SATCOM for Net-Centric Warfare

MilsatMagazine

June 2020 issue

This artistic rendition of a USAF MUOS satellite is courtesy of Lockheed Martin.

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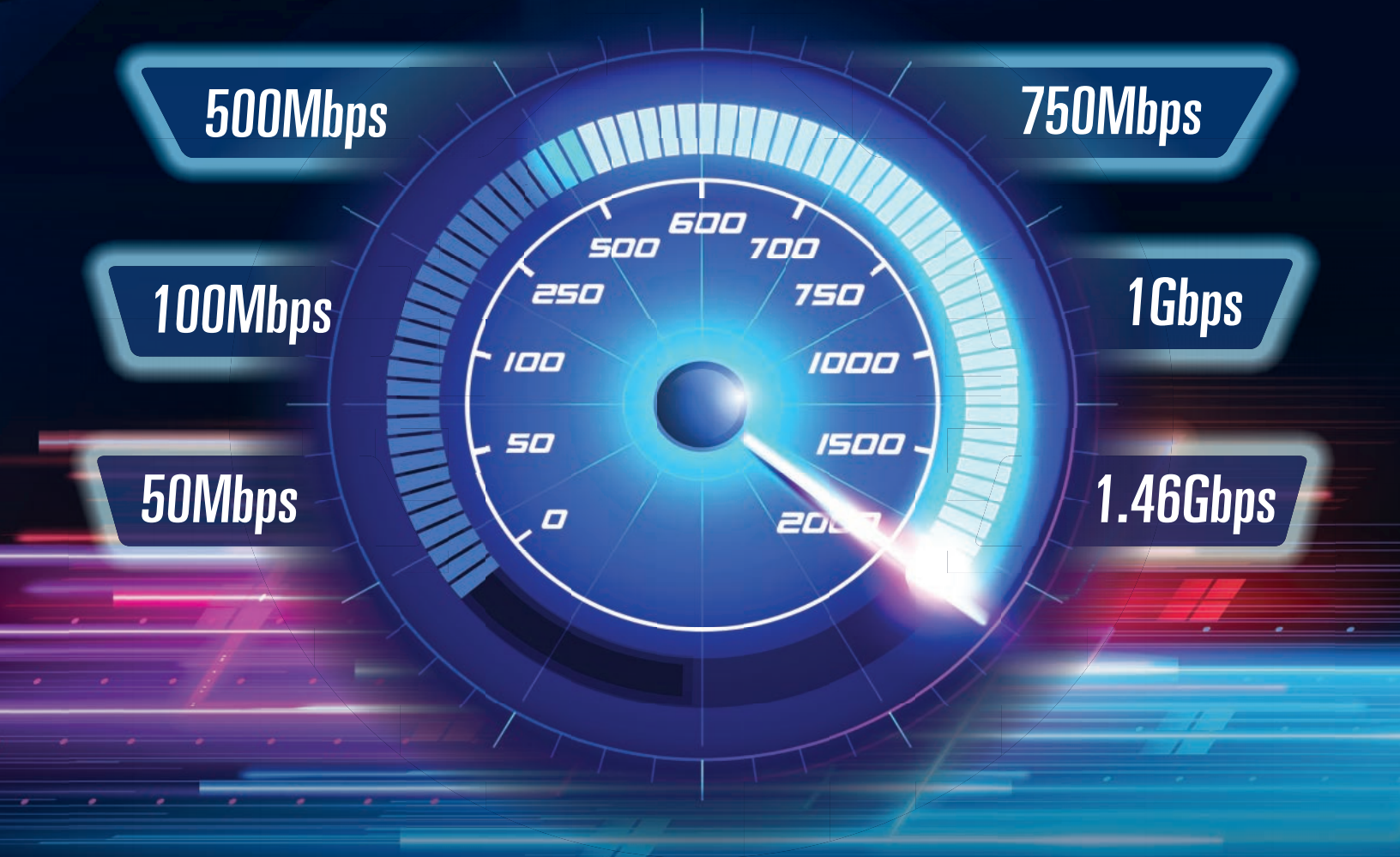

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MUOS MILSATCOM CAPABILITIES EXCEEDING USMC'S EXPECTATIONS

The U.S. Marine Corps Systems Command (MCSC) is updating their tactical satellite system that provides increased communication on the battlefield — based on field user evaluations, the upgraded technology is performing beyond expectations.

The Mobile User Objective System (MUOS) is a next-generation, narrowband satellite communication capability that enables Marines to connect to SATCOM networks. It encompasses updated firmware to the AN/PRC-117G radio system and one of three antenna kits that help users simultaneously access these networks.

Initially fielded in March of 2019, the system enables mobile or stationary Marines to leverage cellular technology to increase access to voice and data communication. It also improves overall reliability in urban environments.

Lt. Col. ***Jeff Decker***, MCSC's Ground Radios product manager, said that MUOS gives the USMC a 3G capability using satellite constellations,. It is similar to a cell phone capability in the sky that covers the entire globe, adding that the 3G networks used with MUOS remain far superior to the Marine Corps' legacy SATCOM channels.

Decker noted that the Ground Radios program office continues to monitor the latest technologies and looks toward working with other services for future incremental improvements to the capability. He stated MCSC is looking to support the warfighter with a lethal and sustainable capability, which is the command's focus. The more robust and resilient the capability, the more we can start adding on back-end systems to help Marines. MUOS is changing the way the USMC looks at a tactical satellite architecture.

From March to May 2020, MCSC conducted various field user evaluations with I Marine Expeditionary Force at Twentynine Palms, California, to assess an updated version of MUOS that increases network stability while executing missions. During the testing, Marines participated in fire support simulation exercises where they employed MUOS for coordinated air strikes and mortar support. They also used the technology during scenario-based exercises that involved rehearsing command and control operations.

Decker said the system was tested through user evaluation exercises to understand what the capability can do on paper as well as how it can be uses to increase lethality and provide redundancy across the [Fleet Marine Forces].

The testing enabled users to grow familiar with the system, ask questions and provide feedback. It allowed MCSC to learn more about MUOS, including the system's strengths and limitations. Leveraging Marine feedback, the program office can make additional updates to MUOS as needed.

Eddie Young, project officer of Multiband Radio II Family of Systems at MCSC, said the testing helped the Ground Radios Team assess MUOS in combat-operational environments, which will better prepare them to employ the system during real missions and noted MCSC wanted to bring in these units and make sure the system is working as it should to ensure the warfighter's needs are met.

Both Decker and Young said the feedback on the updated MUOS from Marines has been overwhelmingly positive, and that the system has exceeded performance expectations. Decker noted how Marines commended the new waveform for its lack of performance gaps, its adaptability and the absence of any technical difficulties while testing.

The launch of the U.S. Navy's MUOS 5 satellite via an Atlas V launch vehicle in November of 2016. Photo is courtesy of ULA.

Decker commented that the Marines showed no frustration while trying to execute point-to-point calls while employing MUOS in an operational environment. The system is doing what we expect it to do, and that is exciting."

Sgt. ***Mason J. Roy***, video chief for Communication Strategy and Operations at I MEF, participated in the communication exercises. He raved about the benefits of the exercises in training Marines for future missions that involve MUOS employment. He related that he believes the exercises went really well. The idea that a video or photo can be sent from the field to a command post [using MUOS] shows the Marines can rapidly inform commanders with visual information in order that commands could potentially adjust battlespaces to promote mission accomplishment and protect our troops.

The program office will begin fielding the updated version of MUOS this summer.

HUGHES DEMOS HELOSAT TRANSMISSION OF FMV VIA SATELLITE FROM IN-FLIGHT BLACKHAWK

Hughes Network Systems, LLC (HUGHES) has announced the in-flight demonstration of Hughes HeloSat™ satellite communications (SATCOM) from a Black Hawk helicopter.

The HeloSat solution—including a Hughes HM series modem with proprietary through-the-rotor waveform, fuselage-mounted antenna and network management — transmitted consistent, real-time, full-motion video (FMV) to a live global audience from the Black Hawk as the helicopter surveilled the Tennessee landscape on May 21

Customers from as far away as Spain, India and the United Arab Emirates watched the Hughes HeloSat demonstration in Tennessee via livestream — the epitome of Beyond Line of Sight (BLoS) communications, said *Wayne Marhefka*, Senior Ddirector, Hughes Defense.

He noted this flight validates the Hughes HeloSat capability to support missions such as Intelligence, Surveillance and Reconnaissance (ISR), search and rescue, emergency response and airborne command aboard rotary aircraft such as the Black Hawk.

John Wellington, Chief Dflight Instructor, XP Services Inc., and former 160th Special Operations Aviation Regimen flight lead, who piloted the Black Hawk for the demonstration, reported that throughout the 30-minute flight, HeloSat maintained the live-stream video feed — something he said he's never experienced before on a rotary wing. Maintaining connectivity for the duration of the mission is critical, because when it is time to go, everything needs to be ready to go.

With the low Size, Weight and Power (SWAP) necessary for in-flight applications, HeloSat has been tested on more than a dozen different types of rotary-wing aircraft.

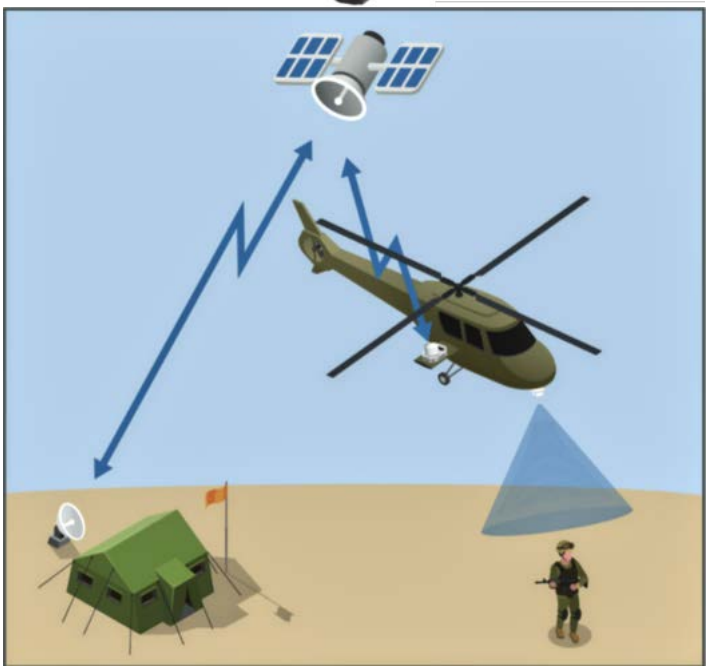
The wideband SATCOM solution supports mission-critical transmissions ranging from basic voice and data to bandwidth-intensive, high definition camera and electro-optical/infrared (EO/IR) feeds.

Several partners contributed to the success of the demonstration, including GetSat, DataPath, Applied Concept Group, Intelsat and XP Services.

Watch a video recap of the Hughes HeloSat In-Flight Black Hawk demonstration ***at this direct link***.

www.hughes.com/collateral-library/hughes-helosat-solution

HM200 Modem



Hughes HeloSat provides connectivity between the blades connectivity. Graphic is courtesy of the company.

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LAND COTM SERVICE BREAKS OUT FROM INTELSAT GENERAL CORPORATION

Intelsat General Communications LLC (IGC), a wholly owned subsidiary of Intelsat, has launched their FlexGround Communications-On-The-Move (COTM), a portable land-connectivity solution designed specifically to meet the advanced communications needs of today's military, government and emergency responders, including border patrol agents and humanitarian aid workers.

IGC's FlexGround COTM solution offers expansive global broadband coverage and the ability to transmit high-definition, full-motion videos using compact, low-profile satellite antennas.

FlexGround COTM leverages the strength of the Intelsat Epic high-throughput satellite fleet to deliver high-speed broadband mobile connectivity for a host of applications, including converged voice, data and video.

