of other satellites, ground stations, and cloud datacenters, yet capable of advanced processing in isolation in denied or congested communications environments.

In addition, Loft will develop a machine learning software package to autonomously detect, identify and mitigate cyber threats onboard the spacecraft, an important capability for government missions.

Loft Orbital was previously awarded an AFWERX SBIR Phase I contract. In combination with private capital investment, this SBIR Phase II award will allow Loft Orbital to enhance this processor based on USSF feedback from Phase I.

Loft Orbital is targeting a future mission as the first flight of this second-generation processor, with the goal of making it as a standard offering for US Government satellite programs.

"*There is an unprecedented convergence occurring between commercial and government space infrastructure. Capabilities, threats, and vulnerabilities are now increasingly shared between these communities*," said **Andrew Berg**, Loft Orbital's VP of Business Development. "*We're pleased that SMC is placing its confidence in Loft Orbital to advance its innovative onboard processing architecture. This commercially-derived enhanced capability will offer a leap ahead in the pursuit of seamless Joint All- Domain Command and Control in support of national security space objectives, and we are excited to be selected as a partner to SMC in defining that way ahead.*"

DoD Combatant Command Issues Award To SES Government Services For GEO SATCOM

SES Government Solutions **(SES GS), a wholly-owned subsidiary of SES, has been awarded a new $35 million GEO satellite communications program contract in support of a major Department of Defense (DoD) combatant command.**

To provide reachback capabilities from forward-stationed units in remote locations to Europe, the solution includes a VSAT network that has the performance to support emerging mission needs and is capable of handling smaller, sub-meter, antennas.

The VSAT network provides more than 100 Mbps of throughput using multiple access methods, from time division multiple access (TDMA) that is shared sequentially and frequency division multiple access (FDMA) allowing simultaneous transmission, to various types of remote deployments and end-users.

The satellite service provides expansive coverage of countries from Turkey to Pakistan, with reachback to Europe, enabling collaborative tools and enhanced situational awareness in a distributed way.

"*We are proud to provide satellite communications support for this critical combatant command mission*," said President and CEO of SES Government Solutions, Brigadier General **Pete Hoene**, USAF (retired). "*This new program allows personnel to reach out to the tactical edge for fast and dependable real-time data and represents a further extension of our current mission support to warfighters using both GEO and MEO satellite communications capabilities*."

HIGH AVAILABILITY MARITIME SATCOM STARTS ON THE SHIP

Author: Dr. Rowan Gilmore, Chief Executive Officer, EM Solutions

Discerning customers who require broadband communications at sea are completely dependent on satellite communications as it provides the only bearer available anywhere, anytime.

Many would not bear the expense unless the satellite link were resilient and high availability. Redundancy can be improved by using multiple satellite systems, and multiple transmitters, since high power solid-state power amplifiers (SSPAs) are usually the most failure prone component in the link.

Frequency stealth can improve resilience by switching or spreading either the modem output frequency or the RF frequency. Changing to a lower frequency band can also protect against weather effects that cause attenuation of the satellite link at higher frequencies such as Ka-band, in spite of their superior bandwidth and capacity.

More specifically, the shipboard terminal determines one critical part of the reliability equation. Communications availability can be improved when the link budget is optimized by using the highest power transmitters possible, the most sensitive receivers, and steered antennas to maintain maximum antenna gain and achieve the best lock on the satellite.

Terminals such as the ***EM Solutions*** maritime ***Cobra*** terminal are in demand by the world's greatest navies as they offer all of these features. With multiple band resiliency in a single package, the Cobra covers both commercial and military Ka-bands, as well as X-band simultaneously [1,2].

The new Cobra Fleet terminal uses a 2 meter antenna and will cover X-band and the entire available Ka-band spectrum on any satellite system.

Even given these features, time-on-satellite is a big contributor to the availability equation: minimizing the time for an on-the-move terminal to acquire or reacquire the satellite is crucial, as is maintaining the link under violent motion conditions. That is achieved in the Cobra through its sophisticated monopulse pointing and tracking system.

However, what if the line of sight to the desired satellite is blocked, say, by the ship's infrastructure due to the vessel's temporary orientation? The solution can be seen on premium ships that have two terminals (or '***above deck equipment'***, *ADE*) mounted on opposite sides of the bridge.

Most simply, traffic can be switched at the data layer, using IP addressing, from the blocked terminal to the other terminal with the best 'view.' However, while this might be acceptable for commercial traffic, such a data layer approach is too intrusive for government or defence users.

Rather than at the IP layer, the Cobra's new ***Antenna Diversity System*** (***ADS***) achieves this switching at the physical layer, so that encryption and security wrapping around the data is preserved intact. The ADS mediates between two antennas and one or more modems by directly switching the modem traffic to the desired terminal.

Figure 1 to the right illustrates the concept. Also, consider the features a government or defence user might require, through the lens of maximum resilience and flexibility:

- *Operating with a modem bank that supports multiple frequency bands and satellites, for instance the WGS satellite system (X-/Ka-), Inmarsat GX (Ka- commercial), and other Military or Commercial satellite networks*

- *Operating each ADE from either individual (separate) modem banks or a common modem bank*

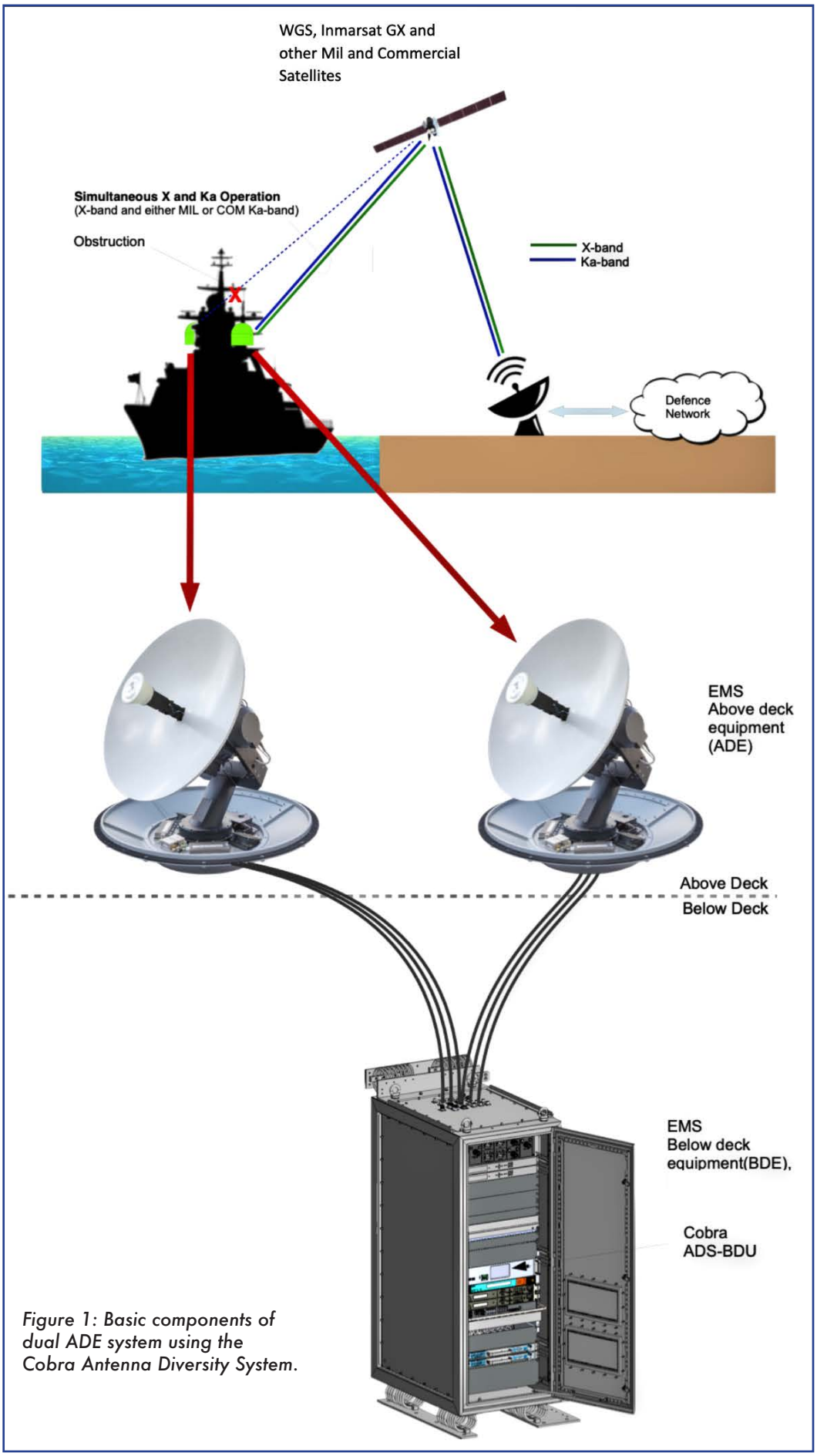


Figure 1: Basic components of dual ADE system using the Cobra Antenna Diversity System.

Figure 2: The Antenna Diversity System ADS is a rack-mounted unit that can mediate between above deck antennas and multiple modems operating at multiple frequencies.

- *Switching both X- and Ka-band traffic to one or both ADEs*
- *Supporting single look operation (both ADEs to the same satellite) or dual look operation (both ADEs to independent satellites)*

The ADS (***Figure 2, above***) is able to support all possible combinations of the above, but shields its complexity through a simple interface to the user. The ADS is able to support all of these through its proprietary, in-built IF switch matrix that switches the output signal of up to eight separate modems to one or both ADEs, and multiplexes the resultant signal, for both outbound and return traffic, onto a single cable pair for each ADE.

As illustrated in ***Figure 3*** below, an IF-pair switching matrix allows any modem to be connected to any RF path of the two ADEs. There are four RF paths (paired for transmit and receive) available:

- *ADE 1 Ka-band*
- *ADE 1 X-band*
- *ADE 2 Ka-band*
- *ADE 2 X-band*

Each RF path can be connected to a single modem, or no modem, depending upon configuration. The four paths can be used simultaneously, depending on satellite features and satellite resource allocation.

Figure 4: The Cobra Antenna Diversity System viewed from the rear, showing the switch matrices internally and connectors for multiple modem connections on the rear panel.

Figure 4 shows the ADS from the rear, with its top panel removed. Supporting multiple modems, some with different interfaces, as well as multiple RF outputs and management interfaces, means that the ADS also serves as a convenient single 'wiring' hub.

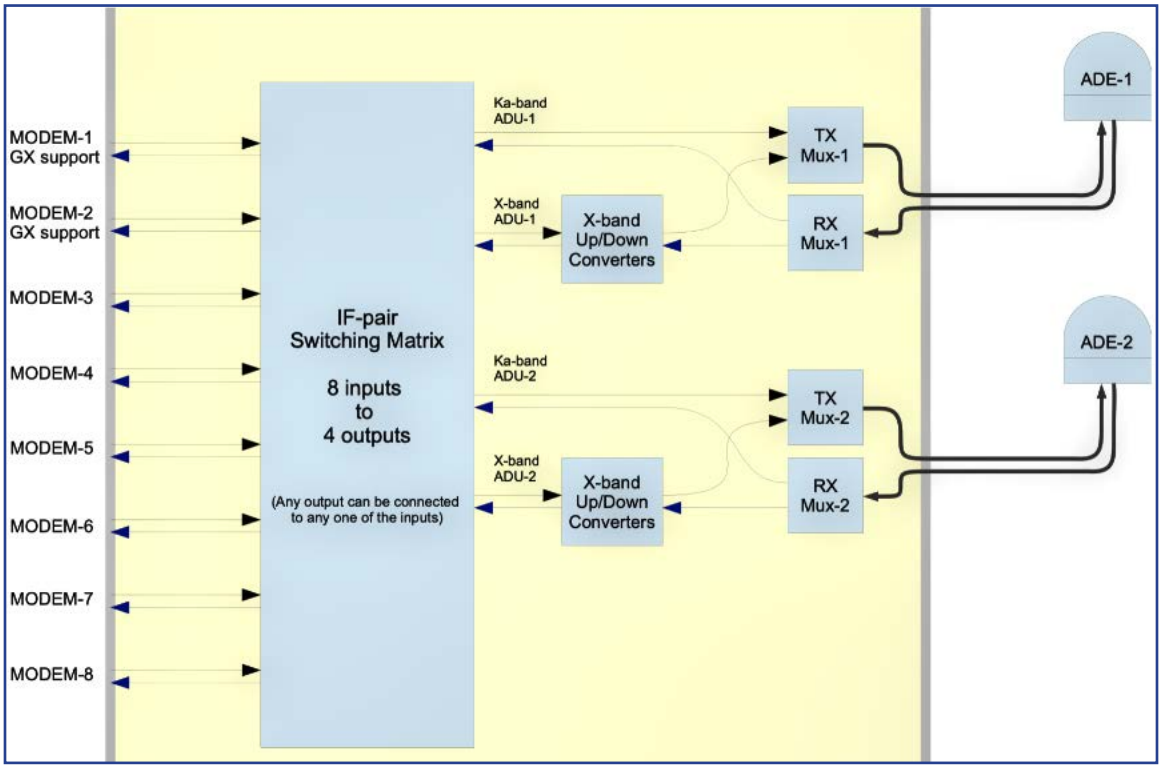


Figure 3 shows the simplified functional block diagram of the modem selection function.

Example Usage Scenarios

On the following feature page, various usage scenarios for a defence customer are based on operation across two military satellites (*for example, WGS and Optus C-1*) and one commercial satellite (*Inmarsat GX*). Other satellite systems can be added into the ADS operation as required.

Single Satellite Look Handover mode (obstruction mitigation)

In this mode, the BDU configures both ADEs to track the same satellite, but only one ADE at a time is allowed to transmit to the satellite. The BDU selects which ADE to connect to the active modem(s) to avoid obstruction outages. This is illustrated in ***Figure 5*** *and* ***Figure 6****.*

The target satellite can, for example, be from the WGS or other MILSATCOM network, or from the Inmarsat GX network. When operating on a Military satellite with multiband capability, the active ADE can simultaneously support both an X-band and a Ka-band carrier.

As the ship maneuvers, the below deck unit (BDU) monitors how close each ADE is to an obstruction. The configured wooded arcs and exclusion zones are used as the definition of obstruction zone.

The BDU will switch between ADEs if the active ADE becomes too close to an obstruction and the other ADE is not obstructed. The threshold for switching is user configurable.

*To minimize outages during ADE switch over, the BDU supports the tactical modem's "**Antenna Handover**" features (if available) and also complies with the Inmarsat GX antenna handover process.*

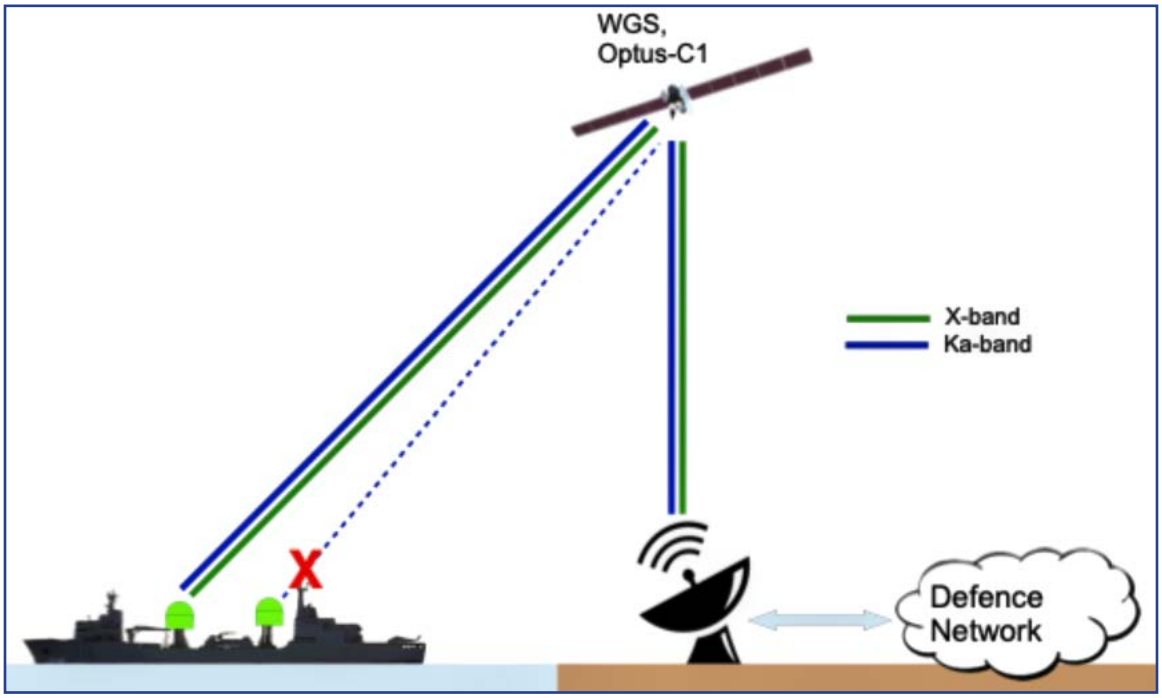


Figure 5: Dual antennas in handover mode operating on a military satellite.