Specifically, IGC's FlexGround COTM manage service delivers:

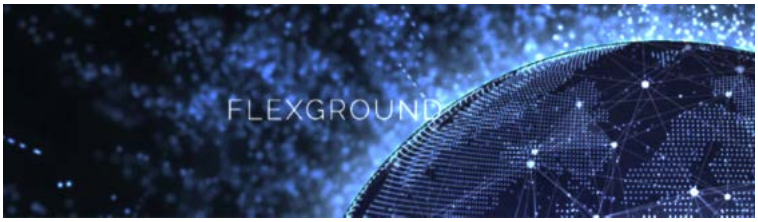
- *High-speed data transmission rates: with speeds up to 5x2 megabytes Maximum Information Rate (MIR), FlexGround COTM enables the transmission of high-definition, full-motion video using small antennas – all while users are on the move;*
- *Compact, easy-to-use hardware: small terminals and low-profile antennas are designed for easy use by non-technical operators;*
- *Affordable, flexible pay plans: with gigabyte and shared plans, plus a flexible, pay-as-you go model, FlexGround COTM is ideal for both occasional first-responder missions and around-the-clock military operations;*
- *Global coverage: the managed service leverages Intelsat's integrated global satellite and terrestrial network, which covers 99 percent of the world's populated areas, and it is comprised of more than 50 satellites worldwide, including the only global high-throughput Ku-band satellite fleet in operation; and*
- *Secure, reliable communications: anti-jamming capabilities, combined with multiple layers of resiliency, ensure secure communications and seamless connectivity.*

Skot Butler, the President of Intelsat General Communications, said ground forces and emergency responders often work in remote areas far from any communications infrastructure, or where that infrastructure has been destroyed. Intelsat General customers have told us they need a more advanced and affordable solution, one that goes beyond the capabilities of the push-to-talk radios and low-bandwidth satellite communications currently on the marke.

Scott added that FlexGround COTM meets this need, enabling military personnel and first responders to securely, reliably and easily access and share information while in a moving vehicle.

FlexGround COTM is the third product in the FlexGround managed services platform, which also includes FlexGround Communications-On-The-Pause (COTP) and FlexGround Manpack.

www.intelsatgeneral.com/flexground/



GPS III CORE MATE SUCCESS BY LOCKHEED MARTIN

The United States Space Force's Space and Missile Systems Center's (SMC) Global Positioning System (GPS) III program reached a major milestone with the successful core mate of GPS III Space Vehicle 08 at Lockheed Martin's GPS III Processing Facility in Waterton, Colorado. With core mate complete, the space vehicle was named in honor of a NASA trailblazer.

The two-day core mate consisted of using a 10 ton crane to lift and complete a 90 degree rotation of the satellite's system module, and then slowly lowering the system module onto the satellite's vertical propulsion core. The two mated major subsystems come together to form an assembled GPS III space vehicle.

Despite the COVID-19 pandemic, SMC and its mission partner Lockheed Martin ensured that SV08 core mate took place — in accordance with all Centers for Disease Control and local guidelines to minimize exposure or transmission of COVID-19.

The GPS III Processing Facility's cleanroom high bay was restricted to only key personnel who were directly supporting the operation.

Katherine Johnson.
Photo is courtesy of NASA.

When the core mate operation is successfully completed, a GPS III satellite is said to be "born." In keeping with the team's tradition of naming GPS III satellites after famous explorers and pioneers, SV08 was named "Katherine Johnson" in honor of the trailblazing National Aeronautics and Space Administration (NASA) mathematician and "human computer" who designed and computed orbital trajectories for NASA's Mercury, Apollo and space shuttle missions.

One of four African-American women at the center of the nonfiction book by Margot Lee Shetterly and the movie titled "Hidden Figures," Katherine Johnson was awarded the Presidential Medal of Freedom in 2015 for her groundbreaking contributions to the U.S. Space program.

Other GPS III satellites have been named in honor of explorers including GPS III SV01 "Vespucci" after Amerigo Vespucci; GPS III SV02 "Magellan" after Ferdinand Magellan; and GPS III SV03 "Columbus" after Christopher Columbus.

Lockheed Martin technicians successfully integrated the U.S. Air Force's third GPS III space vehicle (GPS III SV03) on August 14, 2017. Note: This is not SV08, which is scheduled to launch on June 30.
Photo is courtesy of Lockheed Martin.

The next step for the newly christened "Katherine Johnson" is the post-mate Systems Performance Test (SPT) scheduled to begin in August. SPT electrically tests the performance of the satellite during the early phase of build and provides a baseline test data set to be compared to post-environmental test data.

Launched in December 2018 and August 2019, GPS III SV01 and SV02 became part of today's operational constellation of 31 satellites, on January 13 and April 1, 2020 respectively. GPS III SV03 is scheduled to launch on June 30.

GPS III SV08 is currently scheduled to launch in 2022.

Lt. Col. ***Margaret Sullivan***, the program manager and materiel lead for the GPS III program, said core mate is the most critical of the GPS space vehicle single-line-flow operations. Despite the restrictions presented by the COVID-19 pandemic, the team adapted and worked tirelessly to achieve this essential milestone.

www.lockheedmartin.com

CLEARBOX SYSTEMS TO ENHANCE AUSTRALIAN DEFENSE'S SATCOM NETWORK

The Australian Department of Defence has selected Australian small business Clearbox Systems to enhance its global Satellite Communications (SATCOM) network.

The multi-year contract, which includes options for extension, will see Clearbox Systems design and implement the Aggregated Monitoring and Control System (AM&CS) to provide remote, centralised operation of Defence's SATCOM ground and space assets in Australia and abroad.

Currently, various SATCOM capabilities are operated in 'silos' causing operators to have to navigate through multiple systems to complete everyday tasks. The AM&CS will mak use of Clearbox Systems' world-leading SATCOM technology to integrate these silos. This will allow Defence to better meet its growing bandwidth needs by making more efficient use of equipment and radio frequency resources as they become available.

The value of the award to date is $12.1 million with the contract allowing for future task orders as the program progresses.

Work has commenced to deploy the system with Clearbox Systems providing locally developed products as well as specialist software engineering, integration and cyber security services. The work is building on over a decade of contribution to Defence's SATCOM capability.

The work is being conducted out of Clearbox Systems' secure facilities in Sydney and Canberra and has led to the creation of new specialist engineering roles within the company.

Jeremy Hallett, Executive Director of Clearbox Systems, said the company's entry into the Defence market over a decade ago was on the back of the firm's leading SATCOM solutions. He stated that it is gratifying that the quality of the company's work over that time has been recognized through the award of this Prime Contract to deliver an enhanced SATCOM capability to Defence. Clearbox Systems look sforward the continuing this close engagement with Defence and ensuring its global SATCOM networks are secure and easy to use.

www.clearboxsystems.com.au/

www.defence.gov.au/

GENERAL ATOMICS PARTNERS WITH THE SPACE DEVELOPMENT AGENCY

General Atomics Electromagnetic Systems (GA-EMS) announced the company has partnered with the U.S. Space Development Agency (SDA) to demonstrate and conduct a series of experiments for an Optical Intersatellite Link (OISL) using GA-EMS's internally developed 1550nm (nanometer) wavelength laser communication terminals (LCTs).

This will be one of the first Department of Defense contracted efforts to develop and deploy a state-of-the-art 1550nm LCT to test capabilities to increase the speed, distance, and variability of communications in space.

The OISL demonstration will consist of two GA-EMS internally designed and built 12U cubesat spacecraft, each of which will host an Infrared payload (IRPL) and LCT payload, with an anticipated launch date in March 2021. Satellite development, integration and testing is being conducted at GA-EMS facilities in San Diego, California, and Huntsville, Alabana. GA-EMS will also provide mission control capabilities from its mission control centers in Centennial, Colorado, and Huntsville.

Scott Forney, President of GA-EMS, said this is an exciting opportunity for GA-EMS to leverage work currently underway to advance OISL technologies. For several years, the company has been developing a series of optical laser communication terminals to improve and increase satellite crosslink data transfer rates and downlink data rates. These experiments will demonstrate robust communication capabilities through multiple mediums, from Earth, to and between satellites in multiple orbits and on into deep space. GA-EMS' LCT technology will modernize and enhance space communications permitting faster communication transmission across longer distances and with greater fidelity.

Nick Bucci, VP of Missile Defense and Space Systems at GA-EMS, added that the company's small satellite designs offer unique solutions to many of the challenges that arise when developing demonstration assets, such as LCTs including addressing specific size, weight, and power requirements. With GA-EMS' proven spacecraft and capabilities, coupled with the company's significant investment in LCT research and development, the firm anticipates this demonstration to show data rates up to 5 GB a second at ranges up to 2500 km, and this LCT can support out to greater than 4500 km. This increased speed in communications is necessary to advance a variety of space applications in intelligence, surveillance, telecommunications, reconnaissance, and more.

www.ga.com/

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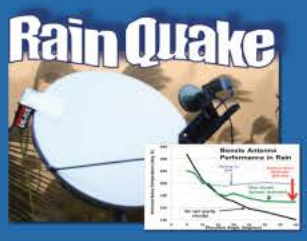

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COMTECH EF DATA AWARDED $500 MILLION CONTRACT BY DOD CONTRACTOR

Comtech Telecommunications Corp. (NASDAQ: CMTL) has revealed that, during the company's third quarter of fiscal 2020, their Tempe, Arizona-based subsidiary, Comtech EF Data Corp., which is part of Comtech's Commercial Solutions segment, received a $4.7 million contract for engineering services from a large prime U.S. Department of Defense ("DoD") contractor to support a critical Air Force and Army Anti-jam Modem ("A3M") program under the U.S. Space Force's Space and Missile Systems Center ("SMC").

The A3M program will provide the U.S. Air Force and U.S. Army with a secure, wideband, anti-jam satellite communications terminal modem for tactical satellite communication operations.

The jam-resistant modems will support SMC's Protected Tactical Waveform technology, an anti-jam capability operating on military satellite communication terminals through the Wideband Global Satcom constellation.

The prime contractor was awarded a five-year, $500 million ceiling, indefinite delivery, indefinite quantity ("IDIQ") contract. The prime has received an initial delivery order in excess of $30 million for the development and prototype phase.

Comtech EF Data will be a key subcontractor providing both engineering and hardware services and has received initial funding of $501,000 with additional orders expected during the Company's fourth quarter. Once development is completed, Comtech EF Data expects to receive significant hardware orders in future periods during the production phase.

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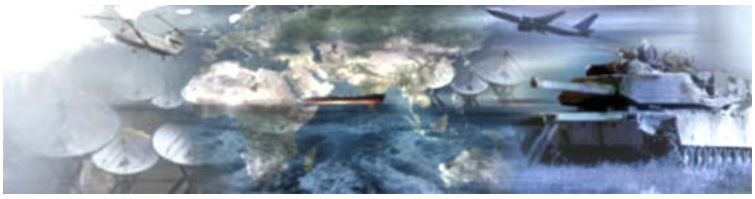


RAYTHEON I&S HAS SUCCESSFUL SENSOR DESIGN PAYLOAD PDR FOR USAF

Raytheon Intelligence & Space's competitive sensor payload design passed its Preliminary Design Review for the U.S. Space Force's Next Generation Overhead Persistent Infrared Block 0 GEO missile warning satellites being designed and built by spacecraft prime contractor Lockheed Martin Space.

Wallis Laughrey, VP of Space Systems for RI&S, stated the early detection of launched missiles starts in space. Each layer, or orbit, provides a necessary and unique view of the Earth to initially detect and then track a missile. Passing the Preliminary Design Review (PDR) shows that the company's approach meets mission requirements, putting this 'Go Fast' program one step closer to launch.

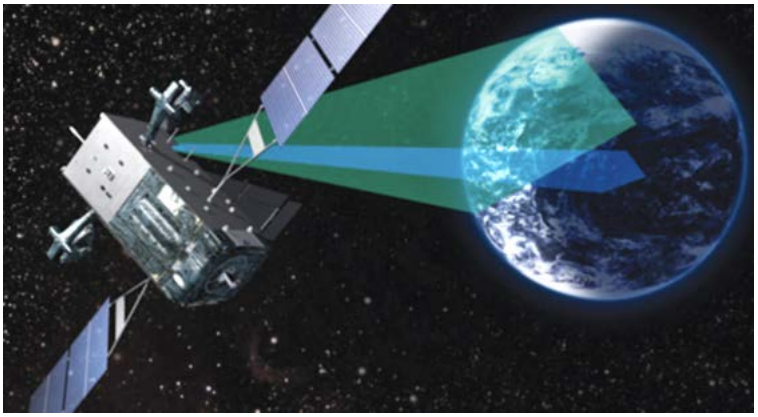
Following PDR, RI&S is focusing on manufacturing hardware and building and testing critical components to reduce risk ahead of the competitive program's Critical Design Review in 2021. The team is building an engineering development unit that will go through a number of tests to ensure it functions as planned. Tests include environmental testing to simulate space's harsh environment, such as the thermal vacuum chamber, which tests a system under extreme temperature conditions.

Laughrey added that what sets Raytheon I&S apart is the firm's deep technology bench. Being able to pull or modify critical technology, such as focal planes and electronics, from the company's other programs allows for the rapid development of new designs for any orbit.

Planned to succeed the Space Based Infrared System by providing improved, more resilient missile warning, Next Gen OPIR Block 0 was implemented by the Department of the Air Force as a "*Go Fast*" acquisition program.

Prime contractor Lockheed Martin Space competitively selected Raytheon to design a potential payload for the program just 45 days after the program was initiated. The first geostationary orbiting satellite is targeted for delivery in just 60 months.

www.raytheonintelligenceandspace.com/



2ND SPACE OPS SETS NEW STANDARD AND PERFORMS FIRST GPS III MANEUVER

The 2nd Space Operations Squadron performed the first station keeping maneuver on a GPS III satellite to Satellite Vehicle Number 75 at Schriever Air Force Base, Colorado, May 14.

The maneuver set a new standard for how GPS maneuvers should be conducted for the squadron that provides precision, navigation and timing signals to billions of users around the world.

A station keeping maneuver is performed to keep vehicles in their node (or parking spots in orbit) and involves burning the satellite's thrusters and changing the vehicles speed at a particular point in its orbit. This causes the orbit to change, in turn, keeping the vehicle in the ideal position to provide coverage.

"*All operational GPS vehicles are assigned nodes, when all nodes are filled with healthy vehicles there is good global GPS coverage*," said 1st Lt. ***Michael Gallagher***, GPS subsystems *analyst. "When new vehicles are launched they typically aren't launched directly into their final node. This means that the 2 SOPS analysis flight must perform a re-phase maneuver to put a vehicle in its node*."

The maneuver required GPS III's signal to be turned off. Turning off the navigation signal while performing the maneuver prevents users from receiving inaccuracies generated by a change in satellite velocity.

"*This was a new process that we could learn from as it was the first station keeping [maneuver] performed for the newest generation of GPS satellites*," said Senior Airman ***Harrison Sherwood***, 2nd SOPS satellite systems operator, who sent the commands to the satellite during the maneuver. "*[Since] this was the first [maneuver] of the newest generation satellites, it was a bit of a guinea pig for future maneuvers.*"

Johnathon Caldwell, Lockheed Martin Space Vice President of navigation systems, right, presents Lt. Col. Stephen Toth, 2nd Space Operations Squadron commander, with a GPS III model satellite as a token of appreciation for the 2nd SOPS critical mission in space at Schriever Air Force Base, Colorado. U.S. Air Force photo by Airman 1st Class Jonathan Whitely.

Artistic rendition of a GPS III satellite on orbit

However, the unit was able to complete the maneuver flawlessly. The maneuver was completed in a special mission area and there were no changes to the normal operations floor.

"*This maneuver had no effect on the rest of the [GPS satellite]* constellation," Gallagher said. *"SVN-45 was in the node SVN-75 was being placed into, so there was no decrease in GPS signal quality as a result of this maneuver*."

This procedure was also the first of its kind to be performed with the 2nd SOPS Architecture Evolution Plan, which all active satellites in the program are operated. Since GPS III vehicles are fully integrated into the program with this maneuver, all maintenance is conducted through AEP.

"*Station keeping maneuvers are essential to satellite operations and must be done for regular maintenance*," said 2nd Lt. Tyler Gorman, 2nd SOPS navigation payload engineer. "*This activity helped validate a nominal maintenance activity for a new generation of vehicles.*"

The unit plans to continue to use this new method and program for future GPS satellites that are being launched and need to be re-phased into their operation slots. The next satellite that will need a station maneuver performed is SVN-76, which is scheduled to launch in the next few months.

"*GPS maintenance requires a coordinated effort to ensure our worldwide service is preserved*," Gorman said. "***That means careful planning and execution from our analysts in 2 SOPS, our satellite system operator and the operational support from Lockheed Martin and the Aerospace Corporation.***"

Story by Airman 1st Class Jonathan Whitely, 50th Space Wing Public Affairs

USAF PRIME CONTRACT TO MASTEN SPACE TO SUPPORT U.S. SPECIAL OPS FORCES

Masten Space Systems has been awarded a contract from the US Air Force to change the way supplies are airdropped to frontline Special Operations Forces — the study will explore rapidly landing supplies under rocket power rather than a long, slow fall under a parachute.

Under the Phase 1 award from the Small Business Technology Transfer (STTR) program, and in partnership with Rhea Space Activity and Purdue University, Masten will conduct a feasibility study to produce an initial design for a rocket-powered landing craft, named XERMES, to deliver supplies to frontline units.

The vehicle, based on Masten's proven Vertical Takeoff Vertical Landing (VTVL) rocket technology, would slow itself from free-fall to a safe landing through an aggressive retro braking burn, pulling above 9 g's of force, which is twice as much as a typical rocket launch.

Once XERMES lands, ground troops will recover the cargo stored onboard and then the vehicle could be reused for another supply drop.

Dave Masten, founder and CTO of Masten Space Systems, said that creating a rugged cargo vehicle for the Air Force fits well within the company's design philosophy. He noted that the company has always designed landers to be robust. The firm also found that companies are more willing to allow companies to fly their valuable payload when the vehicle has already had dozens of successful flights.

Rhea Space Activity came up with the idea to deliver supplies via a rocket-powered lander after an incident in 2016 when a Special Operations resupply crew was endangered as its aircrew flew 800 feet above a besieged compound to deliver supplies as accurately as possible, taking fire as it passed overhead.

Rather than drop payloads from low altitude to achieve high precision, the proposed system would guide itself in from high altitude. Starting the drop from above 20,000 feet, well out of the range of small arms fire, the lander would freefall to just 500 feet above ground. Then, the vehicle would fire its rocket engine and land within three feet of a designated area.

This high-impulse deceleration burn would last only seconds, providing little opportunity for adversaries to intercept or destroy critical supplies.

Steven Collicott, a professor at Purdue University and partner on the contract, said that this project is the latest step in Purdue's long history of developing innovative space technology and said that from Neil Armstrong to next-generation space habitats, Purdue University has made multiple contributions to the space industry. There's a certain amount of satisfaction in seeing

Masten Space's Xodiac rocket

technology made for a Moon landing come full circle to landing here on Earth.

Rhea Space Activity worked with Masten Space Systems to develop the idea as a parallel application for their current work with lunar landers under the NASA Commercial Lunar Payload System. Masten has been flying rocket-powered landers for more than ten years, with 600+ successful VTVL flights accomplished across five vehicles.

These vehicles have demonstrated high levels of positioning and navigation capabilities including winning both level one and level two of the Northrop Grumman Lunar Lander Challenge X Prize in 2009 with an average landing accuracy of less than 8 inches from the target.

Beau Rideout, an engineer at RSA said that the adaptation of space technology to other applications should be considered more frequently, noting that especially in today's space industry, where innovative new ideas are being developed continuously, it's hard to know if one company has solved someone else's problem. This is especially relevant to conversations between small businesses and the government. Lots of space companies have developed technology that solves this and other problems in national security, such as secure communications, novel sensor devices, and intelligent reconnaissance platforms.

Following the completion of this Phase 1 award, Masten will apply for a Phase 2 contract to bring operational lander hardware to USAF personnel. The Phase 2 effort will include hot-fire tests of the proposed design along with tests of contingency measures to ensure the safety of ground personnel and supplies.

www.masten.aero/

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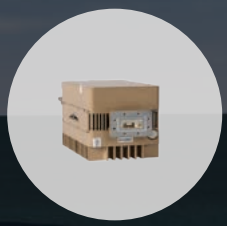
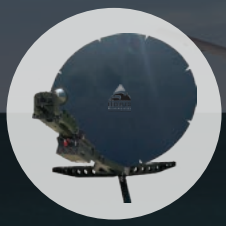


X-Band SSPAs/BUcs
GaN & GaAs configurations



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COMMUNICATION SIGNAL INTERFERENCE + DSSS = EFFECTIVE ANTI-JAM

By Karl Fuchs, iDirectGov Senior Vice President of Technology and MilsatMagazine Senior Contributor

One mechanism to support anti-jam on a commercial product as opposed to relying solely on purpose-built frequency hop spread spectrum systems is to couple the coding gains of direct sequence spread spectrum (DSSS) with the channel-hopping capabilities native to a time division multiple access (TDMA) very small aperture terminal (VSAT) system.

In research and testing of anti-jam technologies, I have been impressed with the potential of signal excision for highly sensitive defense, homeland security, government and first responder communications use.

First, it is worth defining the term *signal excision*. Signal excision is any technology, either analog or digital, which can identify and remove an interfering signal without the need for additional bandwidth. These interfering signals can be intentional such as adversaries attacking by signal jamming or unintentional interference.

Signal excision contrasts with the traditional method of anti-jam, which relies on spread spectrum necessitating, of course, a large spread factor and thus enormous amounts of bandwidth to overcome even small jamming signals. Employing a signal excision anti-jam as a first line of defense against interference for the military can be beneficial.

Quite often, there simply isn't enough available bandwidth in theater to overcome a threat. A number of signal excision technologies exist on the market today.

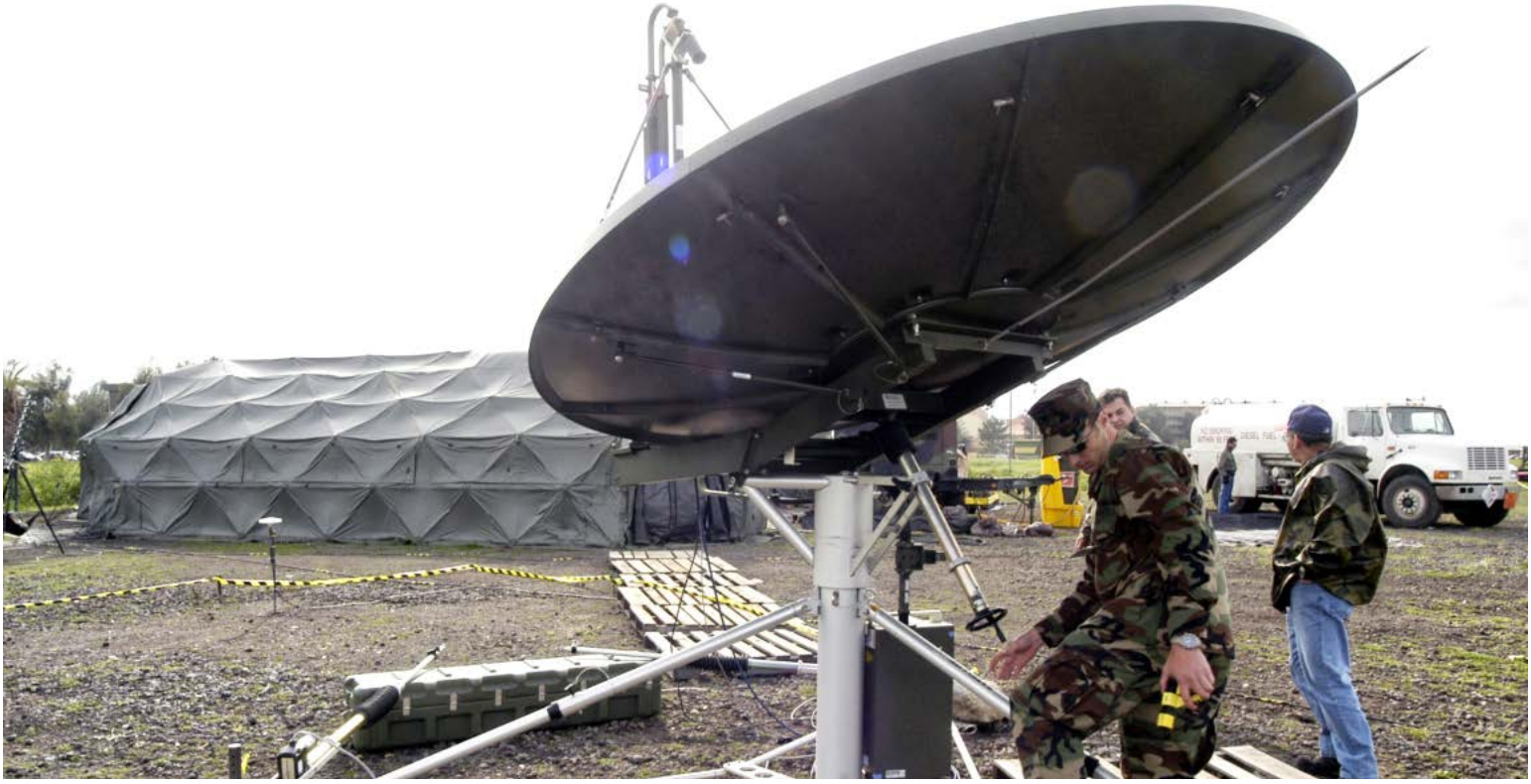
Analog filter manufacturers have been building active filters for years. In the digital domain, successive interference cancellation (SIC) is a common method used for signal excision. For SIC to be effective, however, the interfering signal must be at a significantly higher power or lower power from the signal of interest.