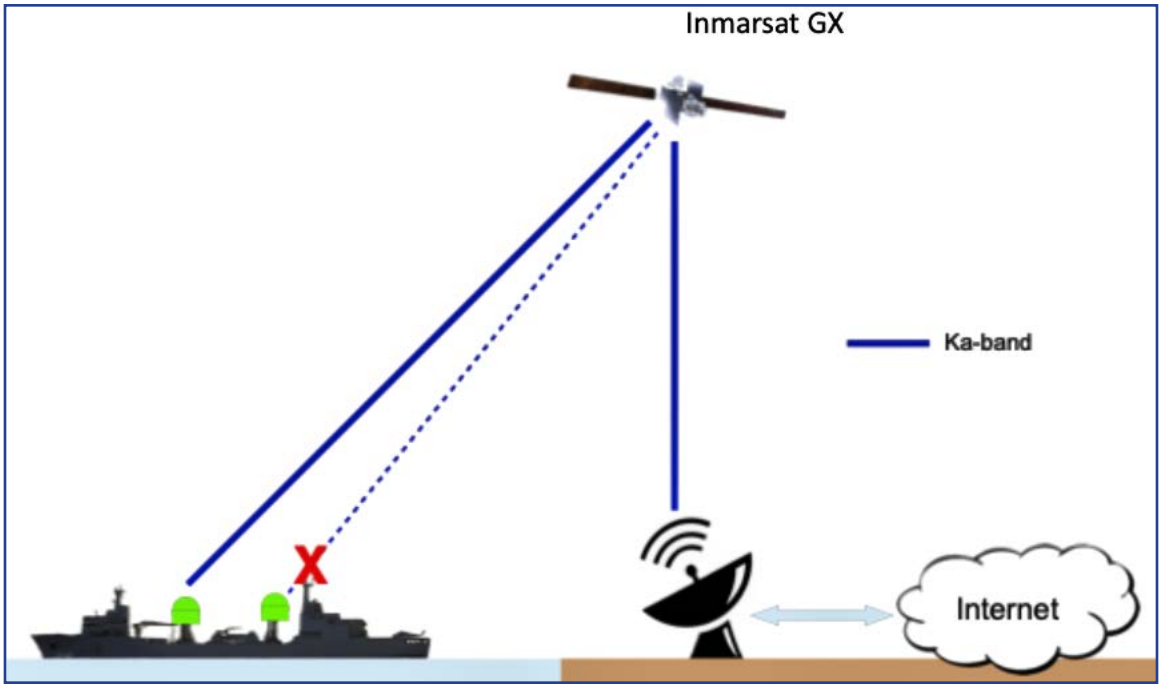


Figure 6: Dual antennas in handover mode operating on Inmarsat GX.

Independent ADEs Mode

In this mode, the system configures the ADEs to operate independently. Each ADE can either track the same satellite, or different satellites (when supported by the network). This is illustrated in ***Figure 7*** *and* ***Figure 8*** on the next feature page.

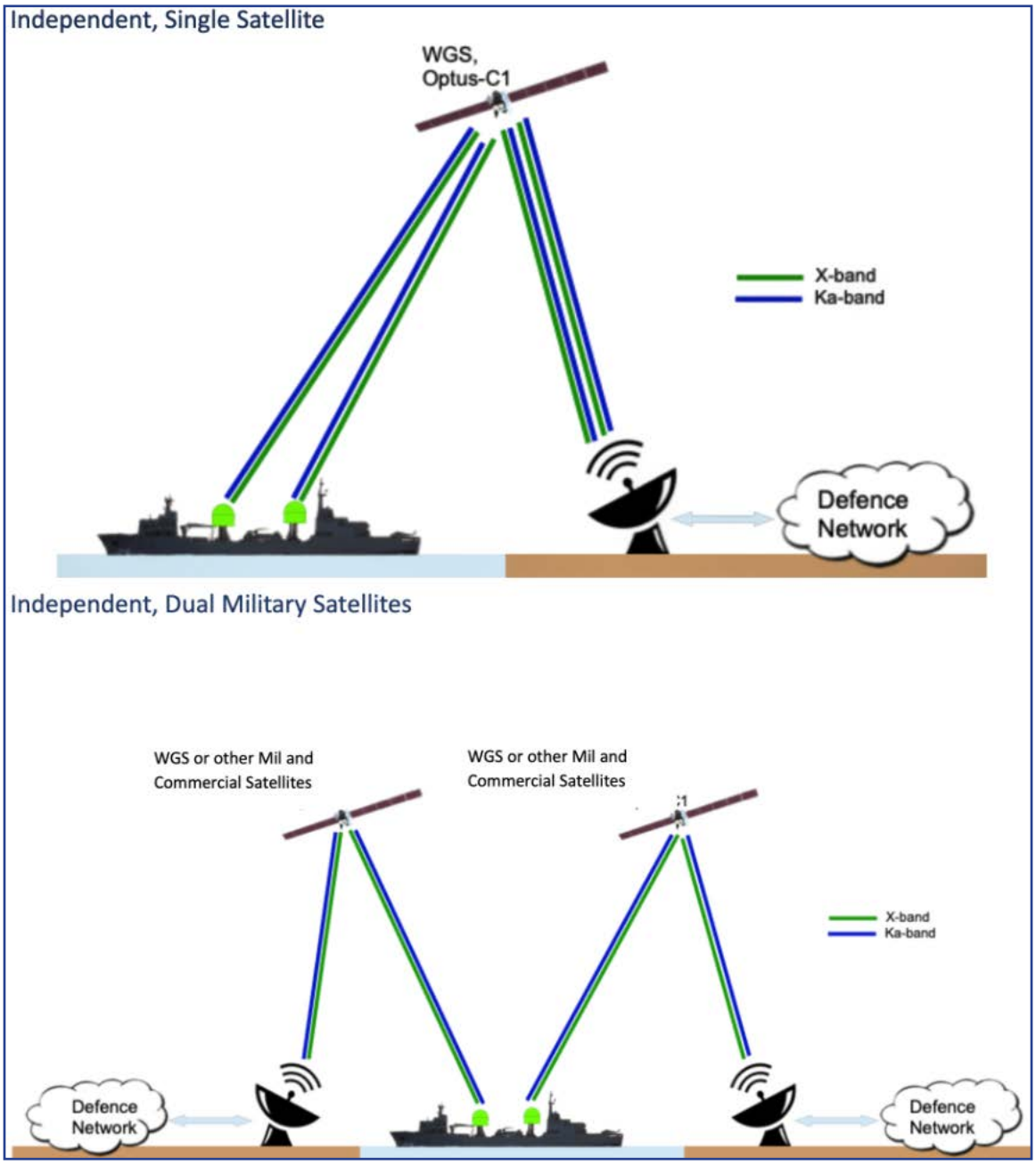


Figure 7 (top): Independent ADEs operating on single satellite.

Figure 8 (bottom): Independent ADEs operating on separate satellites.

Providing resilient, high availability satellite communications is the job of both the satellite network operator and the ground terminal provider.

Today, terminals such as the Cobra or Fleet that switch automatically between satellites and frequency bands can provide redundancy in the space segment. Redundancy on the ground can be provided, as well, with dual terminals and the flexibility to configure them in such a way that traffic flow continues uninterrupted when one terminal is blocked or fails.

Systems such as EM Solutions' Antenna Diversity System provide such flexibility, and strengthen the resilience required of high availability broadband satellite communications.

References

[1] "Robust Satellite Tracking On The Move," R. J. Gilmore, MilsatMagazine, March 2017.

[2] "Equipping Defence Forces for Assured On-the-Move Communications", R. J. Gilmore, MilsatMagazine, October 2016.

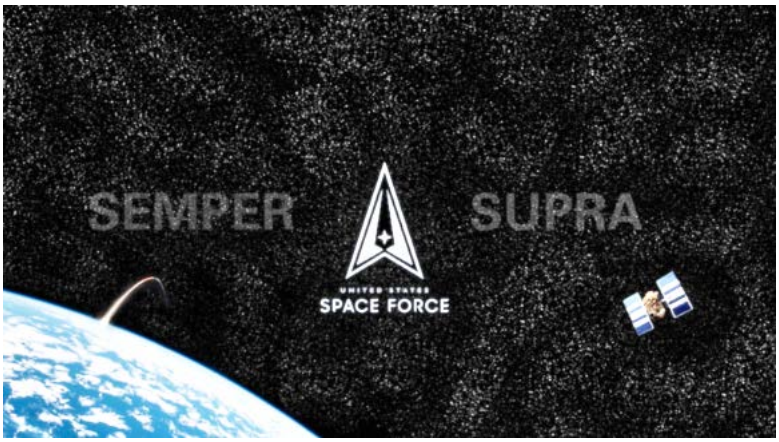
www.emsolutions.com.au

Author Dr. Rowan Gilmore joined the EM Solutions Board of Directors in 2007 and became Chief Executive Officer in October 2011. His role as CEO is to lead EM Solutions to achieve its vision to inspire customers globally, as a trusted technology developer of the most innovative microwave and on-the-move radio and satellite products that help to deliver high speed telecommunications anywhere in the world.

His previous experience includes Vice President, Engineering at Compact Software, where he introduced the world's first harmonic balance nonlinear circuit simulator, and as Vice President, Network Services Europe for SITA-Equant, the global airline IT company, now part of France Telecom's Orange network. Most recently he was CEO of the Australian Institute for Commercialization, where he helped numerous start-up companies and worked to accelerate technology transfer between research institutions and industry.

Rowan obtained his D.Sc. in Electrical Engineering from Washington University in St Louis. He is an adjunct professor of Electrical Engineering at the University of Queensland, and was elected a Fellow of the Academy of Technological Scientists and Engineers in 2009. Rowan will be known to many in the microwave engineering community who have attended his short courses on microwave circuit design and RF wireless systems offered by Besser Associates and CEI Europe since 1990.

U.S. Space Force Unveils Their 'Vision For A Digital Service'



Building on formal guidance issued last fall by the Chief of Space Operations to "*Create a Digital Service to Accelerate Innovation***," a new document outlining *U.S. Space Force*'s "***Vision for a Digital Service***" has just been released. The Vision provides a clear description of what it means to be a "***Digital Service***" and outlines the four areas of focus essential to making this vision a reality.**

Acknowledging that space is the only physical domain without humans in place to conduct military operations, the digital vision document states "*everything our operators experience is derived through data received from space and our ability to rapidly analyze that data to our advantage*."

The document goes on to describe how the characteristics of the space operating environment and the growing threat presented by near-peer competitors generate an imperative to undergo large-scale cultural and technical transformation.

General John W. "Jay" Raymond.

"*The establishment of the United States Space Force gave us a generational opportunity to create a Service purpose-built for a contested space domain*," said Chief of Space Operations Gen. **John W. "Jay" Raymond**. "*Moreover, we are in a unique position because of the global, data-driven nature of our mission to harness data and analytics across the enterprise and serve as a change agent for the entire Department of Defense*."

The *Vision for a Digital Service* is founded on three key tenets that provide a pathway to a faster, more innovative, and agile service designed to meet the unique demands of the space operating environment: an Interconnected, Innovative, Digitally Dominant force.

- *First, an Interconnected force effectively and efficiently shares relevant information with a broad array of stakeholders in support of the mission.*
- *Second, an Innovative force routinely embraces new approaches and readily challenges the status quo.*
- *Third, a Digitally Dominant force depends on people – establishing an empowered, digitally fluent workforce that advocates for innovation from every angle.*

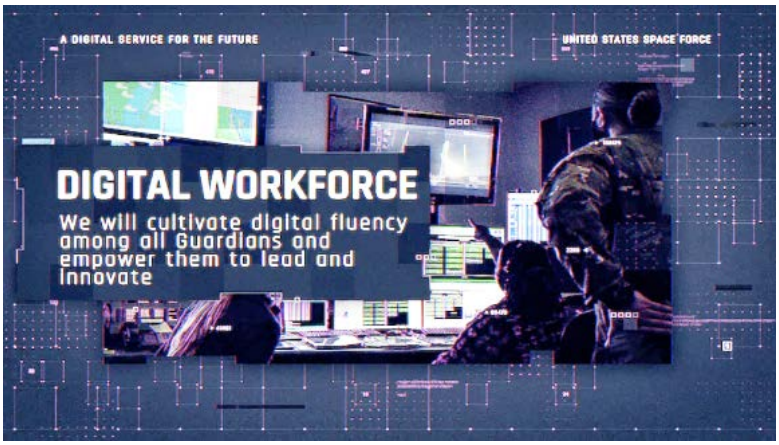
Informed by these tenets, the Vision for a Digital Service outlines four focus areas that serve as lines of effort for the necessary digital transformation Guardians must lead to achieve this vision:

Digital Engineering

The Space Force will foster an interoperable, resilient, and secure *Digital Engineering Ecosystem* (*DEE*) that will enable *Guardians* across the force to rapidly mature innovative concepts into integrated solutions and deliver critical warfighting capability faster.

Digital Workforce

The Space Force will attract, educate, develop, and retain the vital talent they need to cultivate digital fluency among all Guardians, and the USSF will equip and empower them to unleash their talent and energy toward bold, innovative solutions.

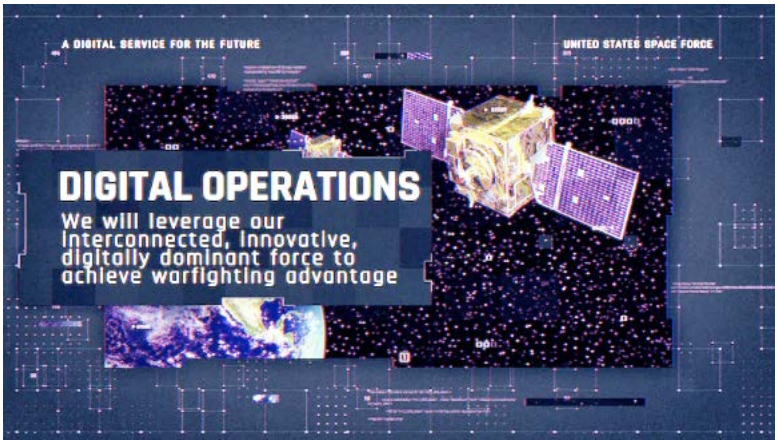


Digital Headquarters

This focus area refers to a function, rather than a location – it represents the ability for all Guardians to make decisions efficiently by removing layers of bureaucracy and enabling and incentivizing data-driven decision making.

Digital Operations

The Space Force will drive joint, all-domain solutions in, from, and to space, exploiting advantages provided by interconnected infrastructure and an innovative, digitally-fluent workforce.



The Digital Vision will be accompanied by a subsequent Transformational Roadmap product that will delve into more detail and identify the key ongoing and planned actions required to make progress toward achieving the Vision. The roadmap is expected to be released in summer of 2021.

Paradigm's SWARM950 Is Now Intelsat Flex Service Certified

Paradigm's SWARM950 **is now an** ***Intelsat*** **certified terminal, offering greater flexibility to operatives who need high performing, ultra-portable VSAT terminals with military-level security.**

Authorized to operate on the ***Intelsat Flex*** service, this latest qualification complements Paradigm's existing range of terminals with TRANSEC/FIPS140-2 capability, which includes the compact, rugged HORNET950, popular with military units and special operational forces across the globe. Paradigm HORNET.

Powered by Paradigm's proprietary PIM® technology, the SWARM950 offers extreme user-simplicity through a common terminal interface that has revolutionized the ease of pointing and operation. The integration of modem, router, satellite alignment tool, management and power distribution, is conducive with rapid deployment and minimal training. Paradigm PIM.

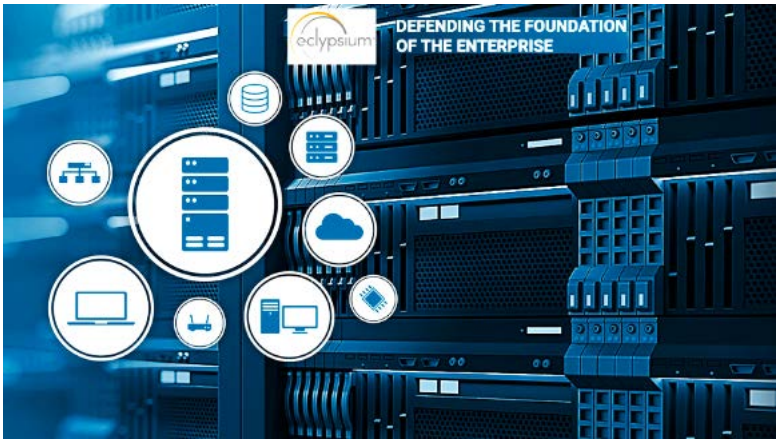
Paradigm's General Manager, **Jon Godfrey**, said, "*We've seen a significant upturn in demand for our own terminal range since the introduction of the Paradigm Interface Module (PIM), which is leading the industry's advance towards more intuitive, simple user interfaces.*

Jon continued, *"Although we've kept the PIM technology terminal-agnostic, our military clients have naturally sought the same level of performance and reliability across their VSAT arsenal and so gravitated towards Paradigm terminals. When you consider this high level of confidence alongside the ruggedness, high throughput, ultra-portability of the SWARM950, it makes for a compelling proposition. The SWARM has an extremely strong record in the field on major networks, so we're delighted that the extended iDirect950 modem capability has been keenly supported by Intelsat with whom we have a longstanding partnership. This latest qualification supports our objective to give users real confidence, however critical the mission, wherever they are in the world.'"*

Eclypsium's technology provides comprehensive device visibility and defends against vulnerabilities and threats hidden within devices. This lower level of visibility is essential to a resilient cybersecurity strategy.

"*Nation states represent a significant, persistent cyber espionage and attack threat to our military and critical infrastructure systems*," said **John Loucaides**, VP Federal Technology at Eclypsium. "*As adversaries continue to expand their capabilities into the many devices in our infrastructure, the DoD must deploy the most advanced cyber defense measures available. We are pleased that they have chosen Eclypsium to bring more holistic device visibility and security across an array of devices, components, and environments to the Air Force.*"

Eclypsium Awarded AFWERX SBIR Phase One Contract To Explore Into USAF Use of Enterprise Security Platform



Eclypsium®v has been awarded a U.S. Air Force, AFWERX Small Business Innovation Research (SBIR) Phase 1 contract.

This contract will allow Eclypsium to conduct feasibility studies with the *Department of Defense* (DoD) to demonstrate how the company's enterprise device security platform supports unprecedented device visibility, risk management as well as threat detection.

With ongoing supply chain attacks burying deep into critical information technology assets, little-known firmware and hardware components stand as some of the highest impact, most unguarded threats facing modern organizations.

The risk posed to government systems has become far more widespread, due to the availability of tools, hardware and firmware knowledge, and the wealth of vulnerabilities for attackers to target.

Kratos 1st Company To Exhibit The Optimization Of Wideband SATCOM Using Enterprise Management and Control

Kratos Defense & Security Solutions, Inc. (Nasdaq: KTOS) has been the first company to successfully exhibit an integrated SATCOM capability that provides real-time Situational Awareness (SA) to an operationally secure environment.

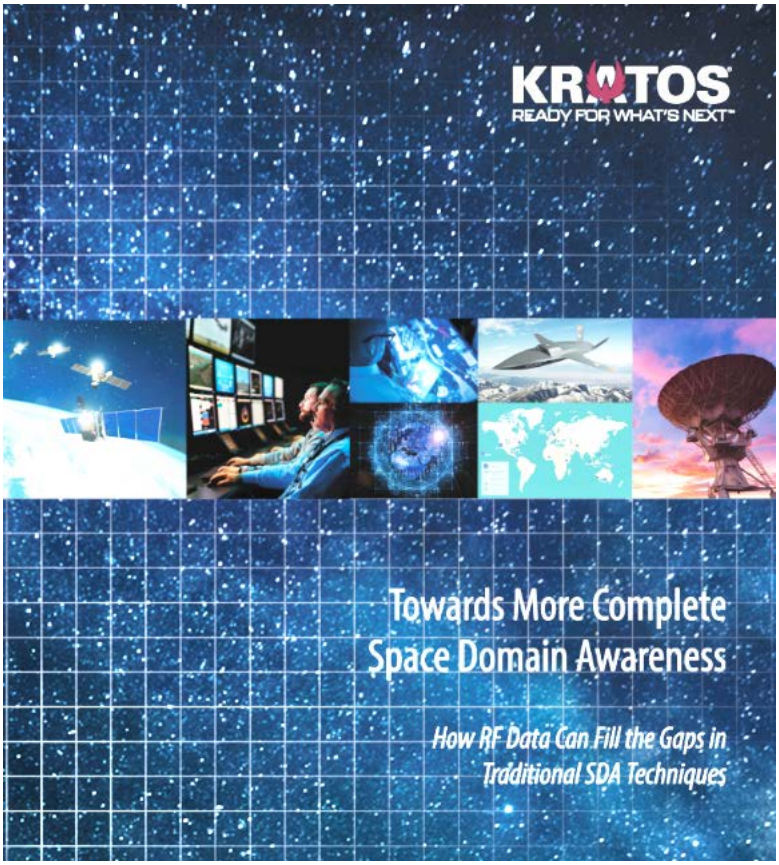
The demonstration included roaming among different networks to optimize wideband satellite communications (SATCOM) using *Enterprise Management and Control* (EM&C). EM&C is an effort by the *Department of Defense* (DoD) to plan, initiate, monitor and restore rapid, automated access to hybrid satellite constellations and networks, operated by various service providers.

The demonstration was part of a multi-national *Joint All Domain Command and Control* (JADC2) demonstration hosted by U.S. European Command, U.S. Air Forces in Europe and Air Forces Africa, and the Department of the Air Force Chief Architect Office. EM&C capabilities provided by Kratos and its industry partners highlighted a means for providing real-time satellite communication end-to-end connectivity status and operational readiness including spectral data, link and equipment status and detecting/geolocating electromagnetic interference (EMI).

The event also highlighted a method to restore satellite service in response to interference and the capability to gather and fuse information from sensors and satellites through the ***Unified Data Library*** (UDL) which is a U.S. government owned, cloud-enabled database accessible by the DoD and coalition partners. The capabilities available through EM&C are important as they support real-time warfighter communication across domains in times of war or conflict.

EM&C is an important strategic goal of the military to effectively operate an integrated SATCOM enterprise by increasing assured SATCOM access for the warfighter with legacy and next-generation terminals. It improves the effectiveness of the DoD's critical SATCOM infrastructure by enhancing resilience and giving more satellite link choices, reducing resource allocation times and improving bandwidth efficiency.

Funding for the recent European demonstration was provided through the Air Force Life Cycle Management Center Advanced Battle Management System (ABMS) Broad Agency Announcement, of which Kratos is an award recipient. Kratos' partnered with Knight Sky, LLC., for terminal and Gateway equipment supporting the Flexible Terminal Interface (FTI), and SES Government Solutions (SES GS) to provide SATCOM capacity.



Lieutenant Colonel **Gary Thompson**, Chief, Fighting SATCOM Capability Integration, SMC SATCOM Capability Integrator Office said, "*This demonstration of EM&C helped the warfighters better understand the key satellite links used for communication and enabled precision identification, characterization, and troubleshooting of interference along the long-haul communication pathways. In addition, utilization of the UDL allowed the sharing of critical information across the joint forces for timely, fused situational awareness and lethality.*"

Space Micro Receives Five Contracts From U.S. Government Programs

Space Micro Inc. received five, separate, SBIR contracts to develop and enhance Space Micro products for scientific, defense and dual purposes. These Q1 2021 awards were received from U.S. Army, U.S. Air Force AFWERX and NASA.

Space Micro stated that their core expertise in developing and orbiting reliable radiation-hardened space subsystems, including communications (RF and optical), processors and cameras, provided a foundation for the award-winning proposals:

U.S. Army: STTR contract for "*Machine-Learning Based Sensing and Waveform Adaptation for SDRs Operating in Congested and Contested Environment*."

U.S. Air Force AFWERX: STTR contract "Modular Software Defined Radio for Resilient SATCOM" to enhance Space Micro's ***Nanocom™ Software Defined Radio (SDR)*** for new U.S. Space Force programs, including smallsats and cubesats.

NASA: Phase I SBIR award for "*Radiation Tolerant Artificial Intelligence (AI) Processing in Space*."

U.S. Air Force AFWERX: Phase 1 SBIR contract for "*SpaceCam: A Dual Use Space Imaging and SSA Camera*" to further enhance Space Micro's ***SpaceCam™*** cameras.

U.S. Air Force AFWERX: Phase 1 SBIR award for "*Multi-Layered Space Communications Full Duplex RF-to-Optical Converter for SATCOM*."

"*These SBIR awards add to the $50M in government investment in Space Micro products we've received over the past two decades as we've successfully engineered highly reliable, space-qualified and flight-proven technologies*," said **David J. Strobel**, Space Micro CEO.

The USAF's AFWERX Awards Solstar Space With An SBIR Phase 1 Contract

***Solstar Space* has been awarded a U.S. Air Force, *AFWERX* SBIR Phase 1 contract — as a participant in the Phase 1 cohort.**

Solstar Space will conduct feasibility studies with the *Department of Defense* (DoD) to demonstrate how the company's onboard, satellite *Critical Data Relay* supports continuous connectivity and provides vital global communications for spacecraft in LEO orbit.

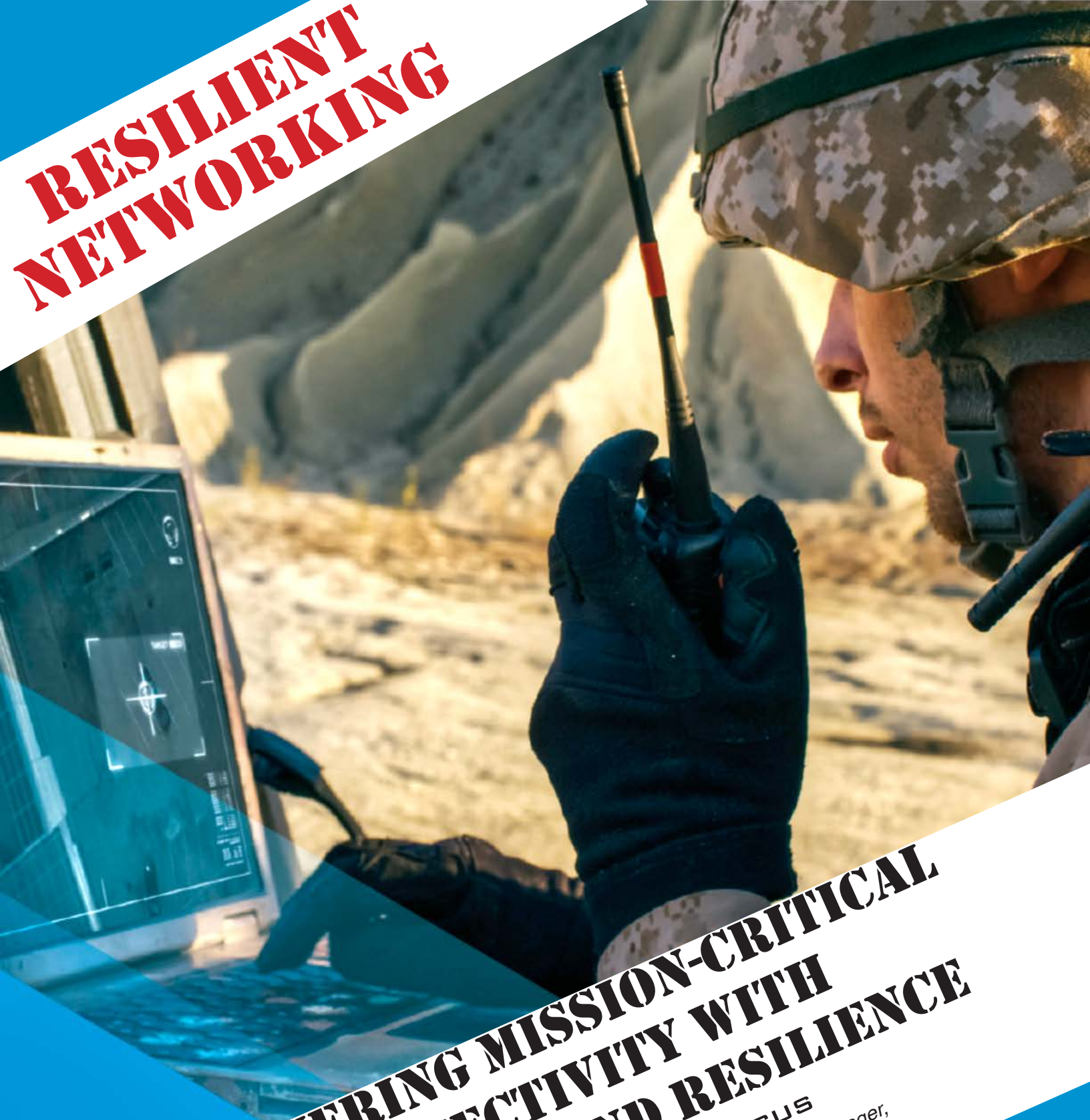
LEO smallsat operators, including the DoD, have limited opportunities to communicate with spacecraft to ensure optimal operation.

Troubleshooting of any issues is constrained to pass over windows where downlink stations are available leading to downtime, protracted recovery processes, and risk for catastrophic loss.

Continuous 24/7 connectivity through a space-based IP network will seek to increase asset utilization and efficiency while mitigating risks associated with limited communications links.

"*Space-based connectivity is critical to providing immediate notification of spacecraft anomalies and to support worldwide recovery command capabilities," said M. Brian Barnett, Founder and CEO, Solstar Space. "Under this Phase 1 contract, the practicability of Solstar's short burst data (SBD) services and the Critical Data Relay will be assessed.*"

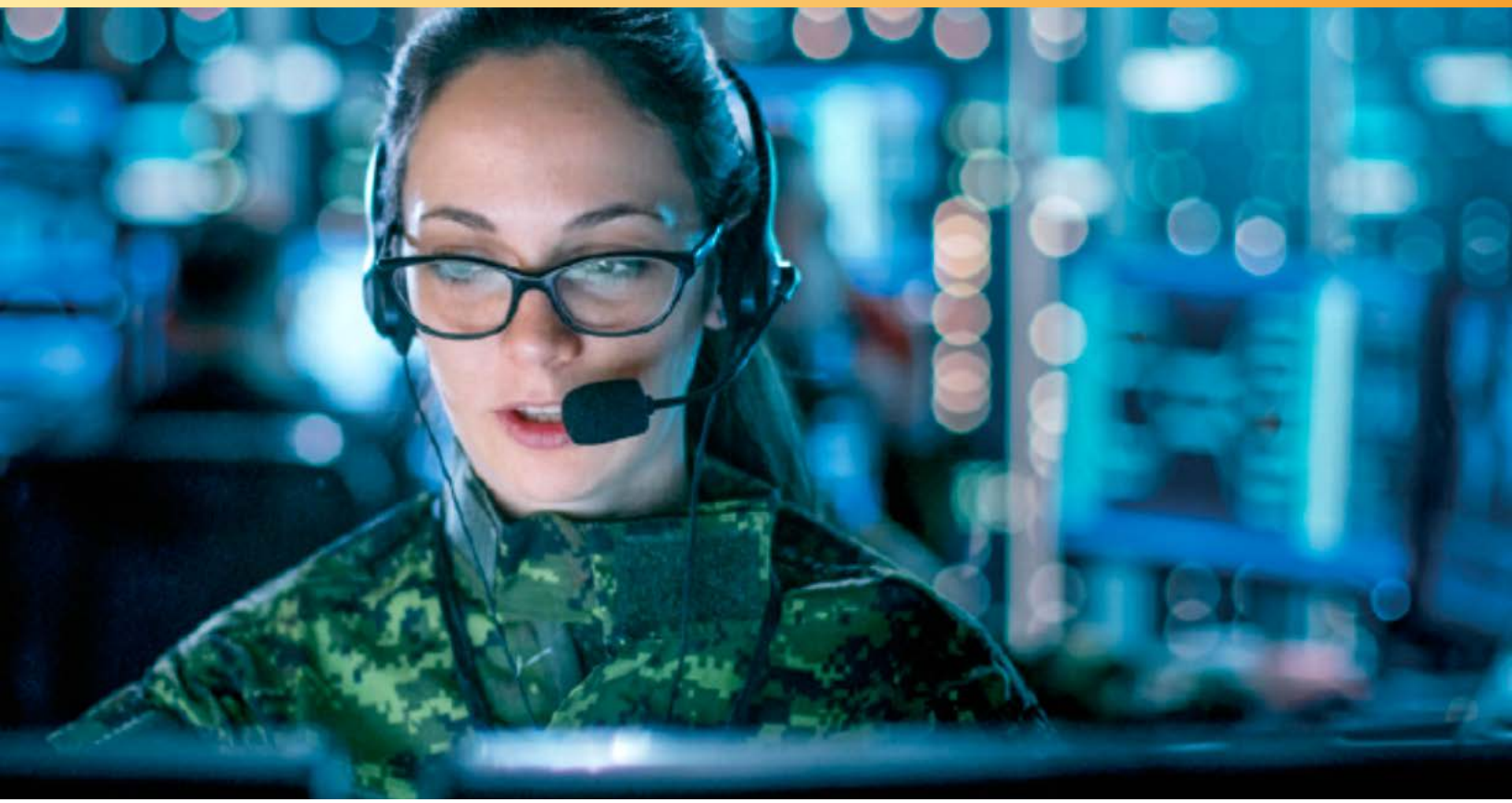
RESILIENT NETWORKING



DELIVERING MISSION-CRITICAL CONNECTIVITY WITH RELIABILITY AND RESILIENCE

A Hughes Tech Focus

Author: Rick Lober, Vice President & General Manager, DISD, Hughes Network Systems.