If the interfering signal is a carrier wave (CW), the difference in power between the signal of interest and the interferer is typically on the order of 4 dB to 5 dB, which is not significant.

If the interfering signal is a modulated carrier, the power delta required between the two signals for SIC to be effective is even higher.

A signal excision technology known as Communication Signal Interference Removal, or CSIRTM, came to my attention at SATELLITE 2018. At that show, CSIR was already a mature technology with a number of impressive and useful characteristics showing a great deal of promise for anti-jam use for defense and government.

For instance, unlike SIC, the power difference between the signal of interest and the interferer can be very small when using CSIR™. This is important because adversaries always are implementing signals intelligence (SIGNET) so they can attack military and government spectrum use by jamming transmissions used for radio communications, radar and various operations.



When considering threat assessments, many people think in terms of either very large modulated carriers or huge CWs. Quite often, in either blue-on-blue (friendly vs. friendly) signal interference or red-on-blue (malicious vs. friendly) interference, the interferer power level is close to that of the signal of interest. This type of threat requires the use of a signal excision methodology, which can differentiate small differences in power.

Another key differentiator of signal excision systems is their ability to remove a wide range of interferer types. In the real world, we see a number of types of interferers including carrier waves, modulated carriers, sweeping tones, multiple CWs or combs, hopping carriers, and at times, a combination of multiple threats. Having tested CSIR, we found it to be effective against all of these interferers. Another substantial benefit of CSIR is the relative compactness of the field-programable gate array (FPGA) image, making CSIR technology particularly portable to existing FPGA-based radio systems.

Of course, no signal excision system can adequately address all jam threats. We have found the CSIR implementation of signal excision to reach its limits when the interfering signal is a modulated carrier with a symbol rate that is a significant percentage of the signal of interest.

For example, if the signal of interest is quadrature phase shift keying (QPSK) modulated 10 MHz and the interferer is QPSK 2.5 MHz, the CSIR signal excision will provide excellent headroom and coding gains to overcome the interferer. As the interferer's symbol rate approaches that of the signal of interest, the signal excision will no longer be effective and another, more brute force anti-jam methodology such as spread spectrum will be required.

The exact point where signal excision stops being effective will be determined by various factors — most importantly the forward error correction being employed. There are two broad categories of spread spectrum, frequency hop and direct sequence.

Historically, frequency hop spread spectrum has been employed to address jamming threats, though both methods provide the same gains for a given spread rate. Interestingly, we are discovering the coding gains realized when CSIR and DSSS are used in tandem far exceed a simple addition of the two separate gains. This combination of CSIR and DSSS leads to a highly efficient anti-jam solution.There are other benefits to employing a DSSS anti-jam solution. A DSSS waveform is inherently compatible with existing TDMA VSAT architectures.

Given the Department of Defense (DoD) drive toward leveraging commercial off the shelf (COTS) products and avoiding expensive, often disappointing customized developments, augmenting existing TDMA infrastructure with DSSS and CSIR would be a boon for all. A combination of anti-jam techniques seems to yield the greatest benefits and enables the use of cost-effective and proven technologies.

Certainly, the state-of-the-art is not static. As analog filters, digital signal processors and waveforms improve, so will anti-jam technology. The state-of-the-art must continue to evolve as jamming threats become more common place, and in the case of red-on-blue, the adversaries become more sophisticated.

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Karl Fuchs is the Senior Vice President of Technology at iDirect Government (iDirectGov). Fuchs leads iDirectGov's team of federal systems engineers and serves as chief architect for new product integration. Fuchs has more than 20 years of experience in the areas of technology and the federal government and is a Senior Contributor to MilsatMagazine; ***kfuchs@idirectgov.com****.*

Benefits of Employing a CSIR and DSSS Anti-Jam Solution

- *Compatible with existing TDMA VSAT architectures*
- *Removes a wide range of interferer types*
- *Tested effective against carrier waves (CWs), modulated carriers, sweeping tones, multiple CWs or combs, hopping carriers, and a combination of multiple threats*
- *Features compact field-programable gate array (FPGA), making CSIR technology portable*
- *Supports the DoD drive toward leveraging commercial off the shelf (COTS) products*
- *Uses cost-effective and proven technology*
- *Eliminates the wait for time-intensive custom development*

Vice President, Marketing and Sales Operations, Envistacom

John Sciberras is a technology leader with over 30 years of industry and business experience. He brings extensive experience in satellite communications, broadcast engineering and business knowledge to Envistacom. John's understanding of the customer, the federal acquisitions process and the defense industry drives Envistacom's technology and marketing strategy. In addition he manages the sales operations and marketing teams.

Prior to his position as Vice President of Marketing & Sales Operations at Envistacom, John held high profile positions with DataPath, Inc., TriPoint Global Communications Inc. and other technology companies. He is a graduate of Western Kentucky University where he earned a bachelor's in electrical engineering with an emphasis in broadcast engineering and later continued his education at Harvard earning a certification in General Management. John is involved in several professional organizations including executive board member for the American Marketing Association (AMA), youth mentoring at the YMCA and on two advisory boards of other companies.

What are the challenges that stand in the way of satellite communications being able to fully realize communications interconnectivity?

John Sciberras (JS)

DoD commanders have warned that future battlescapes will be increasingly fast-paced even as communications channels grow more congested.

As a result, defense leaders are looking for investments in the right technology that will enable warfighters to have seamless connectivity, operational security and increased information assurance despite the more challenging operating environments they foresee.

The current state of satellite communications is based on purpose-build infrastructure and technologies designed over many years with standards and hardware created for a specific use.

The result is a complex patchwork of infrastructures, standards, form factors, designs and more that served a purpose when initial specifications were created, but which now poses a significant challenge to interoperability. The current paradigm of satellite communications is unsustainable in the long run.

What trends led to these challenges in the first place?

JS

When the current military networks were developed, there was a major focus on designing specifications built for specific missions. Satellite communications were still in their infancy and they required very specific purpose-built hardware that resulted in heterogenous communication systems.

Furthermore, the capital-intensive investments in satellite communications and their mission critical nature made them highly valuable and difficult to modernize.

Fast forward 20+ years and innovations in miniaturization, increased industry collaboration and standardization, a bourgeoning private space industry, and new requirements have accelerated the need for new satellite communication systems — systems that can operate with legacy infrastructure as well as accommodate the next generation of technology development.

Envistacom recently announced a trio of patents for virtualization technologies that enable real-time and continuous data to be processed in high performance heterogeneous computing environments.

Break that down for us: what is Transport Virtualization and how does it work?

JS

Transport virtualization is a new paradigm in communications technology, just like cloud computing ushered in a new era of data processing and storage. It refers to the "virtualization" of hardware-based devices, in this case traditionally a modem, which exists in software code rather than in a physical device.

In practical terms, it enables the delivery of data, video and voice information over a common transport medium that most modems recognize.

Instead of a single physical modem that can communicate only in certain bands or frequencies, a virtualized modem can change between these "languages" seamlessly and can even be upgraded via software updates as new needs or specifications develop.

Users achieve significant gains in network user interoperability, application and capacity efficiency as well as general connectivity resiliency.

It's analogous to the smartphone industry. Instead of separately investing in a calculator, a telephone, a map, a flashlight, a camera, a gaming console, and other purpose-built capabilities, users can instead invest in an infrastructure that delivers all of these capabilities and more.

How disruptive is this really? If this is such a problem, why hasn't it happened earlier?

JS

Defense and industry leaders have been talking about achieving communications interoperability for years, recognizing that interoperability is a must-have capability for future mission success.

However, technological and economic limitations have prevented the vision from being fully realized until recently. New space ventures and advances in small satellite technology have opened up the viability of dense LEO constellations that drastically reshape the satellite landscape and the need for new satellite communications systems.

Essentially, there is a new market emerging creating new demand forces and innovation pressures as the underlying cost structure for the entire industry changes.

What are the benefits of the Transport Virtualization Ecosystem to users and partners and what will it enable?

JS

Transport Virtualization amounts to a "universal translator" for satellite communications, allowing communications over any band, or any orbit.

This allows customers to buy a single solution and use it across their existing satellite communications infrastructure while also providing for futureproofing against to-be-developed satellite constellations such as those being developed for LEO right now.

For our partners, our Transport Virtualization Ecosystem builds upon several recently announced technology patents that led to the establishment of an open-architecture environment. Partners leveraging this Ecosystem are able to develop more flexible system designs and cross-platform functionality, taking advantage of built-in interoperability to replace purpose-built modems while delivering the same performance and resulting in faster time to market.

We are poised to enable our technology partners to deliver truly resilient connectivity in preparation for the intersection of terrestrial and space-based networking referred to as 6G.

Tactically, for military customers, Transport Virtualization allows operators to leverage both fixed and mobile satellite systems, increase mission readiness and flexibility, and provides redundancy.

By reducing size, weight and power requirements, Transport Virtualization allows more connectivity across domains and operations, particularly at the tactical edge. It also allows customers to "*wave hop*," which effectively hardens the network against jamming and hacking, making it more difficult for adversaries to interfere with communications.

These numerous benefits factor into making Transport Virtualization a game-changing technology and align with the goals of the Department of Defense and partners.

Interoperability has long been seen as the Holy Grail in the technology world. Is it accurate to say that Transport Virtualization is poised to finally deliver the interoperability promise that we've all been seeking?

JS

Seamless communications across the battle-sphere, from command centers to tactical edge, has forever been a crucial element of warfare. However, with warfare now encompassing five domains and on a global scale, achieving interoperable communications has become increasingly difficult.

While it is one thing to stand up high bandwidth communications at a stationary command center, it is another challenge all together to achieve high availability and user-friendliness at sea or in remote regions where forward deployed units operate.

While there are many other challenges that must be overcome to realize the full interoperability envisioned by military commanders, Transport Virtualization helps remove many barriers and enables a leap forward in interoperability not possible with today's purpose-built technology.

What major initiatives is Envistacom poised to support in the future?

JS

Envistacom is ready to support any network and SATCOM modernization investments the DoD looks to make in the near future.

We were recently awarded a seat on the GTACS II IDIQ contract and are currently working to develop, design, engineer, install and commission two SATCOM Earth terminals to support theater reach back communications for the U.S. Army.

Further into the future, looking at the vision described for Joint All Domain Command and Control (JADC2), it is easy to see Transport Virtualization technology being an enabling part of that future.

According to Air Force Doctrine Note 1-20, the vision of joint operations is to be "*integrated in planning and synchronized in execution, at speed and scale needed to gain advantage and accomplish the mission.*"

This goal is also echoed in the U.S. Space Force's (USSF) vision of ubiquitous connectivity. Interestingly, the USSF hopes to do so without forcing standards as well, which have traditionally constrained innovation by forcing specifications or consuming lengthy development cycles.

Transport Virtualization addresses both visions well, providing an interoperable system that doesn't force standardization, while also providing for the levels of integration, synchronization, speed and scale needed to support the high availability and high reliability of satellite communications in the future.

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THE U.S. USE OF ELECTROMAGNETIC SPECTRUM IS CONTESTED

By C. Todd Lopez, Department of Defense (DoD) News

A soldier who is more than 6 feet away from other soldiers talks on a radio. Photo by Army Sgt. Harry Villarama.