For several years, the U.S. Department of Defense (DoD) has been calling for SATCOM flexibility and interoperability.

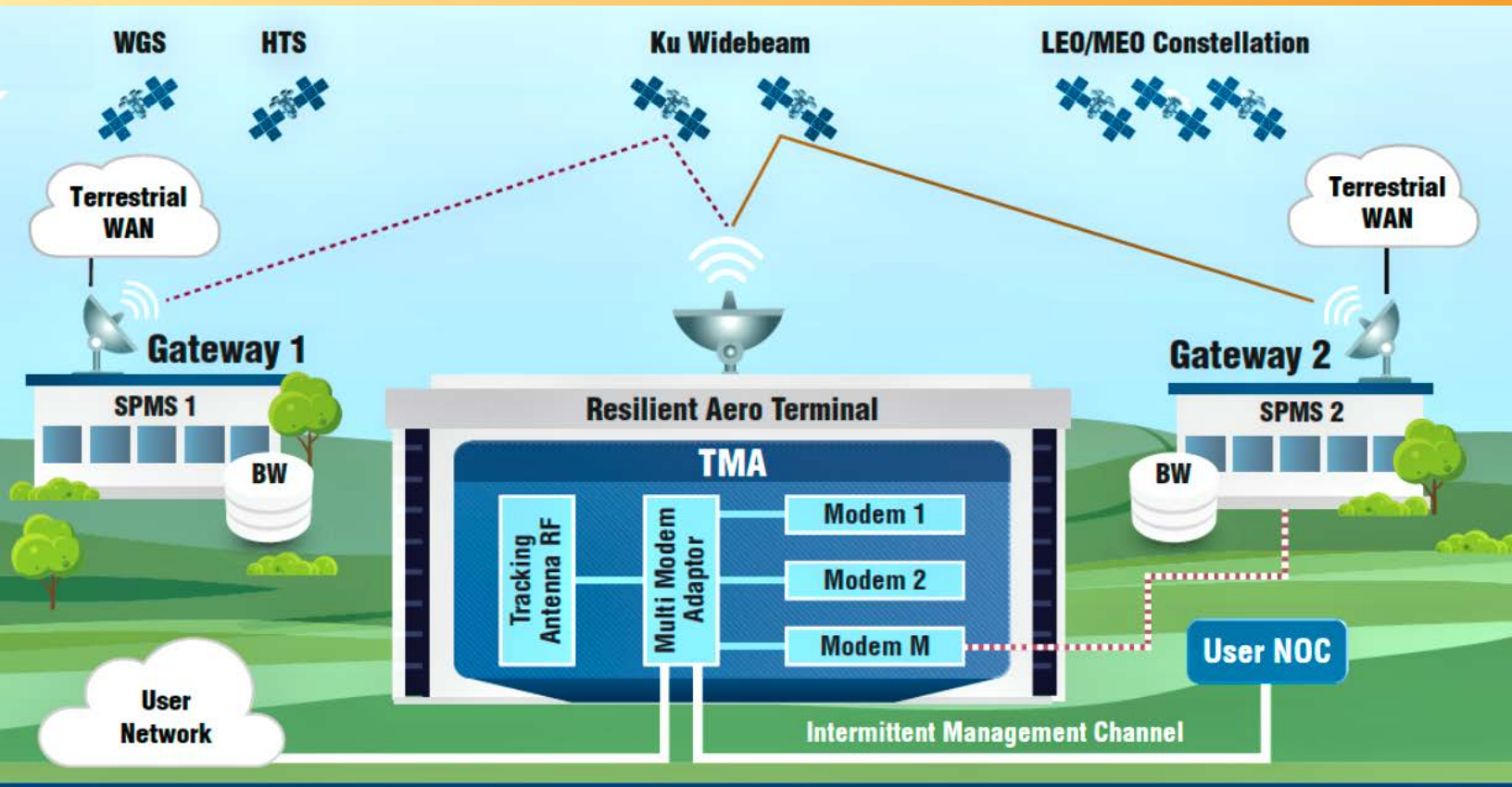
Indeed, in 2017, DoD tapped Hughes for a study to help assess the ideal hybrid White Paper | Resilient Networking: Delivering Mission-Critical Connectivity with Reliability and Resilience SATCOM architecture and how diverse systems can work together. Hughes, based on experience with satellite networking for critical infrastructure operations, recommended that DoD pursue a SATCOM strategy that supports interoperability for wideband government applications to enhance communications infrastructure and reduce acquisition and operations costs.

Now, just three years later, DoD has the key to unlocking the resilient networking they need to deliver on their missions, regardless of service provider, equipment manufacturer and geography. What's more, operators of critical infrastructure worldwide can now implement modern, resilient solutions.

INTRODUCING THE HUGHES TERMINAL MANAGEMENT AGENT (TMA)

Hughes TMA makes networking resilient. Agnostic with regard to provider and manufacturer, TMA automates functions that used to require lengthy and often dangerous field visits. Based on DoD standards for modem and terminal interfaces, which Hughes helped design, TMA delivers the ultimate in SATCOM flexibility, ensuring resilient networking for land, aero and maritime communications.

> *At the end of the day, anyone who's using satellite communications doesn't really care where that information comes from. They really want to know that when they need to use their radio they can use it, and if there's somebody trying to counter them using that radio, that there's an ability for them to pivot to an alternative communications mechanism, because what they care about is getting their message across.*
>
> *— Lt. Gen. Bill Liquori, September 9, 2020*



The Hughes Terminal Management Agent (TMA) powers autonomous satellite terminal control for increased resiliency across diverse modems, services, satellites, and service providers.

HUGHES TERMINAL MANAGEMENT AGENT

Based on an Artificial Intelligence (*AI*) rules engine, the Terminal Management Agent (TMA) from Hughes is a ground-breaking, custom-developed software feature within a satellite terminal that interconnects seamlessly with various satellite modems, regardless of manufacturer or satellite system.

Powering the ultimate in SATCOM flexibility, TMA overrides stove-piped systems to enable user access to diverse platforms from a single terminal — ensuring the reliability and expediency that are essential for defense resilient networking.

RESILIENCY — TWO ORDERS OF MAGNITUDE IMPROVEMENT IN DECISION MAKING

TMA is a transformational software technology, inspired by the industry-leading commercial SD-WAN product from Hughes, and augmented with an AI rules-engine for flexible adaptation for defense needs. Instead of manual reconfigurations which can require hours and days of coordination, TMA can orchestrate within seconds and minutes.

TMA can command terminal modems and antennas automatically based on mission needs specified as executable policies that cover: spectrum priority, spectrum availability, waveforms, networks and operational environments.

With a small software footprint, TMA can be hosted on a terminal computer Virtual Machine (VM) or a small dongle. The software can send and receive RF, device, and cyber monitoring data to and from a management system and is compatible with modern, open enterprise management architectures.

MANAGEMENT AND CONTROL — COMPATIBLE WITH MODERN ENTERPRISE APPROACH

TMA is fully compatible with modern enterprise management and control architectures and can interact with the GNOC over an intermittent channel. TMA autonomously orchestrates various resources, based on mission/service planning policies from the GNOC, to achieve service efficiency, priority and assurance objectives.

With local decision-making, TMA benefits from the GNOC's global guidance in the use of specific satellites, service providers, and resource pools. TMA also collects and provides useful situational awareness data for RF, equipment, and cybersecurity for data analytics and machine learning for future policy refinement.

CYBERSECURITY — PLUG-IN MODULES FOR IPS/IDS

TMA uses a **Commercial-Off-The-Shelf** (*COTS*) **Intrusion Prevention/Intrusion Detection** (*IPS/IPD*) software appliance that monitors traffic transported by each terminal modem via the common Layer 2/Layer 3 packet switch under TMA control.

The IPS/IDS software appliances provide packet-level policing, filtering, and control in both directions (from and to the user network) under guidance from **Global Network Operations Center** (*GNOC*)-based policies.

ANTI-JAMMING — RAPID SWITCHOVERS

With threats to critical communications networks on the rise around the world, TMA adapts to evolving landscapes and brings security measures to the network edge for both monitoring and rapid orchestration.

TMA fortifies terminals against localized jamming by enabling automated and rapid switching among different modems, satellites, and services.

SITUATIONAL AWARENESS — DATA FOR MACHINE LEARNING AND DATA ANALYTICS

TMA monitors various terminal components, collects data and forwards it to the GNOC for global optimization based on data mining and analytics, including:

- *Health monitoring of various terminal components and functions*
- *Signal and noise measurements to assess purposeful and accidental RF interference*
- *User traffic data rates, packet loss and delays*
- *Cybersecurity incidents and malware activities*

BANDWIDTH AND COST — BENEFIT FROM HTS SATELLITES

TMA allows critical application domains to leverage highly cost-effective High-Throughput Satellite (HTS) services which can coexist (with the use of an HTS modem providing managed service in a TMA-equipped terminal) with other mission specific modems and service providers.

TERMINAL MODERNIZATION — HIGHEST RETURNS WITH SIMPLE SOFTWARE UPGRADE

The military typically uses different types of terminals for aeronautical, land, and marine applications. Equipped with auto-pointing — and, often, auto-tracking — antennas, these terminals can be modernized easily and cost-effectively with TMA to roam automatically across multiple service providers, by using their respective modems—and leveraging HTS services.

AI RULES ENGINE – AUTONOMOUS DECISION MAKING AT EDGE

Using an AI rules engine, TMA provides autonomous decisions based on performance, cybersecurity and fault data from terminal components and surrounding conditions.

Covering areas such as terminal state determination, cybersecurity-related sensing, jamming assessment, satellite handover, and modem handover, executable rules formulate knowledge and parametric reasoning that traditionally field engineers have used for any terminal reconfiguration.

To continuously refine the rules, the GNOC processes situational awareness data from the TMA, using pattern recognition, data analytics, and machine learning techniques. The TMA can execute these rules even with an intermittent terminal management channel (either in-band or out of band).

How a rules-engine monitors terminal state and uses rules in decision making:

Some examples of these rules are shown on the following article page...

TMA will be enhanced to control multiple antennas for concurrent use across services in order to manage load-balancing and traffic prioritization objectives and support **Non-Geostationary Satellite Orbits** (*NGSO*), including both ***Medium Earth Orbit*** (*MEO*) and ***Low Earth Orbit*** (*LEO*) constellations.

A fully digital design with ***Field Processing Gate Arrays*** (*FPGA*) will support multiple modem waveforms with reduced ***Size, Weight and Power*** (*SWaP*).

The ***Hughes Terminal Management Agent*** is ready today for aero and terrestrial applications.

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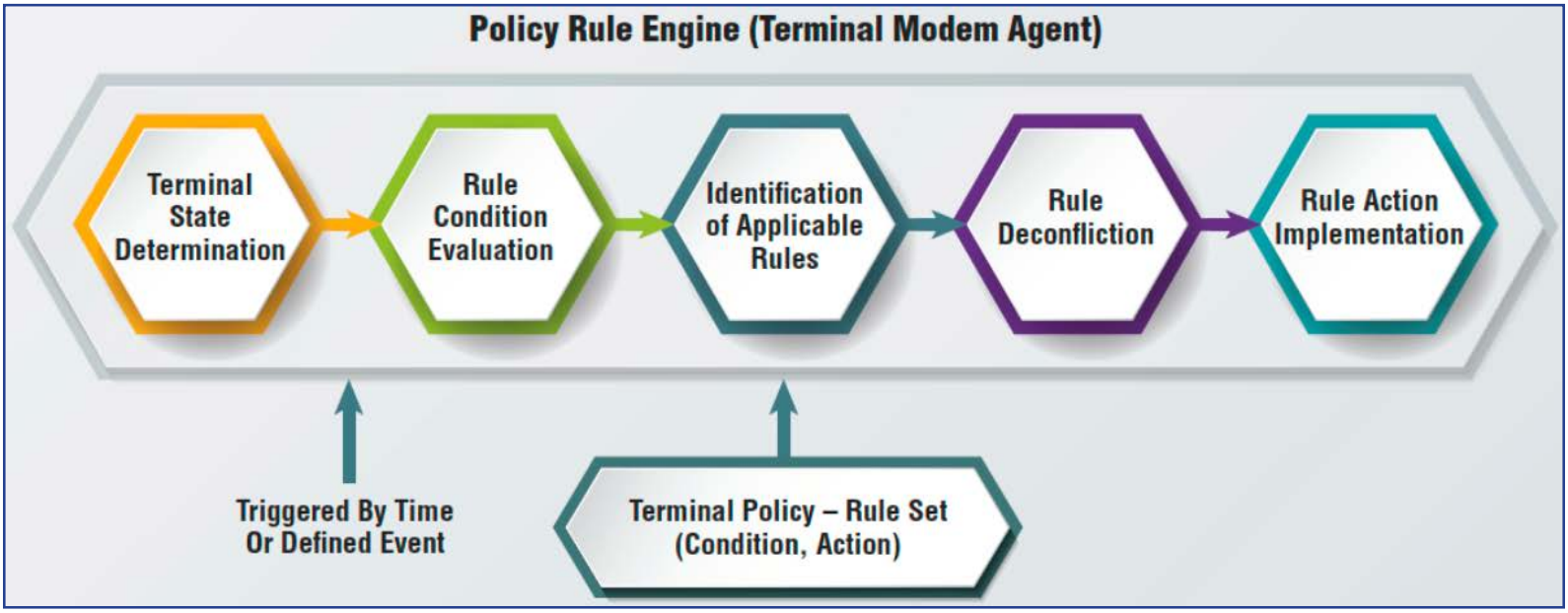

Terminal Rules	Rule Attributes	
	Description	Parametric Values
Transport Service	Described by SLA (data rate, packet loss, delay, availability)	Service ID
Cyber State	Condition of the packet processing part of a specific modem as reported by monitoring the packet switch	Normal, Affected, Unusable
Terminal/ Modem State	Terminal/modem level state with respect to service, power, and operational status	Switched on, Switched off, In service, Out of service, Standby, Idle
RF Link State	Condition of specific satellite RF link (deduced from monitoring RF)	Normal, Affected, Jammed, Attenuated, Unusable

*The author of this Tech Focus feature is Rick Lober, the Vice President and General Manager of the Defense and Intelligence Systems Division at Hughes Network Systems,LLC. He can be reached at **www.linkedin.com/in/ricklober/?_l=en_US**.*

Rick leads the company's Defense and Intelligence System Division (DISD) in serving U.S. and allied defense and intelligence organizations worldwide with advanced SATCOM solutions, including fixed VSAT and Mobilesat systems, network management, ground and airborne communications on the move and classified programs.

Under his leadership, the Defense team has won programs such as: SATCOM for the General Atomics Predator UAV; mission management for the U.S. Air Force Space and Missile Command's Protected Tactical Enterprise Systems (PTES) and Enterprise Management and Control (EMC) program; the application of Artificial Intelligence (AI) and Machine Learning (ML) techniques for the U.S. Army's Narrowband SATCOM Network; and specialized terminal development for the U.S. Special Operations Command (SOCOM).

From his early days as a design engineer, Mr. Lober brings more than 25 years of experience with COTS and full MIL communications and intelligence programs.

Having earned a Bachelor's Degree and Master of Science Degree in Electrical Engineering from the University of Illinois, Urbana, Mr. Lober is a member of Eta Kappa Nu, Tau Beta Pi, TEC, IEEE, AFCEA, AUSA, AAAA, AUVSi and the Society of Satellite Professionals International (SSPI) and holds a patent on cellular communications for emergency response.

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OSNMA

The latest in GNSS anti-spoofing security

Author: Maria Simsky, Septentrio

As technological advances allow GPS/GNSS1 devices to become more and more reliable, our lives are becoming increasingly dependent on accurate positioning andf timing. Today, GNSS time is used to synchronize telecom and energy grids, while precise positioning is used to navigate drones and self-driving cars, as well as to automate agricultural and construction machinery.

As new use cases pop-up on a regular basis, our reliance on GNSS grows across the globe. This means that having secure, spoof-proof, communication channels between satellite and receiver becomes increasingly important to ensure ***Assured PNT*** (*Positioning, Navigation and Timing,*) especially in critical applications.

To further improve transmission reliability, the European GNSS system, ***Galileo***, has developed the **OSNMA** (*Open Service Navigation Message Authentication*) anti-spoofing service. This service allows secure, end-to-end transmission from Galileo satellites to OSNMA-enabled GNSS receivers.

OSNMA will soon be available at no cost to users and has recently moved into the final testing phase. As ESA's long-term partner, ***Septentrio*** has been contributing to the design and testing of the Galileo system since its inception 20 years ago. Today Septentrio is playing a key role in the OSNMA testing efforts, with the company's receivers being the first to authenticate live OSNMA test signals.

During a spoofing attack, modified GPS/GNSS data is sent into the target receiver, fooling it into showing a wrong location

Securing GNSS receivers against jamming and spoofing

OSNMA is one component of a vast array of technologies that protect GNSS receivers from interference.

Both jamming and spoofing are a type of radio interference that occurs when weak GNSS signals are overpowered by stronger radio signals on the same frequency. Jamming is a genre of "*white noise*" interference, causing accuracy degradation or even loss of positioning.

Spoofing is a more sophisticated form of interference that fools a receiver into calculating an incorrect location. During a spoofing attack, a nearby radio transmitter sends fake GNSS signals to the target receiver. For example, an inexpensive *SDR* (***Software Defined Radio***) can fool a smartphone into showing the user's current location on top of Mount Everest.

You might have caught some spoofing events presented in the recent news.

For example, ***C4ADS***, an NGO conducting data-driven analysis of conflict and security matters, concluded that

Russia has been extensively using GNSS spoofing to divert aerial drones from entering airspace in the vicinity of governmental figures, airports and sea ports[2].

HIGHLY SECURE ANTI-SPOOFING PROTECTION WITH OSNMA

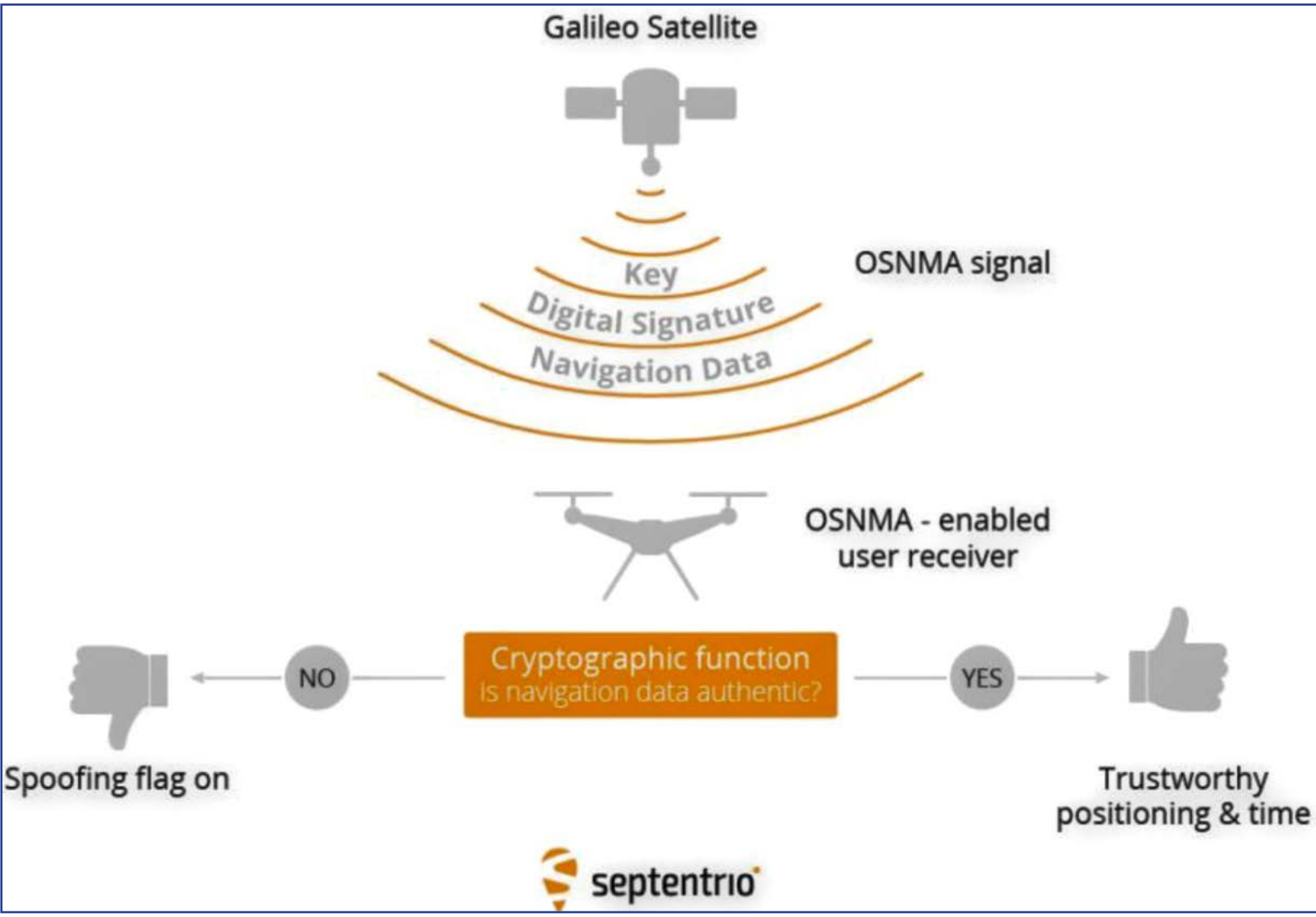
OSNMA secures Galileo signals against spoofing by enabling authentication of navigation data, which carries information about satellite location.

Navigation data security is important because any modification of this information would result in erroneous positioning calculation.

OSNMA makes use of a hybrid Symmetric/Asymmetric cryptography technique. A secret key on the satellite is used to generate a digital signature. Then, both signature and key are appended to the navigation data and transmitted to the receiver. OSNMA is designed to be backwards compatible — positioning without OSNMA will still work.

AUTHENTICATION WITH OSNMA-ENABLED RECEIVERS

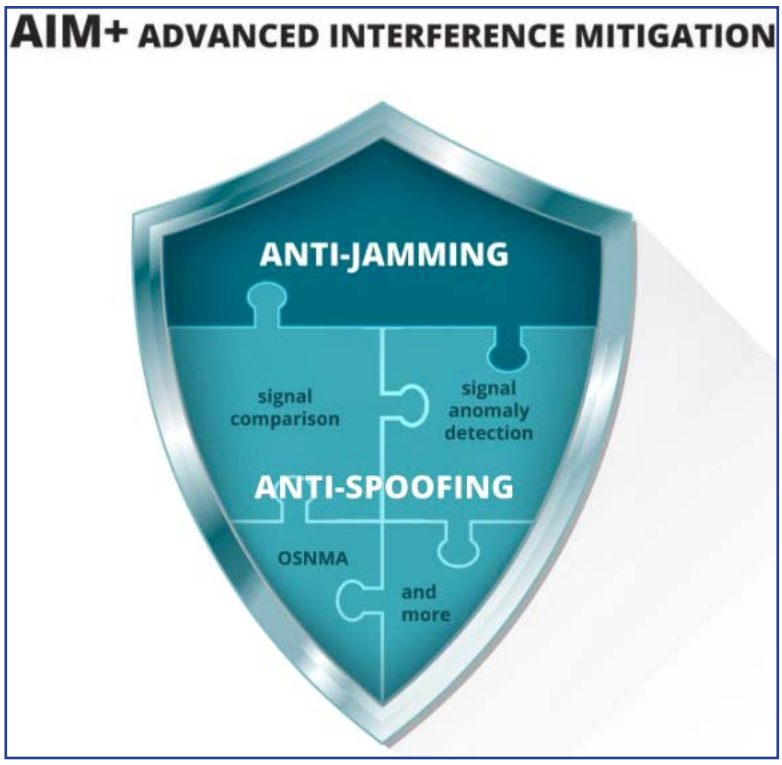
A sophisticated algorithm within the OSNMA-enabled receiver uses a public key to check the authenticity of the transmitted key. It then uses the transmitted key and the digital signature to check the authenticity of



A cryptographic algorithm inside an OSNMA-enabled GNSS receiver authenticates Galileo OSNMA signals.

the navigation data. If a satellite signal is flagged as spoofed, it is excluded from the positioning calculation.

AIM+ can also detect spoofing by searching for signal anomalies, such as unusually high power. It also works together with ***RAIM+*** integrity algorithm to ensure range (distance to satellite) validity by comparing ranging data from various satellites.



OSNMA is one piece of the puzzle comprising a sophisticated interference defense system: AIM+ (Advanced Interference Mitigation) protecting the GNSS receiver against jamming and spoofing.

AIM+ won't even be fooled by an advanced GNSS signal generator, *i.e.*, ***Spirent GSS9000***. Even with realistic power levels and valid navigation data, AIM+ still identifies the simulated signal as "*not authentic.*" Other advanced, anti-spoofing techniques, such as using a dual-polarized antenna, are currently being developed.

FUTURE-PROOF RECEIVERS FOR TODAY AND TOMORROW

OSNMA is already being implemented to secure synchronization of telecom networks in the GSA-led ***ROOT*** project, with Septentrio as a key partner. In the framework of this project, the ***mosaic-T GNSS*** module, equipped with AIM+ technology, provides resilient and accurate timing solution to mission critical infrastructure.

Various global players, such as ***Airbus***, are the first to try OSNMA authentication of live Galileo signals with specialized Septentrio GNSS receivers. The American GPS system is also developing their own authentication mechanism called ***Chimera***.

Future-proof GNSS receivers are designed in such a way that allows users to take advantage of OSNMA, Chimera and other GNSS value-added services as soon as they become publicly available. Integrating future-proof receivers in high-accuracy solutions allows companies to be the first to market with products or services offering the latest in PNT resilience.

For additional information on spoofing, access "***What is spoofing and how to ensure GNSS security.***"

[1] Global Navigation Satellite System including the American GPS, European Galileo, Russian GLONASS, Chinese BeiDou, Japan's QZSS and India's NavIC. These satellite constellations broadcast positioning information to receivers which use it to calculate their absolute position.

[2] Spoofing incidents are regularly reported in the news, read findings about ***recent spoofing attacks*** from C4ADS.

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ThinKom Selected By U.S. Army For Phased-Array SAT Terminals For COTM Options

Mobile Surveillance Solution with ThinSat®300. Photos are courtesy of Broadcast-Solutions.

ThinKom Solutions, Inc., has been selected to supply phased-array satellite terminals for a pilot program evaluating Communications-On-The-Move (COTM) options for U.S. Army Armored Brigade Combat Teams (ABCT).

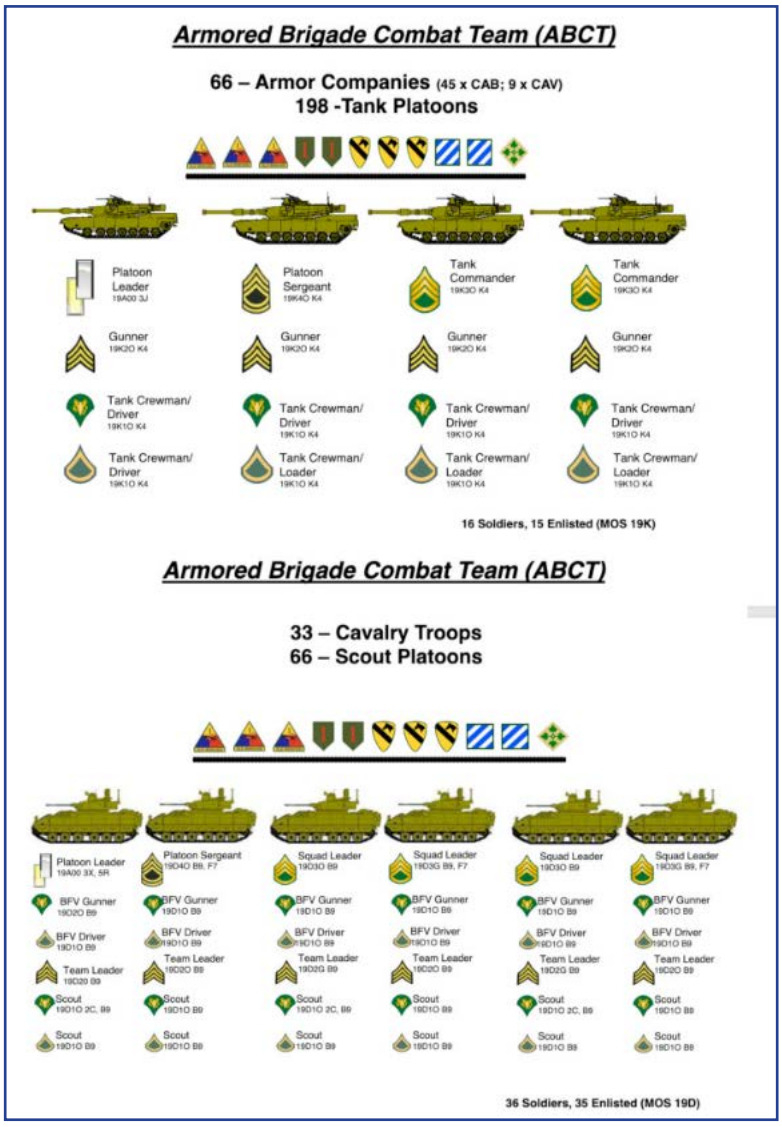
The ABCT COTM solution will integrate enhanced mobile network solutions directly onto select vehicles to make command posts more expeditionary, while enabling soldiers to retain network connectivity as they drive across the battlefield.

The Army is currently setting the stage for an ABCT On-The-Move (OTM) pilot this year to evaluate new commercial network system prototypes integrated onto select ABCT vehicles. The goal is to enhance mobile battlefield ABCT network communications, mission command, situational awareness and ultimately unit lethality.

ThinKom **ThinSat® 300** vehicular satellite antennas were acquired by ***General Dynamics Mission Systems*** for testing as a design option for mounting on command-post vehicles in armor formations. As a subcontractor, ThinKom provided these three antennas as part of the U.S. Army's contract award to General Dynamics to support integration, engineering and fielding services for the ABCT COTM experimentation effort.

The Ku-band ThinSat 300 antennas are based on ThinKom's patented and proven *Variable Inclination Continuous Transverse Stub* (*VICTS*) phased-array technology. VICTS antennas are currently deployed on 1,600+ aircraft with more than 20 million accrued operational hours, representing an impressive 100,000 hours mean-time-between-failure record. Vehicle-mounted VICTS antennas are also widely deployed in a range of commercial and government COTM programs.

ThinKom's low-profile, lightweight antennas provide industry-leading spectral efficiency and are capable of sustaining network connectivity at high vehicle speeds,



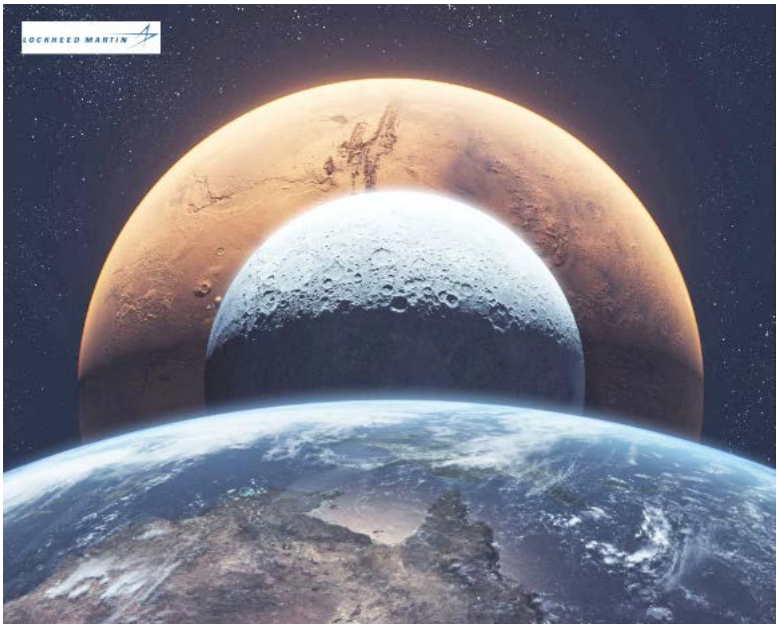
on-road or off-road. They support robust network operations at very high and extremely low elevation-angle requirements with near-instant connectivity recovery after partial or sustained blockages.

Designed to work with a full range of modems and networks, the ThinKom system provides flexible "*future-proof*" interoperability options with current and next-gen satellite systems, including geostationary and low earth orbit constellations.

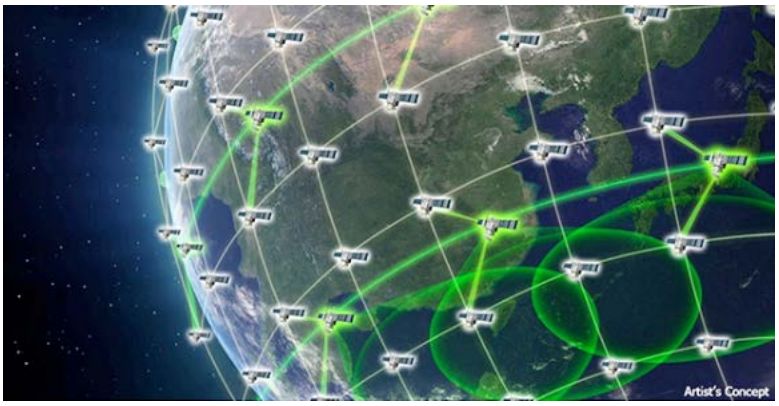
The COTM experimentation program is expected to lead to prototype deployment and testing under the Army's two-year Capability Set cycle in 2023, according to the U.S. Army's *Program Executive Office for Command, Control, Communications-Tactical*.