That the U.S. military is no longer the only — or even the dominant — user of air, land, sea, space and cyberspace is not disputed. In every domain where the U.S. military once went unchallenged, newcomers hope to usurp its long-held dominance.

Less well-known are new challengers in the electromagnetic spectrum, the deputy director for the Defense Department's Electromagnetic Spectrum Operations Cross Functional Team said.

"*The joint force is critically dependent on [the electromagnetic spectrum] across our joint functions and our domains, yet often it is viewed as a commodity. It's viewed as a utility, and it is assumed that it can be accessed at will*," said U.S. Air Force Major General ***Lance Landrum***, who spoke as part of a forum with the ***Association of Old Crows***.

Landrum also serves as the deputy director for requirements and capability development in the Joint Staff's force structure, resource and assessment directorate.

The electromagnetic spectrum, or EMS, includes the array of frequencies used by communications equipment such as radios, GPS, cell phones and remotely controlled devices, for instance.

While the United States has assumed in the past that it was alone or nearly alone while operating in this area, this is no longer the case.

Both commercial interests and adversary militaries are now actively using the EMS for their own interests.

"*For decades, the United States has enjoyed uncontested or dominant superiority in every operating domain*," Landrum said. "*We generally could deploy our forces when we wanted, assemble them where we wanted and operate how we wanted. Today, every day, every domain is contested.*"

Two hands hold a military radio. Photo by Army Sgt. Thomas X. Crough.

American adversaries have been fielding systems and platforms to challenge U.S. traditional areas of advantage such as precision guidance, timing, low observable technology, space-based communications and intelligence, surveillance and reconnaissance systems, the general said.

Additional advances in technology, he noted, have led to an increase in commercial and military EMS-enabled capabilities over the last few decades.

"*The spectrum has become increasingly complex. More players are accessing and leveraging sections of bandwidth, making it congested," he said. "And the spectrum is still constrained by the physics and the reality of that space.*"

To deal with the complexities of new challenges in the EMS, Landrum said the Electromagnetic Spectrum Operations Cross Functional Team and the DoD chief information officer have been drafting a new EMS superiority strategy.

He said he believes that strategy can be signed by January and then work can start immediately to implement it. That implementation will be overseen by the vice chairman of the Joint Chiefs of Staff.

"*The vice chairman will address the changes necessary in governance, manpower, training, readiness and capabilities to achieve the strategies vision, which is freedom of action across the electromagnetic spectrum*," Landrum said.

To address capability gaps in the EMS, Landrum said the team is analyzing past and present investments in EMSO capabilities, and is also providing guidance to inform future DOD investment strategies in EMSO capabilities.

Landrum said that first priority is challenged, in part, by defining what constitutes an EMSO system.

"*A lot of EMS-related capabilities are integrated into other items*," he said. "*And while some are very clear — things like jammers, electronic countermeasure systems and things like that — others are more nuanced. For instance, is investment in a new tactical radio an EMSO investment, or is it a sub-element of the radio, such as software that encrypts the communications or allows for dynamic spectrum maneuver*?"

In terms of informing future investment in EMSO capabilities, the strategy is a comprehensive approach to acquire EMS capabilities suitable for great power competition, Landrum said.

"*The DoD EMSO investment strategy seeks to achieve this objective by providing specific top-down recommendations related to concept-driven, threat-informed, EMSO capability development, addressing and prioritizing gaps across the requirements, acquisition, budgeting and operations processes in the department*," Landrum concluded.

A KRATOS CONSTELLATIONS PODCAST PRESENTATION

This Kratos Constellations podcast discussed the Electromagnetic Spectrum Operations (EMSO) of the Department of Defense. With the RF spectrum used by satellites now considered contested and congested, the particpants talked about the role EMSO plays in electromagnetic attack, protection, and support.

Dr. William Conley

*The guest was Dr. **William Conley**, who, prior to his current position as Senior Vice President and Chief Technology Officer at Mercury Systems, was the former Director of Electronic Warfare for the U. S. Department of Defense, and Executive Secretary for the Electronic Warfare Executive Committee, where he advised leadership on electronic warfare capabilities.*

The original interview was edited for brevity and format.
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John Gilroy (JG), Host of Constellations
Welcome, Dr. Conley. Electronic attack, electronic protection, and electronic support, once considered separate, now fall under Electromagnetic Spectrum Operations, or EMSO, where they are battle managed together. Should the electromagnetic spectrum be considered a domain of military operations alongside land, sea, airspace, and cyberspace?

Dr. William Conley (WC)
Thanks for having me. You've cut to the heart of the domain conversation. It's important to understand the history of why the Department of Defense uses the word domains. Land, air, and sea were recognized as war-fighting domains decades ago and were aligned to the three military departments.

As we increase the jointness of our force, the concept of the domain has evolved in terms of how it's included in our operational doctrine, namely as a way for the joint force commander to have subordinate commanders that are responsible for a part of the fight. William Conley: When we talk about the EMS as a domain, it really comes down to having the joint force commander that's responsible for all those operations, commanding and controlling and making sure the right decisions are being made.

JG
In the context of emerging space operations, how do you see space signals intelligence (SIGINT) supporting electronic warfare (EW)?

WC
Domains are really more about the command relationships and not about the fundamental physics. Electromagnetic spectrum is unique because all multi-domain operations, which include space, depend on the EMS to coordinate the desired effect. The coordination typically is going to occur through a radio link.

Interestingly, if you look at the dividing line between the air and the land, it typically is 3,000 feet. Obviously, a helicopter flying at a couple hundred feet is operating in the air, but the command relationship is really based around 3,000 feet. the reason for that is it allows a helicopter to be retained from a command relationship by the land commander that's working to execute all of that maneuver.

For a system that impacts aircraft, or even space vehicles, it makes sense for that to be a coordinated response. Typically the command relationship for the EMS should be aligned to the supported commander as they have the best ability to orchestrate all of those different maneuvers.

JG
Should there be a specific service to focus on this domain? Much like we have today with the Army, Navy and Air Force focusing on physical domains within the operating environment.

WC
I would say no. The reason is that multi-domain operations that will be executed by anyone really are executed by everyone. Expecting a service to go in without any of their radios, without the ability to get the battle space awareness through radars, would not make a lot of sense. Every service has to have some core capability in this part of the electromagnetic spectrum.

JG
With the proliferation of electronic warfare capabilities and more spectrum getting used or saturated, the ability to navigate this contested environment is becoming more difficult. What are your thoughts on the new capabilities being developed in the SATCOM market?

WC
There is always a need to continue to expand our ability to move out of band and leverage a variety of commercial advancements. For example, the Ka band communications being developed for the 5G market is exciting. I'm not advocating that we directly use a commercial solution, but instead use those underlying technologies, things like system on ship transceivers and wide band signal mixers, to give us more capability as we look into the future.

Interestingly, if you look at the spectrum surveys of major metropolitan areas, we really are not out of spectrum. Rather, we lack the coordination tools to make that spectrum available on much shorter timescales than we do today. The ability to dynamically shift what we're doing, based on software defined radio technology, gives us the ability to manage how all of these different devices are operating in coordination with each other. The question is, how do we set the correct policy to make that a reality?

JG

As we look at the capabilities of near peer adversaries, can you talk about the convergence of electronic warfare and cyber as it affects spectrum?

WC

Earlier, I mentioned multi-domain operations and the need for the electromagnetic spectrum to communicate across all these different diverse capabilities. The vast majority of that is envisioned to be machine to machine (M2M), sending data without humans typing values into their individual system. M2M connections are obviously vulnerable to cyber-attack.

Commanders need to have confidence in the data they use to make decisions, which includes trust in the sensors collecting the data, trust in the signal processing, and trust in the movement of the data.

Similarly, a commander will want ability to interrupt the multi-domain operations of an adversary. An electronic warfare attack, for example, might go after the physical and media access control layers, whereas a cyber-attack would go after things like encryption, authentication, perhaps even the application layer. Defending all of these, as well as being able to attack them is essential.

JG

You have said that we are on the verge of being able to directly process all 110 of the gigahertz that are most usable for RF in a way that we couldn't dream of a decade ago. What are the implications for our Air Force and Army working in a multi-domain environment to lose these gigahertz capabilities?

WC

It's huge. We've seen the evolution of terms like low probability of intercept, low probability of detection. We're really moving more toward LPX, where X is the more holistically low probability of anything that would interfere with your mission. As more broadband signal collection is coupled with artificial intelligence, signal processing opens up a greater battle space awareness. The ability to hide or tactically deceive an adversary gets harder on both sides.

General Holmes from Air Combat Command recently showcased this vision for AI to support what is called joint all-domain C2, or JADC2, to process all of that data. I expect the data to be at diverse portions of the spectrum. Again, that sets up that need for trust in the data, its collection, and management.

JG

You've talked about the critical importance of signal processing to EMSO and making sure we are getting the necessary information to make the right decisions. Are we working on those capabilities?

WC

Yes, we are working to make sure that we can make the right decisions in a timely fashion. The Army Electronic Warfare Planning Management Tool is a specific example. There's also commercial investment that we can bring over to the defense ecosystem.

In the 1960s, federal investment in R&D was double that of commercial industry. Today, it is the inverse, with 2.7 times more money spent by the commercial sector on R&D. So, how do we bring those tools for signal processing over from commercial and make them applicable to the defense ecosystem? There are areas where the government is leading, such as hypersonic weapons. But there are other areas, like in telecommunications, where the commercial investment is absolutely critical.

JG

Traditionally, the U.S. way of war has been to control the skies. But we cannot count on this with near peer adversaries developing similar technologies. Is the U.S. looking to accomplish its objectives in other ways, such as by protecting and controlling access to RF data links?

WC

The short answer is yes. Protecting and controlling the access to the RF data links as well as the sensor, such as radar, will be the first step in seeking air superiority, or security, or for that matter in land, sea, and space. Having a decision-making advantage in a tactical engagement is huge. The ability to detect at longer ranges, to guide weapons farther, creates the substantial advantage that we are after. Today's aircraft have amazingly complicated systems that can't be built quickly during a conflict. But using the spectrum to improve the survivability and the lethality is a key foundation in any future conflict for us.

JG

Multi-domain refers to the desire to network U.S. forces operating in all environments, land, sea, air, space, and cyberspace so they can coordinate their military operations seamlessly, overwhelming

the enemy with attacks from all directions. Is it possible to do this without radio frequency network?

WC

I believe the answer is yes, but it's going to require extensive training. And the analogy is akin to a football team when they're playing at home versus on the road. At home, the quarterback is able to audible and readily change a play at the line of scrimmage. Whereas on the road, when that audible part of the spectrum is fully contested by all the fan noise, they end up using hand signals and careful timing.

Building off that analogy, in an uncontested environment, spectrum provides U.S. forces the ability to coordinate in real time between all of these different distributed platforms. Without the EMS, each operator has to make that decision individually based on what they expect the other U.S. forces to do. The only way to build that confidence, similar to a football team, is to practice regularly. Train regularly, as we might say.

JG

We've been talking about EMSO mostly through a U.S. lens. Can you talk about that relationship with our partners?

WC

The U.S. obviously has lots of allies and partners that are very important. We tend to go into conflicts together. And so how do we execute electromagnetic battle management, not just us, but with all of those allies and partners. Having the necessary trust, the ability to share data back and forth, and the ability to maneuver no different than we do in the air with our allies and partners. We have to be able to do that in the electromagnetic spectrum as well. Having those tools, but also to be able to share that data, the visualization, the command and control structure across our allies and partners, is going to be essential in future conflicts.

JG

With the growing demand for more bandwidth, yet limited radio spectrum can we effectively share and manage this finite RF resource?

WC

It is a challenge in terms of how we share it. There has been a lot of congressional interest in spectrum efficiency. Like I mentioned earlier, the majority of the electromagnetic spectrum is actually not instantaneously in use. However, I think many people on the commercial side would prefer an exclusive lease as opposed to worrying about the issues that come with sharing in real time.

However, through better electromagnetic battle management tools, I believe we can address the many heterogeneous spectrum users in a way much like we coordinate driving today.

The ability to take tools like the software defined transceiver, and the ability to rapidly reconfigure and reprogram is essential. That wasn't possible with advent of radio when everything was hardware defined, but it is possible today.