"*The ABCT pilot program will demonstrate that our field-proven commercial off-the-shelf technology can provide a reliable and low-cost solution to meet this demanding requirement in support of U.S. armed forces*," said **Bill Milroy**, ThinKom's CTO and Chairman.

DARPA Selects Lockheed Martin For Blackjack Work



Lockheed Martin (NYSE:LMT) has been awarded a $5.8 million contract by the Defense Advanced Research Projects Agency (DARPA) to define and manage the interfaces of satellite integration with the agency's Blackjack program.



Blackjack intends to develop a high-speed global network comprised of 20 satellites that will operate in LEO to provide autonomous, highly connected, resilient and persistent coverage for payloads of all genres and missions for the *Department of Defense* (*DoD*).

The expectations are that a demo constellation could be launched between 2021 and 2022, if the building of the project and subsequent testing go as planned.

This contract will entail Lockheed Martin getting involved with the definition of, and the interface for, DARPA's Blackjack bus, the payload as well as the space-based command and data processor that is called ***Pit Boss.***

An important aim of this project is reduce the cost of custom building spacecraft by developing satellites that can "plug-and-play" payloads without requiring bus redesign.

Sierra Nevada Corp. Creates Sierra Space Commercial Company

Sierra Nevada Corporation (SNC) has created *Sierra Space*, a new, commercial, space company. The new company's "space-as-a-service" business model will leverage cutting-edge technologies, such as Dream Chaser® spaceplanes and expandable *LIFE*™ habitats, within the fast-growing new space economy, which is projected to grow to $1.4 trillion by 2030.

With assets transitioned from the SNC's Space Systems business area, Sierra Space will deliver the future of space transportation, destinations and infrastructure, including plans to offer the first free-flying commercial space station.

The new commercial space station integrates the large size and versatility of LIFE habitats with the high cargo capacity, and non-toxic runway returns to Earth, of the Dream Chaser spaceplane. Under NASA contract, Dream Chaser will perform the first of at least seven cargo missions to the International Space Station starting next year.

Sierra Space will take advantage of synergies made possible by SNC's broad customer base and industry-leading space technology. Sierra Space will have the independence to seek creative partnerships and market opportunities to scale its growth quickly and capitalize on a fast-growing and competitive marketplace.

The company starts their journey with $3 billion+ in active contracts and anticipates revenues exceeding $4 billion within the decade.

Innoflight Teams With Lockheed Martin On Avionics For SDA's Transport Layer

Innoflight has been awarded two subcontracts from Lockheed Martin (NYSE: LMT) and Tyvak Nano-Satellite Systems (Tyvak) for the delivery of key avionics for 10 satellites produced by Lockheed Martin under the SDA Transport Layer Tranche 0, consisting of 20 space vehicles total.

This program will be the first generation of SDA's Transport Layer, an important step toward the development of a National Defense Space Architecture including networked satellites with Optical InterSatellite Links (*OISLs*) capable of sending and receiving wideband data to and from other space vehicles and ground stations.

The capability demonstrated in the Tranche 0 will provide our warfighters with periodic regional access to low-latency data connectivity via space-based extensions of existing tactical data links.

Under its contracts with Lockheed Martin and Tyvak, Innoflight will be delivering communications, cyber-security, and processing/networking avionics for all 10 satellites and three engineering development systems.

Innoflight Compact Flight Computer CFC-400X Flight Unit

More specifically, Innoflight will be delivering Ka-band Software-defined Compact Radios for *Telemetry, Tracking, and Control* (TT&C) data link. Furthermore, Innoflight will be delivering its "Mesh" Networking and "Bulk" *End Cryptographic Units* (*ECUs*).

Finally, Innoflight will deliver its network switch/router, based on the Compact Flight Computer CFC-400X hardware platform.

"*Innoflight's extensive and unique offering complements Lockheed Martin's vision for a Joint All-Domain Operations battlespace fueled by agility and innovation from space*," said **Chris Winslett**, Lockheed Martin's SDA Transport Layer Program Director. "*Innoflight's technology will help Lockheed Martin connect space to other domains and pioneer interoperability for our customers*."

"*Lockheed Martin has been a key and excellent customer contributing to Innoflight's rapid growth*," said **Jeff Janicik**, Innoflight CEO and President. "*Innoflight is proud to be part of Lockheed Martin's team for such a high-profile and important program for U.S. National Security Space (NSS)*."

A GUIDE FOR UNDERSTANDING AND ASSESSING U.S. SPACE SUSTAINABILITY INITIATIVES

Author: Dr. Michel P. Gleason, National Security Senior Project Engineer,
The Aerospace Corporation's Center for Space Policy and Strategy

In the last few years, the United States has taken significant steps forward in establishing a framework for protecting the sustainability of the space domain and in demonstrating U.S. leadership and commitment to preserving the safety, stability, security, and long-term sustainability of space activities.

The framework is implicit in the first ever ***U.S. National Space Traffic Management Policy, Space Policy Directive-3*** (*SPD-3*),[1] which is re-emphasized and promoted in the December 2020 ***U.S. National Space Policy*** (*NSP*).[2] This paper identifies key lines of effort, extrapolated from SPD-3 and reinforced in the 2020 NSP, to guide understanding and assessment of recent efforts, and provides insights into where new and continuing efforts should be focused.

Population Explosion in Space

Since the Space Age began more than 60 years ago, about 9,800 satellites have been placed in orbit with about 6,700 still there, and as of March 2021 about 3,100 of those are still operating.[3] In 2019, several commercial companies proposed satellite constellations ranging from potentially 1,000 to 30,000 satellites each, totaling 75,000 or more new satellites in orbit for a single generation.

The number of proposed satellites changes nearly every day with some recent estimates reaching more than 100,000 additional satellites in orbit by 2030. This anticipated rise in the number of satellites in such a short period of time will lead to a significant increase in collision risk. The resulting space debris, along with the new vehicles themselves, will challenge the overall sustainability of the space environment.

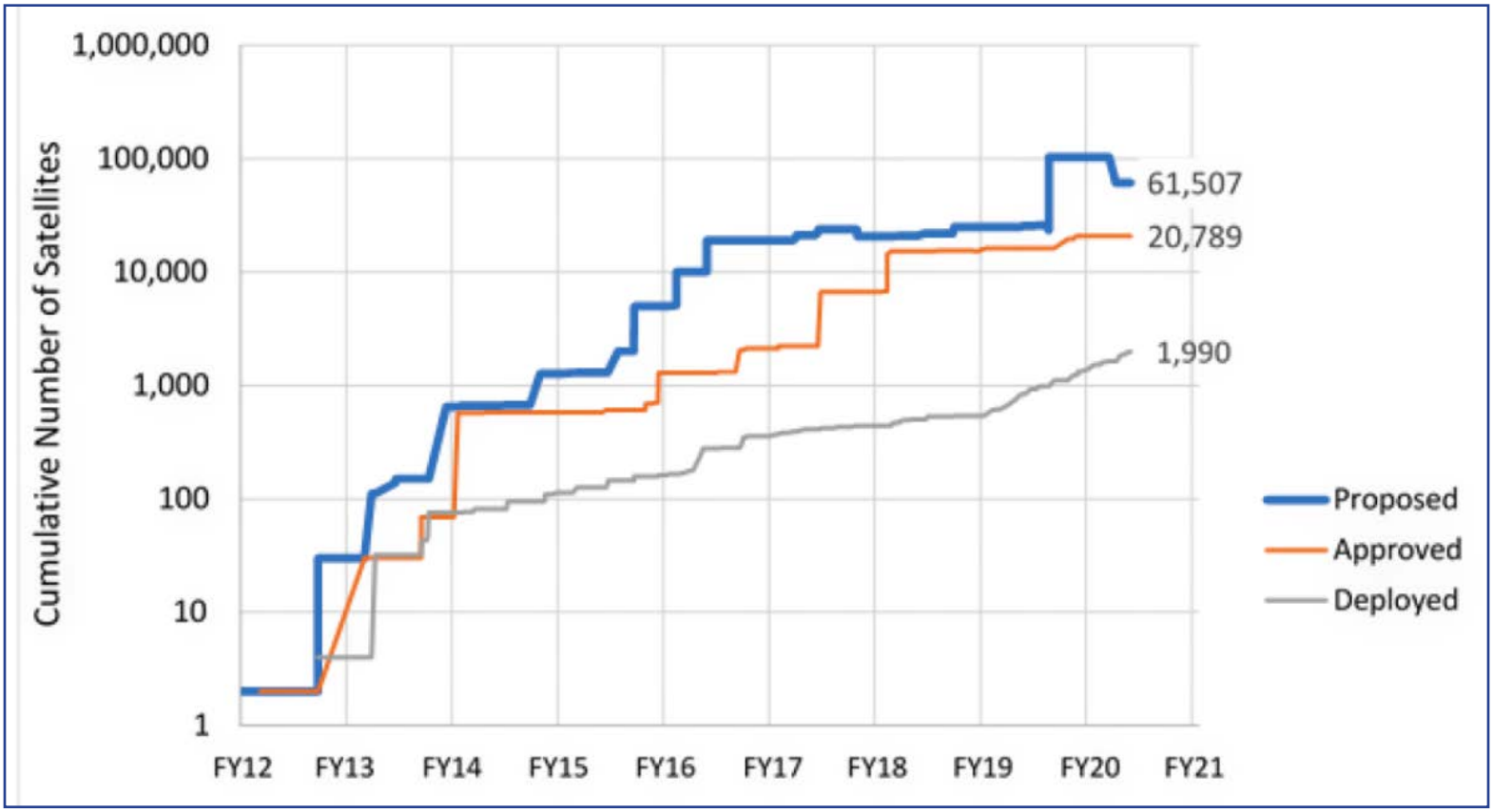


Figure 1: Growth in commercial GS constellations – number of satellites per FCC filings since October 2012 (logarithmic scale).

While it is unlikely that all of the planned satellites will be launched, ***Figure 1*** on the previous article page illustrates that almost 2,000 new commercial satellites have been placed in ***non-geostationary orbits*** (*NGSO*) since 2012 and the upward trend continues to accelerate. *****The United States is beginning to address the fundamental changes occurring in the space environment.

U.S. Government Orbital Debris Mitigation Standard Practices

Among its top priorities, SPD-3 called for an update to the ***U.S. Government Orbital Debris Mitigation Standard Practices*** (*USG ODMSP*) from the year 2000. The standard practices apply to all U.S. government organizations involved in space operations and serve as the U.S. government's foundation for issuing specific orbital debris mitigation requirements and technical guidance.

Furthermore, the ***Federal Communications Commission*** (*FCC*), ***Federal Aviation Administration*** (*FAA*), and ***National Oceanic and Atmospheric Administration*** (*NOAA*), three U.S. space regulatory agencies, mandated the compliance of U.S. private spacecraft companies with agency or commission regulations based on USG ODMSP.

The 2000 USG ODMSP aimed to limit the amount of orbital debris and the amount of time that such debris and spacecraft could remain in orbit. The standard practices include all spacecraft program phases, from concept development to space hardware disposal. SPD-3 highlighted the need to update the USG ODMSP "*to enable more efficient and effective compliance and establish standards that can be adopted internationally.*"

In December 2019, 18 months after SPD-3 was published, the U.S. government released its new ***Orbital Debris Mitigation Standard Practices***.[4] The 2019 update, a U.S. whole-of-government effort led by the ***National Aeronautics and Space Administration*** (*NASA*), introduced operating practices for emerging space activities—including large constellations and smallsat (including cubesat) operations, *rendezvous and proximity operations* (*RPO*), *active debris removal operations* (*ADR*), and satellite servicing.

It also introduced quantitative limits on debris released during normal operations, probability limits on accidental explosions and collisions with large and small debris, and a reliability threshold for post-mission disposal.

In addition, the new ODMSP includes preferred and new end-of-mission-life disposal and storage options for structures in ***Low Earth Orbit*** (*LEO*), ***Medium Earth Orbit*** (*MEO*), ***Geosynchronous Orbit*** (*GEO*), inclined GEO orbits, ***Highly Elliptical Orbits*** (*HEO*), and other orbits to minimize the impact on future space operations.

Nevertheless, many observers viewed the update as modest given the dramatic rise in the number of satellites projected to be placed in orbit.[5]

Many were disappointed that the 2019 USG ODMSP did not change the previous ODMSP guideline recommending that satellite operators remove spacecraft and orbital stages from useful and densely populated orbit regions no longer than 25 years after mission completion, colloquially referred to as the "*25-year rule.*"

Many observers advocate for reducing the time frame to under 25 years, even though compliance rates with the current 25-year standard are poor.[6] These observers argue that the current approach will not scale to the expected increases from satellite constellations consisting of hundreds or thousands of satellites.[7]

Nor does the current approach account for the short mission lives of cubesats, which represent a growing sector of the satellite industry.

Other observers argue that the effect on the debris environment of shorter lifetimes is relatively small, and the new USG ODMSP's addition of a 90 percent or better post-mission disposal requirement addresses the lack-of-compliance issue by making the success rate an active consideration.

The 2020 NSP states that the United States shall periodically update the USG ODMSP, but it is unclear how often that will occur. Given the rapidly changing space environment, the debates surrounding the 25-year rule and measures for managing large numbers of satellites are likely to continue and ideally the USG ODMSP will be updated more frequently than the previous 20 years between updates.

U.S. International Leadership

The coming few years will also show if the 2019 USG ODMSP follows a similar path as the 2000 USG ODMSP to wide international acceptance. The 2000 USG ODMSP influenced the development of the ***2002 Inter-Agency Space Debris Coordination Committee*** (*IADC*) *Space Debris Mitigation Guidelines*, which in turn influenced the ***United Nations (UN) Committee on the Peaceful Uses of Outer Space*** (*COPUOS*) *Space Debris Mitigation Guidelines*.[8]

** See the Annex, "**Proposed, Approved, and Deployed Satellite Constellations**," for more detailed numbers.*

Today, the 13 IADC-member agencies have, to various extents, incorporated these debris mitigation standards into their domestic regulation and law.†

SPD-3 endorsed development of congruent international approaches to minimize debris and called for the United States to promote the USG ODMSP as a model for consideration in international forums such as ***IADC***, ***International Organization for Standardization*** (*ISO*), and COPUOS.

The 2020 NSP establishes policy consistent with this approach as well. The United States was successful in following this approach and could continue to lead the rest of the world forward along this proven path. And with an increased sense of urgency, the United States could benefit by promoting the 2019 USG ODSMP in the IADC and in COPUOS.

In addition, the 2020 National Space Policy and SPD-3 call for U.S. leadership in the development of international and industry standards that will help preserve the space environment through organizations such as the ISO.

As the most important of the ISO space debris mitigation standards, **ISO Standard 24113** represents another line of effort in which momentum should be maintained. ISO Standard 24113 was updated in July 2019, with several revisions including important updates to the probability of successful post-mission disposal.9 The probability is now calculated from the beginning of the mission rather than from just before disposal.

Also, the required success rate is at least 90 percent, which is in line with the 2019 ODMSP, which was taken from **NASA Standard 8719.14** and **AFI 91-217** (now in **AFI 91-202**). While ISO 24113 remains the primary debris mitigation standard, two additional standards — **ISO 20893**, which was completed in March 2021, and **ISO 23312**, which is under development — will be new supporting standards for 24113. It is likely that revisions to ISO 24113 will begin well before the standard review cycle with a goal of synchronizing development of the related debris mitigation standards.[10]

The United States could benefit by continuing to encourage development of these new standards on an accelerated timeline.

SPD-3 and the NSP also encourage the international adoption of guidelines and best practices for safe space operations through U.S. participation in COPUOS. In June 2019, COPUOS achieved consensus among 92 countries (including Russia and China) and adopted a set of 21 voluntary "***Guidelines for the Long-term Sustainability of Outer Space Activities***" (*also known as LTS guidelines*).[11]

In adopting the guidelines, the committee agreed to establish a follow-on working group for 2020 through 2024 to examine issues associated with implementation, capacity building, and possible new guidelines.

However, the formation of this "*LTS 2.0*" working group has been slowed by COVID-19 and continued efforts by Russia to inject disarmament-motivated proposals (such as a guideline for non-cooperative rendezvous and proximity operations) which exceed COPUOS's longstanding mandate to address "bottom up" measures for spaceflight safety.

The United States and like-minded nations continue to encourage Russia in COPUOS to agree to the follow-on LTS working group or at least not stand in its way.

Space Traffic Management.

Perhaps the most ambitious line of effort in SPD-3, and reinforced in the NSP, is transitioning civil ***Space Situational Awareness*** (*SSA*) and ***Space Traffic Management*** (*STM*) service responsibilities from the ***Department of Defense*** (*DoD*) to the ***Department of Commerce*** (*DoC*).

In December 2020, Congress approved this course of action in law, and directed the DOC ***Office of Space Commerce*** (*OSC*) to initiate a STM pilot program and an ***Open Architecture Data Repository*** (*OADR*) pilot project. Congress provided increased appropriations to the DOC/OSC in fiscal year 2021, marking a significant increase in funding compared to the appropriations OSC received in previous years. Despite its constrained budget, however, DOC/OSC has been making progress since 2018 in establishing the OADR.