JG

This approach with software defined networks and software defined radio signals are enabling this efficiency in addressing the spectrum allocation problem?

WC

It is beginning to allow us to do that. I think we're beginning to collect the data. We are beginning to understand that, but it's going to be a long journey as we have progressively more devices entering that electromagnetic spectrum. It will force us to be more innovative and make better decisions going forward. It's going to be both a combination of what happens with technology and policy.

That's what I really enjoyed at the Pentagon, that ability to work on the technology and policy, and now in the role of CTO for Mercury Systems, that ability to work the technology piece and make sure we're bringing all of those fascinating advancements from the commercial side and bringing them over. That is what enables that long term solution. It will be a healthy ecosystem with many of us taking those necessary steps.

JG

Thanks for your time, Dr. Conley.

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FIGHTING COVID-19 FROM SPACE

A Government Satellite Report by Ryan Schradin, Executive Editor

The COVID-19 pandemic has had a massive impact on a number of Americans. While many people have managed to stay safe and healthy by social distancing and confining themselves and their families to their homes, many have fallen sick, been hospitalized, or worse.

The disease has also created problems for many small businesses, forcing retailers to shut their doors, restaurants to get creative and some businesses to close for good.

It's safe to say that every single American has — in some way — been impacted by the pandemic. And, with so many people having their lives at least inconvenienced by COVID-19, it's not surprising that the impact of this virus on America's military has failed to garner much press or discussion — with very few, tragic exceptions.

The fact is, America's military personnel are dealing with this global pandemic, too. And most of them are doing so while quarantined away from family, deployed away from home and in other locations that many of us would not want to be in when confronting an incredibly infectious and often fatal disease.

With the military operating under a restrictive "*stop movement*" order, and with personnel becoming infected with the disease in some very isolated places — including aircraft carriers and other ships at sea — there are a number of ways that satellite communications (SATCOM) can play a role in the military's COVID-19 response. Let's explore a few SATCOM use cases that could help the military keep soldiers safe, happy and sane during the ongoing pandemic.

Telemedicine Delivery

The most important thing in a pandemic is access to healthcare services. Unfortunately for many deployed soldiers, access to healthcare services or specialized care could be limited. And

that's not just the case overseas. Some soldiers and veterans in rural and geographically-isolated locations within the U.S. could also find themselves without access to specialized, quality healthcare services.

Telemedicine has already exploded as a result of COVID-19, with many doctors and specialists embracing telemedicine to treat patients while social distancing orders are in effect. That same technology could be deployed by the military to deliver quality care and specialized healthcare services to deployed soldiers, personnel on ships at sea, and veterans at home.

Unfortunately, in many of these geographically-isolated places, the high bandwidth connectivity and terrestrial networks needed to carry the real-time, HD video necessary for effective telemedicine implementations are either unavailable or untrusted. In those places, SATCOM can help to fill the connectivity vacuum and deliver essential telemedicine services.

With today's advanced high-throughput satellites operating at orbits closer to Earth, the military can effectively deliver fiber-like connectivity to virtually anywhere on the planet. This connectivity could be used to deliver the real-time, high definition video teleconferencing that is needed for delivery of telemedicine services.

With satellite delivering healthcare personnel and specialists to virtually anywhere on the planet, soldiers and veterans cannot only access healthcare services that may have been previously unavailable, but they can even see medical professionals while still socially distancing.

Enabling Morale, Welfare and Recreation (MWR)

Everyone that's currently quarantined or otherwise socially isolating themselves in an effort to "*flatten the curve*" is probably filling the time with a combination of on-demand movies, streaming music, downloadable books and online video games. They're also getting support and peace of mind by calling and video chatting with their friends and families.

Those are things that we take for granted in much of America's more populated areas. But they're things that may not necessarily be available for deployed troops.

Imagine being unable to video chat with an elderly loved one that was diagnosed with COVID-19 because connectivity wasn't available. Imagine not being able to have a face-to-face discussion with a spouse while quarantined with COVID-19. Imagine being quarantined with COVID-19 and not having anything to do while isolated for fear that you could infect everyone around you. This is the reality that some deployed troops face.

Satellite is the answer to delivering those communications services and capabilities to deployed soldiers. Much like how high-throughput, low-latency satellite communications can empower telemedicine implementations, they can also be used to deliver voice, video and data to practically anywhere on the planet. That means that satellite can deliver the same communications services and capabilities to deployed troops that they may have access to and enjoy in their own homes.

MWR are essential for keeping troops happy and connected during this unprecedented time. Being away from family, friends and loved ones is always difficult. Being separated and isolated during a troubling time – like during a global pandemic – is understandably mentally, physically and spiritually draining.

MWR services can help to connect troops with their support systems, provide them with entertainment while socially isolated or quarantined and ensure that morale stays high — even as America struggles with one of its most challenging crises in modern times.

This truly is an unprecedented, and candidly, quite frightening time for many Americans. It's essential that our deployed soldiers have access to healthcare during this global pandemic. It's essential that they be kept connected and their spirits lifted. Satellite connectivity can often serve as the best, and possibly only, way to deliver these essential services to the men and women of our armed forces wherever they're stationed.

For additional information on the role that next generation commercial satellites can play in delivering essential government ***select this direct infolink***...

This article first appeared at ***GovSat*** and is republished with permission.

Ryan Schradin is the Executive Editor of GovSat Report. A communications expert and journalist with over a decade of experience, Ryan has edited and contributed to multiple popular online trade publications focused on government technology, satellite, unified communications and network infrastructure. His work includes editing and writing for the GovSat Report, The Modern Network, Public Sector View, and Cloud Sprawl. His work for the GovSat Report includes editing content, establishing editorial direction, contributing articles about satellite news and trends, and conducting both written and podcast interviews. Ryan also contributes to the publication's industry event and conference coverage, providing in-depth reporting from leading satellite shows.

BUILDING STRATEGIC RELEVANCE

BY MELDING SECURITY, RELIABILITY AND INNOVATION

By Eisa Al Shamsi, Deputy General Manager, Yahsat Government Solutions (YGS)

A few years ago, television images emerged of scientists accessing the Worldwide Web while orbiting the Earth on the International Space Station. This created headlines in the media, but came as no surprise to anyone working in government and military satellite communications.

Yahsat Government Solutions (YGS) is the government focused division of Yahsat dedicated to providing managed communications solutions to the UAE and other national administrations and organizations globally. It is distinct from Yahsat's commercial arm and from Thuraya (in which Yahsat now has a majority stake), but draws on their services and expertise to provide a broad government focused offering.

YGS enables SATCOM platforms in addition to defense and mission-critical applications to support government customers in their critical task of protecting borders and sovereign interests. Comprehensive and secure coverage is provided through the satellite capacity of Yahsat, Thuraya and strategic partners.

To stay ahead of competition, we are constantly innovating and improving our solutions, working in close partnership with government and industry leaders. When supporting our customers, we maintain the premise that "*the mission is everything,*" the ultimate measure being mission success. We provide versatile satellite-based solutions that are designed and optimized to operate across our Mil-Ka and L-band networks.

As a result, we are able to guarantee anywhere/anytime availability and resilience, maximum capabilities, flexibility, and industry-leading security.

YGS's Products and Solutions

- *Ensure network security, resilience, integrity and flexibility*
- *Are optimized to meet the wide array of government customer requirements*
- *Build on field proven innovation with a game-changing impact. A noteworthy example would be Thuraya Aero and line-fit offerability certification*
- *Address emerging requirements including seamless network interoperability and integration*

Ensuring "Secured Resilience"

Cyber threats are relatively new in satellite environments but security has been always a concern in government networks. The UAE and Yahsat are way ahead of the game and are market leaders in cybersecurity for government and MILSATCOM users. We have been building end-to-end network security into the design and operations of our robust systems for years. We call this "*secured resilience.*" It encompasses every aspect from the satellites, to the ground, shipborne, and airborne network of terminals, to the ground stations, and to the terrestrial fiber that connects the different ground segments. For example, we can help by securely connecting multiple groups in remote areas, enabling them to coordinate and streamline links between operatives while maintaining security and network integrity. This is even possible when some are using different terminals or satellite networks. Not all government requirements are the same. We can help customers select the most suitable solution and underlying network

Yahsat Government Solutions assists governments to achieve strategic advantages on land, at sea and in the air.

architecture, and customize them to fit specific strategic and operational needs.

Optimized for Various Government Customer Requirements

Every product and solution provided by YGS guarantees maximum flexibility and choice. At the most fundamental and critical level, this means ensuring effective, secure communications with headquarters over tactical, regional or global networks. YGS products and solutions are designed specifically for government and military requirements and are assured for secure performance. They include reliable and fielded solutions that are ruggedized and tested for use in harsh environments.

YGS is focused on integration with government platforms and sub-systems rather than on standalone solutions. Our end-to-end network solutions leverage Yahsat's satellite constellation of 5 satellites, with services directly controlled, managed and delivered to the customer.

We provide extensive specialist support to ensure customer requirements are met. This includes 24/7 centralized support from our dedicated and highly responsive network operations center, which is complemented by an expert field service team to support onshore, offshore and air operations. YGS' state-of-the-art products and solutions are tested rigorously with government customers.

YGS recognizes that one-size-fits-all products and solutions cannot satisfy military and government requirements. On land, at sea and in the air, our customers require maximum flexibility, while being assured of secure, reliable service.

YGS offers a wide spectrum of configurations and formats for a range of scenarios, including: handheld; portable Comms-On-The-Halt (COTH); quick deploy; fixed; Comms–On-The-Pause (COTP); Comms-On-The-Move (COTM); and tracking.

We fully support the dismounted soldier and offer a menu of mounting requirements for vehicular, naval/maritime, manned and unmanned airborne settings.

Our solutions cover the full array of government operational applications, including voice; messaging; data; push-to-talk (PTT); intelligence, surveillance and reconnaissance (ISR); search and rescue (SAR); and command and control situational awareness (C2SA). Communications security is inbuilt, with full defense-grade encryption, while our transmission security (TRANSEC) protocols ensure that links are secure and reliable across multiple frequency bands, including Mil-Ka-, Ku-, Ka-, C- and L-bands.

Field Proven Innovation

At YGS, we continually innovate to push the boundaries of our offering to government and military customers. This was evident in November of 2019 when we demonstrated our L-band Aero Mobility beyond line-of-sight (BLOS) capability live to key government customers by replicating an ISR mission over satellite communications. Real-time surveillance imagery, flight tracking, and duplex data from the aircraft were displayed on the ground on a portable receive station that supports critical applications such as real-time exchange of ISR information, transmission of border/coastal patrol imagery and first-responder back-up.

L-band Aero Mobility has been recently approved by Airbus as a Line-fit BLOS solution on one of their rotary wing platforms. It offers full situational awareness and coordination at every level of the command chain. This L-band capability gives troops on the ground and at sea an "*eye in the sky*" and a common operational picture, which is of paramount importance to the success of any mission. It facilitates steady network access, voice calls, text messaging, and real-time, high-speed data applications including video conferencing, tracking, sensor and data collection and transmission. It has built-in video compression capability, handling HD streaming speeds of up to 384 kbps on a single L-band channel. Aero Mobility is uniformly available within Yahsat's Thuraya satellite constellation footprint. This covers more than 160 countries across the Middle East, Asia, Europe, Africa and Australasia. The service is appropriate to fixed and rotary-wing aircraft and to UAVs.

As the example of L-band Aero Mobility illustrates, the YGS solutions enable government and military customers to deploy strategic capability when and where it is needed most. We aim to confer the same advantage to all of our customers, helping them overcome major operational challenges swiftly and with game-changing impact.

Addressing Emerging Requirements

The requirements of government and MILSATCOM customers are continuously evolving with renewed focus on communication security, network resilience, and more importantly: seamless interoperability and network integration. Seamless integration between terrestrial and satellite communications and interoperability between different space-based networks are also emerging must-haves for government customers.

As a network effectively combining fixed satellite services (FSS) and mobile satellite services (MSS) with over 30 years of expertise, Yahsat's capabilities enable multiple military solutions that work seamlessly on both L-Band and Mil-Ka. They also give our customers more options for securely integrating personnel mobile devices with government networks.

With Yahsat Government Solutions supporting government's needs, we can successfully factor security, reliability and interoperability, while designing and deploying satellite communications to help our customers gain strategic advantages.

The author, Eisa Al Shamsi, is the Deputy General Manager at Yahsat Government Solutions (YGS)

FROM FIREFIGHTING TO SATELLITE

How firsthand experience can shape emergency communications

Bringing together a team with deep knowledge and experience is an important part of Isotropic Networks' philosophy. A nuanced understanding of a particular situation creates empathy and a rapport with customers.

This is especially important in the emergency communications sector, where understanding and expertise is essential when dealing with unexpected and often distressing events and, ultimately, people's lives.

Ryan Zbierski, Director of Mission Assurance at Isotropic, exemplifies this approach. With 15 years spent as a firefighter and paramedic, he knows firsthand what it takes to react in an emergency and fully appreciates the critical role that communications play.

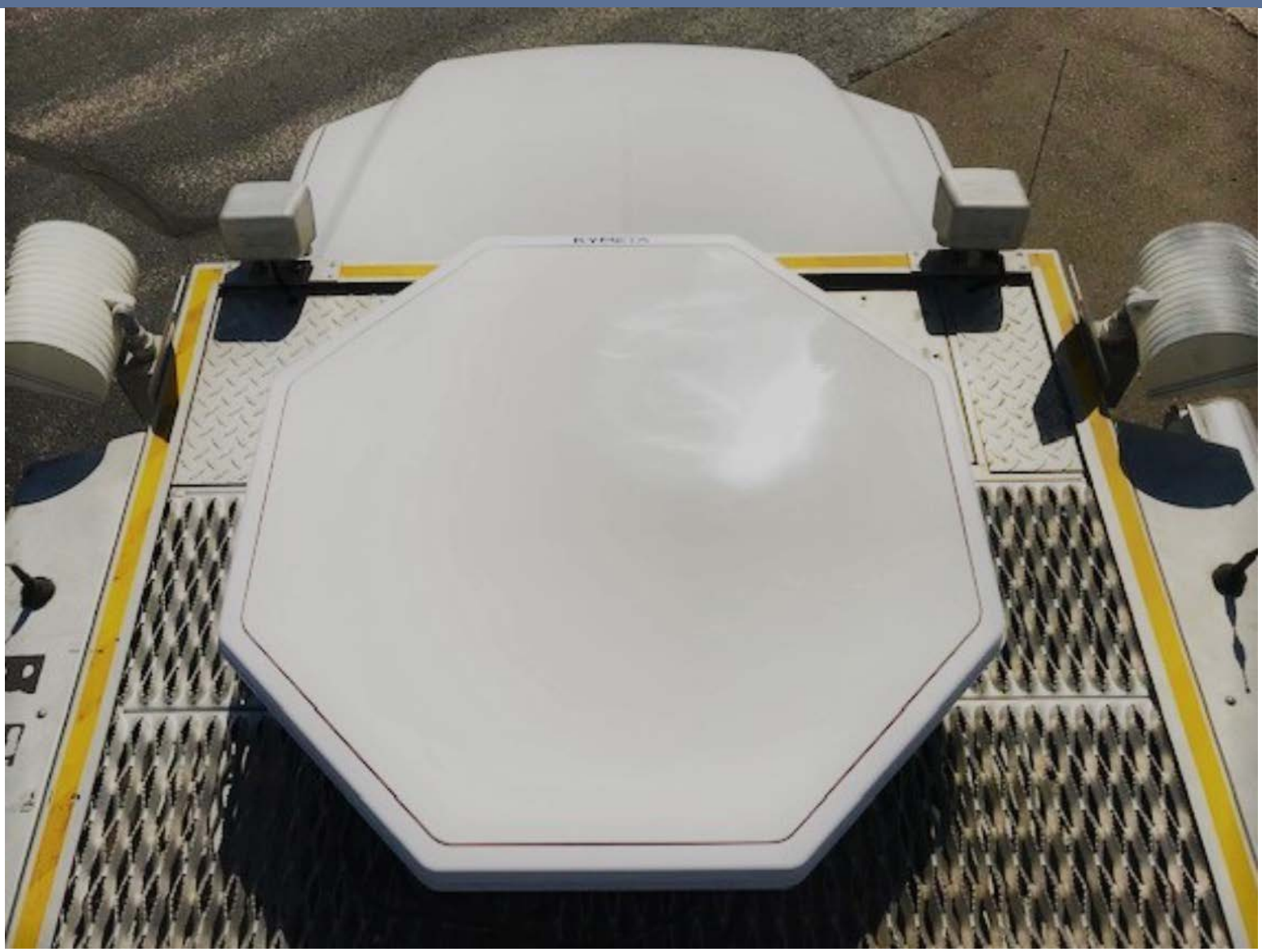
"*I learned a lot about what it takes to deliver certainty, and what it means to be on both sides of delivering certainty and receiving certainty from a provider or caregiver,*" said Zbierski. "*It's about communications and, more importantly, being able to rely on those communications without a second thought.*"

In 2016, Zbierski decided that the time was right to take his experience and to make the move to join the family business. Established by his father, Hank, Wisconsin-based Isotropic delivers global internet services and network management solutions. With a promise of "*unrivaled certainty*™," Isotropic delivers services to a range of mission-critical industries including oil and gas, emergency response and enterprise.

"*I know how hard my parents have worked in building up the business and making sure that there's a good foundation in place,*" Zbierski said. "*I felt it was the right time to retire from the fire service and come on full-time with my parents. The one word that we always lived by in the service was 'duty.' And I thought that that was a fitting word for what I owed my parent's business.*"

The skills that Zbierski gleaned from his time as a firefighter have given him enormous insight that he has been able to crossover into his work on emergency communications at Isotropic.

"*I apply a lot of what I learned in the fire service to my work,*" he says. "*Having a plan and sticking to it; using your background, your training and your experiences to learn from mistakes; and*



bringing all those different facets together enables you to build a strong team. I consider building a team as one of my greatest strengths—to train them up and set the guidelines for operations, and then see them come together and execute. I'm fortunate to be able to now bring that to Isotropic."

The provisioning of satellite-based emergency connectivity is an integral part of Isotropic's offering. Currently, the company focuses on a range of disaster response situations that leave a county agency or municipality without terrestrial connectivity, such as cell towers or Wi-Fi. Isotropic works with these agencies to effectively and seamlessly transition all communications from dispatch centers to radio, mobile radio and push-to-talk over satellite, so that they can communicate and operate as they normally would.

"*The complexity and the scale of emergency response efforts inherently increases with the number of agencies and amount of resources needed,*" Zbierski noted. "*The one thing that really determines the outcome of a successful operation is the ability to communicate. Inherently, we want to work quickly and smoothly to lessen the loss of life and shorten the duration of the incident.*"

Isotropic in Action

The Isotropic team has assisted during several disaster situations to help re-establish connectivity. This includes hurricane Dorian, which hit the Bahamas in 2019. Isotropic was involved with the relief effort, enabling NGOs to run their mobile communications over satellite in order to determine areas of high danger where heavy waters were problematic. This enabled them to prioritize which areas to focus on evacuating at any given time.

The Isotropic team has also assisted with tornado response efforts, in which insurance companies need to deploy mobile response units to hard-hit areas to distribute funds and issue insurance adjustments on-the-spot that enable affected families to buy supplies. This fast access to money often acts a lifeline.

"In these situations, many buildings in the local area will have been destroyed," Zbierski stated. *"However, if people can be issued a debit card from their insurance company, they can at least go to the neighboring town and get some basic supplies and some clothes that'll tide them over for a few weeks before they get to a hotel or to a relative's house. Our satellite links also allow them to use the Wi-Fi or the VoIP phone from the insurance company's mobile unit so they may contact a loved one to say they're safe and that they need a place to stay."*

Isotropic also understands that emergency connectivity to help prevent potential catastrophes is just as important. For example, deployment of VSAT connectivity can help facilitate surveillance so that agencies can be better informed, enabling them to see the bigger picture and react more effectively.

"We were in attendance in a college town where a law enforcement agency was on alert for an aerial threat or elevated armed subject potentially targeting a pedestrian mall during an annual Halloween party," Zbierski said. *"We were able to use*

one of our interoperability platforms to help the law enforcement agency carry out drone surveillance and stream video utilizing infrared or FLIR camera systems. This allowed for the command staff to continuously evaluate their positioning throughout the event while communicating via secure chat and keeping the area safe."

The Ghostbuster Mobile

Isotropic owns two mobile units that it uses to demonstrate emergency response solutions (***see photo on previous page***). By far the most fascinating is the transformed Ford Excursion, otherwise known as the "*Ghostbuster Mobile.*" Incorporating a Kymeta u7 antenna and using the ST Engineering iDirect iQ 200 modem, Isotropic is able to access Comms-On-The-Move (COTM, essential for emergency situations.

"*The first five minutes dictate the next five hours, or even longer, of the success of the operation that you're responding to,*" Zbierski commented. "*The decisions that you make in that first five minutes are not only based on what you encounter when you arrive on the scene, but on the information that you gather as you're arriving on scene. To have communications on the way to the scene and get these updates is invaluable.*"

Isotropic's New ECP

Isotropic recently unveiled its Emergency Communications Platform (ECP), designed to give first responders unrivaled certainty in their communications solution. The ECP combines state-of-the-art technologies into a single, easy-to-use, and compact solution that includes an iDirect iQ 200 modem board integrated in a Kymeta u8 terminal, all enhanced by Isotropic's Datadragon bandwidth monitoring and management platform.

The ECP is supported by Isotropic's customizable, flat-rate, flexible service plans designed to scale and work not only with the ECP, but also with pre-existing technology configurations.

With the ECP, first response teams can deploy communications on the way to a scene, switch automatically and instantly between VSAT and LTE, and monitor and manage available streams of bandwidth to ensure connectivity when and where it matters.

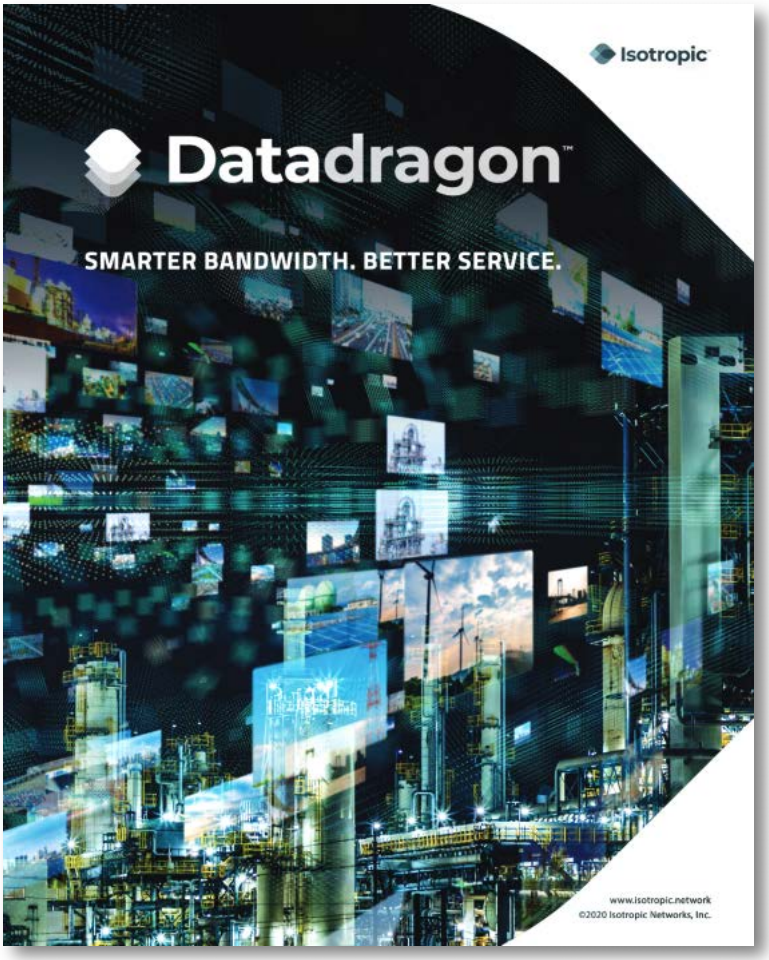
"With the best uptime and service levels in the industry, Isotropic knows a thing or two about reliability," Zbierski said. "*Our satellite links are completely independent of terrestrial communications infrastructure, so there are no single points of failure in your network. We can also help emergency responders partition secure voice and data communications onto a separate network, unavailable to the general public, so they can operate efficiently and effectively even when local cellular networks become strained.*"

The Perfect Match for Emergency Response

Despite its lifesaving attributes, satellite still has a reputation for being the expensive solution and is still overlooked as a highly effective emergency communications solution. Isotropic thinks it's time to bust these myths.