SPD-3 also calls for research and development to support such SSA and STM capabilities and applications saying, "*These activities include improving fundamental knowledge of the space environment, such as the characterization of small debris, advancing the science*

† IADC member agencies include ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency) KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation), SSAU (State Space Agency of Ukraine), and the UK Space Agency.

and technology of critical SSA inputs such as observational data, algorithms, and models necessary to improve SSA capabilities, and developing new hardware and software to support data processing and observations."[12]

The ***January 2021 National Orbital Debris Research and Development*** (*R&D*) ***Plan*** answers that call by providing a national plan to coordinate and prioritize research and development into managing the risk posed by orbital debris. The plan calls for continued coordination and discussion among the interagency, private industry, academia, and international partners.

As the national space debris R&D plan evolves, it will help close critical technical gaps in understanding the debris environment and the capabilities needed to protect space sustainability.[13]

Rules and Regulations

Separate and distinct from the NSP and SPD-3 mandates, on October 25, 2018, the FCC released the "***Notice of Proposed Rulemaking and Order on Reconsideration, IB Docket No. 18-313.***" Importantly, the FCC is an independent agency, not under the authority of the executive branch of the U.S. government as DoC is. The notice sought comments from the public on proposed updates to the orbital debris mitigation rules for all FCC-authorized satellites.

As noted above, the FCC mandates that U.S. private spacecraft companies comply with debris mitigation rules that are based on the USG ODMSP in order to obtain FCC licensing. The proposed update offered many potential new regulations—for example, new rules regarding space object trackability, information sharing requirements, orbit selection, post-mission disposal reliability, and dozens of other technical and operational requirements.

However, this FCC rulemaking effort highlighted the natural tension that exists between the government's need for regulation to protect the safety, security, and sustainability of the space environment and industry's desire for minimal, clear, and consistent regulatory constraints.

While most space industry players acknowledge the importance of orbital sustainability, increasing regulatory constraints on space activities could increase design and operational costs, frustrate commercial innovation, and discourage venture capital investments.

On April 2, 2020, the FCC released a draft of revised orbital debris mitigation regulations and the tensions noted above came to the forefront. The draft rules included stringent new requirements for operators applying for an FCC license and U.S. market access to indemnify the government for damage their satellites might cause; to be bonded for up to $100 million, which would be forfeited if operators did not properly dispose of the satellites; and to design spacecraft flying above 400 kilometers to be maneuverable in order to avoid collisions above that altitude.

These strict new rules were opposed by industry, Congress and others as being detrimental to U.S. space companies and for putting the U.S. space industry at a competitive disadvantage compared to other countries.[14]

On April 23, 2020, in the face of this opposition, the FCC voted unanimously in favor of requiring satellite operators to quantify their collision risk, probability of successfully disposing spacecraft, and the casualty risk associated with spacecraft that reenter Earth's atmosphere, but deferred consideration of the more controversial draft rules until they could be studied further.[15]

Soon thereafter, the FCC issued a "***Further Notice of Proposed Rulemaking***" (*FNPRM*) and began a new round of public comment on the unresolved issues.

Final public comments on this new FNPRM were due to the FCC in October 2020. An additional set of draft rules will be generated based on consideration of the additional comments from industry and government.

Congress and other stakeholders could benefit from following the development of these draft FCC rules and evaluate their alignment with the other lines of effort outlined above.

These various lines of effort toward establishing a new framework for protecting the sustainability of the space environment, as directed in SPD-3 and reemphasized in the NSP, and through the independent initiatives of the FCC, show progress is being made in response to the rapid changes in space activities.

Observers should expect to see continued momentum by the United States along these lines of effort.

Conclusion SPD-3 drove steady, incremental progress over the last few years toward establishment of a new framework for protecting the sustainability of the space domain, and the U.S. government has outlined the way ahead domestically and internationally as reflected in ***Table 1***.

As the new U.S. administration and Congress chart the course for U.S. space leadership, they should find that the 2019 USG ODMSP is now in place to help the United States promote new approaches for orbital debris mitigation in international forums like the IADC and COPUOS, and to inform future revisions to ISO 24113.

Annex: Proposed, Approved, and Deployed Satellite Constellations as of March 2021

Call Signs	NGSO Constellations	Proposed	Approved	Deployed
S3069	SpaceX Starlink Gen2	30,000	0	0
S2992	SpaceX Starlink VLEO	7,518	7,518	0
S2963	OneWeb LEO	7,088	720	110
S2983 & S3018	SpaceX Starlink LEO	4,409	4,409	1,143
S3051	Amazon Kuiper	3,236	3,236	0
S2976	Telesat	1,671	117	0
S2994	Oneweb MEO	1,280	1,280	0
S2912	Planet Labs Flocks of Doves	1,156	1,156	424
S2946	Spire Global	1,000	1,000	84
S3045	Spire Global MINAS	872	636	12
S3068	Magnata	791	0	0
S3064	SWARM Astrobiene	450	0	0
S3070	Kepler	360	0	0
S3041	SWARM	300	150	81
S2985	Viasat	288	20	0
S3065	AST	243	0	0
S2993	Boeing	147	0	0
S2981	Kepler	140	140	8
S2986	Theia Holdings A	120	120	0
S2935	O3b	112	38	20
S2110	Iridium NEXT	81	81	75
S3042	Hawkeye	80	80	3
S3014	Astro Digital U.S.	30	5	1
S3057	Myriota	26	26	0
S3054	Keneis	25	0	0
S2862	Planet Labs Skysat	21	21	21
S3019	New Spectrum Satellite	18	0	0
S3032	Blacksky Global	16	16	6
S2980	Karousel	12	12	0
S3067	R2 Space	8	0	0
S2982	Audacy	3	3	0
S3073	Capella Space	3	3	2
S2978	Space Norway	2	2	0
S3052	LOFT	1	0	0
34 Constellations	**Totals:**	**61,507**	**20,789**	**1,990**

These numbers are estimates based upon analysis of FCC filings and public records of launches from various sources such as *SpaceNews* and *SpaceflightNow*. The FCC does not publish these types of summary statistics. (Courtesy of Grant Cates, The Aerospace Corporation.)

In addition, the COPUOS follow-on working group for LTS guidelines indicates that multilateral efforts to promote sustainability guidelines hold promise but may need a push to overcome the obstacles presented by Russia.

While the DoC space traffic management line of effort matures, expect to see lessons learned from its STM pilot program. Likewise, as orbital debris R&D becomes better coordinated and prioritized, improved knowledge of orbital debris should lead to new understanding and advanced capabilities.

As new FCC rules emerge, stakeholders may evaluate their alignment with the NSP and SPD-3.

Assessing these lines of effort, extrapolated from SPD-3 and the 2020 NSP, provides insight into where efforts going forward could focus in order for the United States to demonstrate and maintain global leadership and protect the sustainability of space activities.

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He holds a Ph.D. in International Relations from George Washington University (GWU) and is an alumnus of the GWU Space Policy Institute. Gleason is the recipient of the Defense Superior Service Medal and the Department of State Superior Honor Award.

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SPACE INVESTMENTS HAVE PAID HUGE DIVIDENDS FOR THE U.S. ECONOMY AND SECURITY

From GPS to Weather Satellites to National Security, Space Assets Loom Large in Everyday American Life

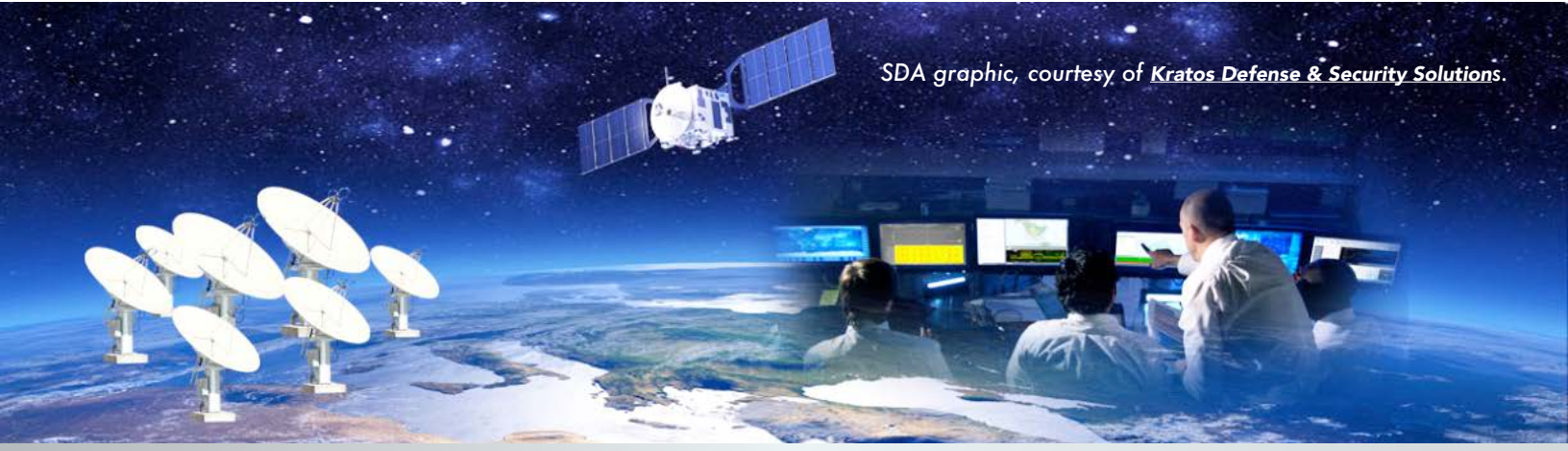
Author: U.S. Space Force Space & Missile Systems Center

Unfettered access to space isn't just a national security concern for the United States. It's an economic one as well, and the U.S. Space Force (USSF) is emerging as the nation's new hope for securing the global commons of space and identifying and mitigating threats.

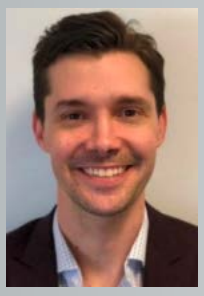
"In the United States, there is no such thing as a day without space," said **Cordell DeLaPena**, Program Executive Officer for Space Production, Space and Missile Systems Center. *"We, along with our program partners are required to continually push the envelope on the capabilities we deliver to users, both civil and military around the globe. The results of the capabilities that we produce and provide greatly help to ensure that our country and our allies are safe."*

The stakes in space for the United States and its allied partners are high. Take the **Global Positioning System** (*GPS*) — originally developed for military use and reliant on space-based satellites. The ***National Institute of Standards and Technology*** recently found that GPS has delivered $1.4 trillion dollars of economic benefit since the beginning of civilian use in the 1980s.

According to the National Air and Space Intelligence Center, at least eight other countries – China, Russia, India, Israel, Iran, Japan, North Korea and South Korea – and one international space organization – the European Space Agency – have the ability to independently launch spacecraft. Dozens more own or operate space assets on-orbit and have established space agencies, seeking the same economic, military and national security benefits as the United States.



SDA graphic, courtesy of **Kratos Defense & Security Solutions**.



Sam Wilson

"*It is hard to think of an industry unaffected by space services,*" said **Sam Wilson**, senior policy analyst, Center for Space Policy & Strategy, ***The Aerospace Corporation***. "*Space systems offer huge advantages in a variety of sectors that people may not realize. With the help of satellites and space-based assets, utility companies synchronize energy flows across the grid, stock market exchanges record transactions, oceanographers track endangered whales, scientists monitor the climate, and farmers increase crop yields.*"

"*GPS is obviously enormously important,*" Wilson added. "*But its other satellite classes as well – communications, weather, and remote-sensing. As examples, communications satellites let air traffic controllers manage planes in crowded airspace. Remote-sensing satellites reveal what is happening on Earth's surface in near real time. And weather satellites give us a better chance of having an umbrella when we need it. GPS is obviously enormously important. But its other satellite classes as well — communications, weather, and remote-sensing. As examples, communications satellites let air traffic controllers manage planes in crowded airspace. Remote-sensing satellites reveal what is happening on Earth's surface in near real time. And weather satellites give us a better chance of having an umbrella when we need it.***"**

Since its start in 1982, the ***COSPAS Search and Rescue Satellite*** (*SARSAT*) system has been credited with supporting more than 48,000 rescues worldwide, including nearly 9,400 in the United States and its surrounding waters — a feat not possible without GPS and weather satellites.

The cost of even a 30 day loss of GPS has been projected at $45 billion by the NIST. To compare, the U.S. invests $1.3 billion annually to protect against an economic loss of 34 times greater magnitude — for only 30 days.

Protecting that investment and other space-based assets is one of the key missions of the USSF, which spends roughly $150 million annually to support the organization's more than 31 satellite vehicle constellations, control stations and other crucial systems.

Space Domain Awareness, which is the ability to monitor and track everything from active satellites to random pieces of space debris, ensures the safety of the global commons, including U.S. and allied astronauts on the *International Space Station* (*ISS*). By always monitoring for potential collisions, the USSF can alert officials in time for collision avoidance maneuvers to be performed.

Gordon Kordyak

"*With the launch of proliferated Low Earth Orbit mega-constellations, Space Domain Awareness is now more critical than ever,*" said **Gordon Kordyak**, Chief, Space Domain Awareness Division, SMC Special Program Directorate. "*As these constellations provide impressive bandwidth for the entire globe, we must prevent collisions that could ruin entire swaths of space for decades to come. The global coverage/monitoring requirements for Space Domain Awareness require a world-wide distributed network of sensors.*"

Tracking more than 24,000 identified pieces of space debris is paramount to USSF mission success. The cost of mitigating space debris pales in comparison to the potentially catastrophic economic impacts worldwide that would occur due to failed space assets that could require decades to reconstitute.

Operating in space is costly, due to the complex requirements of the environment. Space systems must be resilient enough to face extreme environmental challenges over multiple years while protecting and operating sensitive equipment.

"*Our space systems operate 24/7/365 without interruption; tolerate and recover from failures; and survive in a very hostile environment about which there is much we do not know,*" said **Jay A. Landis**, Chief, Mission Surveillance Team at SMC. "*These systems are designed and manufactured by teams of craftsmen using cutting-edge technologies with intricately complex systems interactions. Total failure could result from the slightest error during design, manufacturing and testing — compounded by the fact that repairs and maintenance are very limited, at this time, due to the fact that the assets are in space.*"

As SMC officials explained, try designing a system that can withstand temperature swings of 200 degrees Fahrenheit every 90 minutes, high-energy charged atomic particles and rays that render "*normal*" electronics useless, as well as microscopic pieces of dust traveling at many thousands of miles per hour that can chip a solar cell or glass cover or puncture a shielded wire or cable.

"*Given the space environment and the criticality to our Nation's economy and defense, space systems have traditionally been designed with a high degree of reliability and long life projections*," said Colonel **Kenny Decker,** Chief, Integration & Futures Division, SMC Special Programs Directorate.

A launch has only a single chance for success. The consequences of a launch mishap can easily surpass $1 billion in damages and losses if the launch systems and their payloads don't safely perform as designed, SMC officials said. Preventing a launch disaster involves large infrastructure, specialized test equipment and manning by highly skilled engineers.

"*A successful space launch results when the launch vehicle properly delivers the healthy satellite to its intended orbit, enabling full on-orbit mission life*," said **John Steinmeyer**, executive director, SMC Launch Enterprise. "*Launch mishaps may result from failures in any element of this process. This may include space vehicle environmental exceedances that damage the satellite (vibration, temperature, structural loads), anomalous rocket performance that prevents delivering the satellite to its correct orbit, or, in the worst cases, a catastrophic launch vehicle failure. Damage to the satellite could degrade the satellite's operational performance, or if launch vehicle performance is off, the satellite could be delivered to the wrong orbit and rendered useless.*"

National Security space satellites are large and typically go to orbits that need more expensive launch services that use more powerful launch vehicles than commercial satellites. They often stretch the state-of-the-art in payload or spacecraft bus capabilities and have specialized missions, with higher complexity and performance requirements than commercial satellites.

Additionally, space components are purchased in low quantities and typically have high quality assurance standards, which can be less attractive to industry manufacturers without a monetary incentive, said SMC officials.

manufacturing; however, U.S. laws require purchases be made from U.S. manufacturers and that can drive up costs. Finally, U.S. space systems are required to maintain a higher security posture than systems in other domains.

In spite of all these factors, the USSF — and SMC — have found ways to reduce costs without sacrificing quality. Since 2013, the ***National Security Space Launch*** (*NSSL*) program has executed a strategy that stabilized the industrial base, incentivized economic quantity ordering, re-introducing competition and partnering with industry to develop next-generation, innovative launch systems, Steinmeyer said.

The result? Reduced life cycle costs through 2030 by $22 billion — a 28 percent unit cost decrease. The NSSL also reallocated more than $7 billion in budgeted procurement funds for additional warfighter capacity, Steinmeyer said, while achieving 85 consecutive successful launches. He added that competitive pricing across all required launch vehicle performance regimes cut launch prices for the USSF's most demanding missions by more than 50 percent and preserves commercial-like pricing for commercial-like launches.

The annual recurring and ownership costs over a space system's life cycle are much lower than those of traditional *U.S. Department of Defense* weapons systems. Satellites don't have recurring support costs, such as refueling or resupply and this offsets high initial delivery costs, SMC officials explained.

Many satellites continue to operate two to three times beyond their design life estimates without reinvestment through life extension modifications spent on traditional military assets. The USSF also is actively pursuing partnerships with international allies to cost share the development, deployment and operations of space capabilities for the mutual benefit of all involved.

The USSF's Space and Missile Systems Center, located at the Los Angeles Air Force Base in El Segundo, California, is the center of excellence for acquiring and developing military space systems. SMC's portfolio includes space launch, global positioning systems, military satellite communications, a defense meteorological satellite control network, range systems, space-based infrared systems, and space situational awareness capabilities. Contact Space & Missile Systems Center at ***SMC@Spaceforce.mil*** *and follow us on LinkedIn.*

CYBER

- Cyber operations can threaten the space domain through cyber-espionage and cyberattack, which can attack and exploit every space segment and element of space acquisition. Cyber-espionage is exploiting cyber vulnerabilities to exfiltrate critical information, such as compromising an unauthorized device connected to a secured network. Cyberattack is the physical altering, tampering, or taking control of a satellite, space asset, or supporting equipment in order to degrade or deny system functionality.
- **COUNTRY DATA**
  - The People's Liberation Army has supported cyber-espionage against U.S. satellite and aerospace industries since 2007 with the goal of supporting their military research, development, and acquisition.

HIGH ALTITUDE NUCLEAR DETONATION (HAND)

- Nuclear detonation in space would inflict large-scale damage across an entire space architecture by degrading all satellites that are not radiation hardened. This is likely not a tactic to be employed by Russia or China, but could be an attractive option for countries with few or no space assets.

The Space and Missile Systems Center is the birthplace of military space and center of military space acquisition excellence. Our mission is to deliver resilient, affordable and sustainable space capabilities for the nation. #SpaceStartsHere #SemperSupra

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SPACE AND MISSILE SYSTEMS CENTER

SPACE THREATS

◆ DIRECTED ENERGY WEAPONS (DEW) ◆ ELECTRONIC WARFARE (EW)
◆ KINETIC ANTI-SATELLITE WEAPONS (ASAT) ◆ ORBITAL THREATS
◆ CYBER ◆ HIGH ALTITUDE NUCLEAR DETONATION (HAND)

DIRECTED ENERGY WEAPONS (DEW)

- Directed Energy Weapons (DEW) can be lasers, high-powered microwaves, or other types of radio frequencies that target satellites or ground equipment with the goal of disrupting, damaging, and degrading equipment and sensors. Sensors can be saturated, "whited-out", or damaged to the point of failure; causing electronics to undergo temporary or permanent malfunctions.
- **COUNTRY DATA**
  - China has multiple ground-based laser systems of varying power levels that could blind or damage satellite systems. Russia also has several ground-based lasers that could jam and blind satellite sensors. They probably will field more capable lasers to damage satellites in the mid-to-late 2020s.

ELECTRONIC WARFARE (EW)

- Electronic Warfare is utilizing jamming and spoofing to deny satellites the ability to communicate using radio frequencies. Our adversaries are contesting nearly every radio frequency band we use. Includes the development of systems to deny our access to the sophisticated Extreme High Frequency bands used by Advanced EHF and the MILSTAR constellation for nuclear command and control.
- **COUNTRY DATA**
  - China routinely incorporates jamming against multiple communication, radar, and GPS satellite systems in exercises. They are currently developing jammers to target SATCOM over a range of frequencies, including military protected EHF communications. Russia has fielded a wide range of ground-based EW systems to counter GPS, tactical comms, satellite comms, and radars. Mobile jammers include radar and SATCOM jammers.

SPACE THREATS

KINETIC ANTI-SATELLITE WEAPONS (ASAT)

- Anti-satellite weapons can be ground based or space based and can contain explosive warheads, or achieve destruction of target through high velocity impact.
- **COUNTRY DATA**
  - The COSMOS 2504 (SCC 40555) and COSMOS 2536 (SCC 44424) are prototype Russian ASAT weapons that target satellites in low-earth orbit (LEO). The Nudol is a Russian mobile ground-based missile designed to destroy satellites in LEO. While Russia is still testing a LEO direct ascent ASAT, China's version is considered operational after a successful test in 2007 against one of their own satellites. In May of 2013, China launched a test of a ground-based ASAT capable of reaching satellites in geosynchronous orbit (GEO). Having operational ASATs with capabilities stretching from LEO to GEO virtually puts all space assets at risk.

ORBITAL THREATS

- Orbital threats are onboard satellites that can delivery temporary or permanent effects against other spacecraft. Payloads can include robotic mechanisms, kinetic weapons, jammers, and DEW.
- **COUNTRY DATA**
  - Both China and Russia are actively developing and deploying sophisticated on-orbit satellite inspection and repair capabilities, which could easily be used to tamper with and damage foreign satellites. The Shijian-17 is a Chinese satellite with a robotic arm. Space-based robotic arm technology could be used in a future system for grappling other satellites. COSMOS 2519 (SCC 42798) is a Russian on-orbit weapon system designed to kinetically kill U.S. satellites in LEO.

Threats in Space Increase with Competition, More Space-Faring Nations

The United States isn't the only space-faring nation on the planet.

*"*Given all the commercial, military and national security benefits the United States has enjoyed since the earliest days of space exploration, it's not surprising that other countries have decided they too could benefit with their own space programs*," said Lieutenant Colonel* ***Mark Gould****, Director of Security and Senior Intelligence Officer for the Space and Missile Systems Center.*

*"*Many are developing their own space programs, complete with launch capacity. Others are finding ways to deny, disrupt, degrade or destroy U.S. systems. Our job is to make sure the United States and its allies continue to have access to space and to protect the global commons."

Nearly 80 countries have some kind of space program, and at least eight other countries and one international organization, the European Space Agency, have launch capacity.

The composition and focus of each country's space program varies, but several have developed capabilities that pose potential threats to the United States' space assets, its economy and its national security.

*"*Space enables warfighting on the highest end of conflicts: the most technologically advanced weapons systems all involve space*," said Captain* ***Krishna C. Rengan****, Chief, Intelligence Operations, SMC, Directorate of Intelligence. "*Access to space also enables communications, reconnaissance, navigations, meteorology and missile warning. All these things give us advance warning for potential threats, which can be man-made, or environmental, in terms of meteorology. Everything revolves around space*."*

*"*Threats to the United States include directed energy weapons, electronic warfare, kinetic anti-satellite weapons (ASAT), orbital threats, cyber and high-altitude nuclear detonations*," Rengan added.*

*"*They are on a continuum in terms of aggressiveness, but even a less aggressive attack, such as electronic warfare, can have expensive and potentially devastating consequences. If an adversary cuts those communications between ground stations and users, then we've lost those communications, reconnaissance, and missile warning functions. That would translate into a threat to everything from everyday navigation to national security and we would really lose our competitive edge,*" Rengan said.*

*"*If we can't see something because of some sort of malicious attack, then that prevents us from understanding what's going on in the battle space. We lose the ability to place our ballistic missile defenses in the right places as well as the ability to position and inform our soldiers to deter aggressive action. The safety of the world in terms of nuclear proliferation would also be at great risk*."*

Both the ***Office of the Director of National Intelligence*** *(ODNI) and the* ***Center for Strategic and International Studies*** *(CSIS) recently released their annual threat assessments and both found that China and Russia are the United States' main competitors in space and pose the greatest challenges to our nation.*

*According to the ODNI's Annual Threat Assessment, China "*is working to match or exceed U.S. capabilities in space to gain the military, economic and prestige benefits that Washington has accrued from space leadership*."*

China is expected to have a space station in Low Earth Orbit (LEO) between 2022 and 2024. That country also plans to conduct additional lunar exploration missions and intends to establish a robotic research station on the Moon and later, an intermittently crewed lunar base.

China also has fielded ground-based, anti-satellite (ASAT) missiles intended to destroy satellites in LEO as well as ground-based, ASAT lasers that could possibly blind or damage sensitive space-based optical sensors on LEO satellites.

While pointing out China's counter-space capabilities, CSIS also found that Russia is perhaps the most likely nation to conduct additional counter-space testing and deployment over the coming year.

In addition to testing a space-based weapon that appears to be capable of firing projectiles at other satellites, Russia also tested a co-orbital ASAT weapon in July 2020 that involved a set of "nesting" satellites in LEO that may have performed docking maneuvers. It also tested a direct-ascent anti-satellite weapon in December of 2020.

*"*These activities are not new and reflect a pattern of behavior in which Russia has continued to develop and reconstitute its counter space capabilities*," the CSIS found. While China and Russia were cited as posing the biggest challenges to the United States, CSIS also noted that Iran and North Korea also pose potential threats, mainly in the area of cyber.*

Lt. Gen. John F. Thompson

"One of the greatest challenges we're facing is insufficient space domain awareness," said Lieutenant General ***John F. Thompson****, Commander of the Space and Missile Systems Center and USAF Program Executive Officer for Space.*

"We need to know who is up there and what they're doing. As new technologies such as space debris mitigation systems and robotic fuel trucks start to be launched, we must be positioned to make smart decisions around our high-value national security space assets including our missile warning satellites," the General said.

Tianjin University in China has developed a robot with tentacle-like arms that could be placed onto a satellite and launched into orbit to remove space debris from popular orbits, according to the CSIS threat assessment.

However, if a device could pluck and remove a piece of space debris, it could also potentially grab another country's satellite. The difficulty comes in trying to correctly determine whether an off-line satellite is the result of a software glitch, a collision with a piece of space debris, a deliberate attack by an adversary – or something else.

Dr. Lara Schmidt

"Attribution is critical when determining an appropriate response to an attack and can sometimes be hard to do in real-time," said Dr. Lara Schmidt, principal director of Strategic Space Operations at The Aerospace Corporation.

"For example," Dr. Schmidt added, "understanding whether a system may be experiencing a cyberattack, let alone from whom, is difficult in real-time. On the other hand, some attacks can be observed before they affect a space system. For example, it is likely we would be able to detect the launch of a ground based ASAT missile using our existing missile warning capabilities. But it is no doubt a challenge to maintain space domain awareness and attack attribution by keeping track of everything that is happening above 100 km altitude and in the complex array of ground systems that support our space capabilities."

*Dr. Schmidt said the United States took an important step over the past few years just by changing the lexicon from "*space situational awareness" to "space domain awareness. That may not sound too important, but I think it is key to shifting to a mindset that acknowledges that space is a warfighting domain and adopts some of the constructs used in other warfighting domains.

She continued, "The phrase 'space situational awareness' implied a limitation in scope; it was easy to infer that we only needed to know about 'situations' in which we were operating. Whereas 'space domain awareness' better captures the vastness of the problem. The U.S. needs to be able to understand not just our own 'situations' but also international activity in LEO and beyond. In fact, increasingly extending all the way to the cislunar region."

Compounding the problem is that, while there are several space treaties, they represent a patchwork of nations and there isn't any way to enforce them at present.

*"We need to create norms of behavior in space." General Thompson said. "*Between the U.S., our allies and our adversaries, we need a dialog for what is normal and abnormal behavior. In the event of a threat, a common understanding is required of whether that threat is or is not about to accomplish a hostile act."

*"As is the case with most international treaties, it is difficult to obtain all the desired signatories," Schmidt said. "*But where we are today with space, the rapid pace of development of technologies and new ways to utilize space — spurred by both nation states and the commercial sector — makes it difficult to establish frameworks and attract signatories in a way that can stay ahead of this dynamic environment.

"For example, developments such as on-orbit satellite maintenance capabilities and debris-removal 'tugs' certainly have beneficial uses, but they might also be misapplied for nefarious purposes," Schmidt said. "

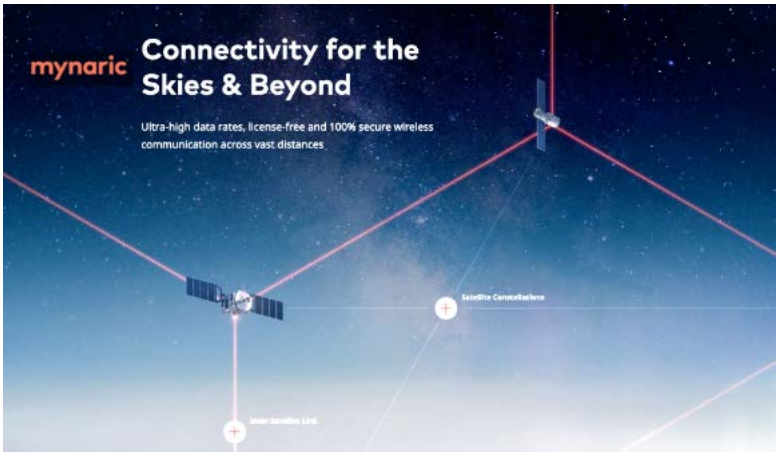
Whether you go the route of treaties or rely on setting norms of behavior, either approach needs to account for the speed of innovation and ingenuity we are seeing in space technology today," *Dr. Schmidt concluded.*

TO LEARN MORE, ACCESS THESE HELPFUL LINKS...

- ***Center for Strategic and International Studies 2021 Space Threat Assessment***
- ***CSIS: Counterspace timeline — 1962 to 2020***
- ***Annual Threat Assessment of the U.S. Intelligence Community***
- ***RAND: Responsible Space Behavior for the New Space Era***

SpaceLink + Mynaric Join Forces For Satellite Relay Network Laser Comms Development

Mynaric and SpaceLink have agreed on the framework of a partnership to expand Mynaric's laser communication product portfolio for use in SpaceLink's data relay network. The strategic relationship will help drive forward the SpaceLink satellite relay service, which provides secure, continuous, high-capacity communications between LEO spacecraft and the ground.



Pictured, left to right: SpaceLink's Rob Singh, CTO, Larry Rubin, COO, Dave Bettinger, CEO. Mynaric's Tina Ghataore, CCO, Joachim Horwath, CTO, Bulent Altan, CEO, Ali Younis, VP U.S. Business Development

The companies will work together to expand Mynaric's product portfolio with an optical inter-satellite link (OISL) terminal for satellites in MEO, where the SpaceLink constellation will operate. The new terminal will also be compatible with the ***Space Development Agency (SDA) Transport Layer***.

Mynaric will supply more than 40 OISL terminals as part of the plan outlined in a term sheet that includes units of the new, advanced product for satellites in MEO as well as units of Mynaric's CONDOR terminals for SpaceLink LEO customers. SpaceLink and Mynaric have also agreed to an option that would increase the number of terminals delivered upon SpaceLink's expansion of its MEO constellation.

Laser communication technology is critical for SpaceLink to build the communications superhighway for the new space economy. Mynaric's product portfolio is a natural choice as it meets SpaceLink's programmatic requirements, provides high performance, and is fully compliant with the OISL Standard driven by the SDA. This is a major benefit that allows SpaceLink to serve the largest possible range of commercial and government customers.

SpaceLink is building its high-capacity data relay network to meet pent-up demand for continuous, fast, and secure access to the growing amount of data available from space. The ***Always in Sight***™ constellation helps satellite operators maximize the value of on-orbit assets with near real time transmission of user data to the ground for immediate access via the Internet, private cloud, or other secure delivery. Mynaric was selected as a supplier to support SpaceLink's mission given its industrialized approach toward the production of advanced laser communication products.

Airbus Meets Milestone, One Step Closer to Building Next Gen Military Satellite

Airbus was awarded the Skynet 6A contract in July 2020 and teams across its sites in Stevenage, Portsmouth, and Hawthorn have been working on the program to achieve this key milestone. Meetings with the UK Ministry of Defence (MOD) were held virtually enabling the review board to take place in October and the PDR being achieved in November.

Teams from across the space and ground segments in Airbus worked closely with their MOD counterparts to keep the program on track.

Skynet 6A will extend and enhance the Skynet fleet. The contract signed with the UK MOD in July 2020 involves the development, manufacture, cyber protection, assembly, integration, test and launch, of a military communications satellite, Skynet 6A, planned for launch in 2025.

The contract also covers technology development programs, new secure telemetry, tracking and command systems, launch, on-orbit testing and ground segment updates to the current Skynet 5 system. The value of the contract is more than £500 million.

The Skynet 6A satellite is based on Airbus' Eurostar Neo telecommunications satellite platform. It will use more of the radio frequency spectrum available for satellite communications and the latest digital processing to provide both more capacity and greater versatility than Skynet 5 satellites.

The satellite will feature electric orbit raising propulsion as well as electric station keeping systems for maximum cost effectiveness. Complete satellite integration will take place at Airbus facilities in the UK followed by testing using RAL Space testing facilities at Harwell in Oxfordshire supporting the UK Space Agency initiative for sovereign UK end-to-end satellite production and support.

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