"*It's a case of seeing it to believe it,*" Zbierski said. "*If people can see the difference it makes, it's the absolute foolproof way of making sure that people understand it lot better. When they experience the power of satellite and how it can literally transform an emergency event, they know it works incredibly effectively and that it's a fantastic augmentation to their bandwidth. Quite simply, satellite can help save lives.*"

www.isotropic.network



Founder and Managing Director, Paradigm

Mr. Sandberg has more than 35 years of experience in the global satellite and telecommunications world. He started Paradigm in 1996, where he has spent the past 24 years as Managing Director.

What services and products does your company provide to the military / agency / government (MAG) market segments and why are these offerings important to these users?

Ulf Sandberg (US)

Paradigm provides rugged, portable SATCOM terminals which are simple to setup, point and packdown. The importance of these terminals to Paradigm's MAG market segments is key, brought down to the fact that they do not require any specialist skills to operate.

Our aim is to make SATCOM simple for any user, so that soldiers and first responders alike can focus on the task in hand, knowing that their comms kit can be relied upon. The success of Paradigm's ongoing simplification of SATCOM is exemplified in the development and integration of the PIM® — the Paradigm Interface Module — an environmentally rugged terminal controller designed to provide a common level of operation to all satellite terminals.

PIM Powered terminals are easy for non-skilled users to setup and point, simplifying a process to one that only requires basic training at most. The action of terminal pointing, control of the entire terminals management and power distribution, network negotiation, transmitting and receiving data can now take less than a minute to perform, with the user guided by easy-to-follow, simple instructions delivered via the PIM's clear unit interface. No other tools or equipment are required.

By minimizing the training requirements and reducing the differences between terminals to situational and environmental use-driven features, Paradigm has created a range of high-throughput VSATs that meet every operational need. The range includes the HORNET, the SWARM® and the MANTA® simple to use satellite terminals.

The HORNET (*lower left image*) is a high-throughput, multiband, modular solution powered by the PIM. Users can interchange between 60cm, 80cm and 100cm antennas, as well as differing power and frequency RF modules, to provide a single SATCOM solution for multi-operational requirements. Packaged in a single, airline-compliant case, the HORNET is rugged and lightweight with rapid tool-free deployment.

The SWARM® is a high-throughput, multiband, ultra-portable solution powered by the PIM. It is back-packable with a sub 90 secs assembly and an achievable on air time of 240 secs. It is extremely rugged and lightweight at 14.4kg (>32 lbs). The SWARM is frequently used for first-on-the-scene requirements. Its extreme portability makes it invaluable when a natural or man-made disaster renders a site inaccessible by vehicles.

The MANTA® is a complete communication solution for Comms-On-The-Move (COTM) or Comms-On-The-Pause (COTP). It is electronically self-pointing with no moving parts, the user just needs to add power. Consequently, it is ideal for sustaining constant connectivity to mobile assets for telemedicine or to portable emergency operations centers, or operational Control Centers.

Paradigm's SWARM.

Installation is easy, both 'in vehicle' and 'on vessel' with the MANTA Quick deploy vehicle kit. The integrated PIM provides live satellite bearing display and modem status, provides a rugged environmental housing for the internal modem and terminal management system, power management and control for the entire MANTA terminal. The MANTA+ terminal also provides managed bearer networks via 3G/4G/LTE backup operation for increased availability and least cost routing, and can also work as an integral part of a VHF/UHF radio network providing the WAN access.

The PIM is universal in its application. It's been specifically designed to simplify the integration of satellite modem technologies into terminals (currently supporting more than 10 of the major modem technologies available in the satellite industry), and has also been carefully designed to operate with other terminal manufacturers "air interfaces" should a customer or user have a specific need offered from another system, or require quick and simple access to alternate satellite constellations. The PIM today has already been integrated into terminals from several other terminal manufacturers, enabling the same simple pointing and terminal RF management ethos that's making SATCOM simple.

What do you believe are the most significant challenges that need to be addressed within the MILSATCOM and related environs?

US

A significant challenge for MILSATCOM is for it to operate cost-effectively and without complexity over a global landscape. There are a number of ways to address this such as:

The ease of use and commonality of our terminals. Operating satellite communication terminals can no longer be the domain of specialized SATCOM engineers. It just isn't practical or cost-effective anymore, particularly for many Special Forces units and 'first-on-the-scene' emergency responders. For MILSATCOM and related comms to be truly effective they need to be within the reach of every user, with assembly and connection times kept to an absolute minimum.

The standardization of equipment, reducing training and deployment time. If every SATCOM solution has its own training requirements and operating protocols then inevitably this wastes both time and resources. The PIM marks a significant improvement in this. It not only minimizes training because it is so straightforward to use but it also reduces deployment times. It is integrated into many different terminals which all adopt the same straightforward pointing process, so once you've setup one PIM Powered terminal, you can setup any PIM Powered terminal. By also focusing on modularity, one terminal can become a single solution for multi-operational requirements.

That our terminals are portable and sturdy. Cumbersome, heavy and fragile satellite equipment can compromise a mission's expediency by being slow and difficult to transport and using space at the expense of other vital equipment. Paradigm's PIM Powered terminals are tough and very easy to transport. Packaging options range from a compact airline carry-on bag to hand carry and IATA compliant hard cases or backpacks. When cargo space is at a premium, the comms kit can be easily stowed and will survive hard knocks and rough handling.

That our terminals incorporate environmental ruggedness. For a SATCOM solution to be completely successful it needs to be able to operate in every location. Network coverage comes into play here but a terminal needs to operate equally well in torrential rain, arid deserts, freezing snow and blazing heat as well as in both low and high humidity. The PIM is built to withstand these sorts of extremes of environment, temperature and moisture. For instance, it is fully waterproof, integrates fin-cooling directly into the chassis (thus avoiding the usual issues of an internal mechanical fan) and all access ports are designed to prevent sand and dust from entering the unit.

Why should a client consider Paradigm as a preferred solutions provider?

US

Many customers highlight the PIM as the crucial feature of our terminals. Its common centralized terminal management for easy deployment as well as its managed power distribution and simple pointing experience (irrespective of terminal type, satellite frequency or network) is significant for the MAG market; it reduces training times and costs during worker turnover and the need for SATCOM experts to be readily available.

All of Paradigm's PIM Powered terminals are field-proven solutions and meet a range of requirements. All have been tried and tested throughout development to create reliable and optimal solutions. We employ high levels of engineering excellence to produce technologically advanced solutions.

Paradigm actively listens to the specific needs of end-users and as an agile, independent company we can respond quickly to provide support, training and feedback. Users can be reassured that they are using something which is fully developed, tested, in use and supported.

We operate on a global scale providing solutions which are operational anywhere and by anyone. The PIM is certified on all major satellite networks to give a range of connection options to the user and it also integrates all the major modem types.

Would you please tell us about some of the firm's product implementation successes?

US

In 2019, HORNET terminals were deployed in Burkina Faso for Operation Flintlock, the U.S. Africa Command's premier special operations forces exercise. Approximately 2,000 personnel from more than 30 African and western nations participated in the operation and the HORNET is used to keep the mix of multinational soldiers connected to family and friends throughout.

The HORNET has also been deployed to Antarctica, providing the Argentinian military and research station with vital communications.

The MANTA+ was adopted in 2019 by US SOF community filling a significant gap in mission critical operations. The MANTA terminal was adopted by the US Army direct action units for deployed mobile operations, freeing up much needed cargo space in HMMWV's and tactical Polaris side-by-sides. The requirement called for a fully integrated system with swift integration onto vehicle and into on-board networking equipment .

The agile and backpackable SWARM has been adopted by the UN and other NGOs and has been able to provide vital communications channels to aid agencies in Mozambique following Cyclone Idai and in the Bahamas after the devastation caused by Hurricane Dorian. It's portability and high bandwidth made it the ideal unit to upgrade communication channels for the US government executive communication teams. The SWARM is also used by Canadian Combat Camera unit to film 'in-the-field' operations for training purposes.

Its also played a key role in the RAF100 centenary expedition to the Himalayas in 2018 by providing a vital high data communications link for media updates, weather reports and team safety and welfare. The terminal was frequently operating for three hours a day in rain/wind/snow and temperatures of -20C at over 5,000 meters in altitude, with no drop in performance.

What may we expect Paradigm to reveal over the next few months?

US

Expect some further expansion of the product ranges for both the HORNET, MANTA and the SWARM terminals. Additional variants will build on increasing accessibility and tactical agility, encompassing the recommendations from our customers in the field.

Paradigm Outdoor PIM terminal agnostic rugged controller.

Paradigm's MANTA.

What does the future hold for Paradigm?

US

Paradigm has proven that satellite communications and the pointing of a satellite terminal does not need to be complicated and can be available for all. Now we want to spread that knowledge and approach to all users and potential users of satellite communications, and continue to develop and provide satellite communications equipment that supports this, and also combines it seamlessly with other communication technologies such as GSM, 3-4 and 5 G, radios, and so on.

We see a future of making SATCOM simple, more accessible and know that the best way to continue this approach is by expanding our existing network of fantastic partners even further, both for terminal integration and network certifications.

paracomm.co.uk/

ENHANCING NATIONAL SECURITY WITH WORLDVIEW LEGION

National security missions require the latest information to make critical, time-sensitive decisions that are based in fact. The organizations responsible for ensuring our safety and security must combine a variety of data sources to create a common operating picture of the situation at hand, and high-resolution satellite imagery provides key foundational information for situational awareness.

Satellite imagery in general allows for monitoring across the globe, no matter how remote the area of interest or how far from the operations base the AOI is located. But the real value is in the right balance of currency (how recent was the image taken), resolution (the level of detail the image holds), and coverage (the amount of area the satellite collects).

By combining the right balance of these criteria, it enables national security organizations to view the whole picture instead of resorting to a "Battleship"-like approach with point-collecting satellites and guessing where activity is happening. With that very current, high-resolution image, analysts understand what's happening anywhere on Earth, identify specific assets on the ground and give end-users unrivaled insights and a competitive edge.

Maxar is manufacturing its next-generation satellite constellation, which will have its first launch early next year. The WorldView Legion constellation will initially include six, high-performance satellites that more than triple Maxar's capability to collect sub 30 cm resolution imagery, the highest resolution commercially available. This capacity will be a game-changer for our mission partners: they will have dramatically more frequent images (up to 15 times per day) over the most in-demand areas throughout the day for their decision-making processes.

This advanced constellation offers high-agility point collects for monitoring targets and large-area collects for mapping missions, enabling more persistent monitoring, near-real time change detection and timely analysis at scale. WorldView Legion will offer Maxar's mission partners superior Earth Intelligence for their national security missions.

Monitoring for National Security

WorldView Legion will complement our partners' existing coverage and fill in the important gaps for more persistent surveillance. Consider, for example, the need to verify and validate treaties and enforce sanctions.

Currently, Maxar satellites collect images at two different times during the day with a few hours between collections. WorldView Legion will provide coverage from sunup to sundown and reduce the windows between collects, allowing for more persistent monitoring of treaties and sanctions.

Over the years, Maxar's WorldView constellation has monitored the development of nuclear and ballistic missile capabilities in North Korea and Iran that have been in violation of international sanctions. These countries are building most of their facilities underground, but Maxar's satellites capture detailed images of activities on the surface that give analysts insight into the activities there, despite inspectors being prevented from visiting the facilities.

Artistic rendition of Maxar's WorldView Legion on orbit.

The Fordo nuclear facility in Iran is seen on the left, as captured by Maxar's WorldView-2 satellite on Nov. 1, 2019. Although Iran built this facility underground in the middle of the desert, the activity on the surface provides analysts with insight into Iran's efforts. North Korea's Sohae Satellite Launching Facility is seen on the right on May 10, 2019, by Maxar's GeoEye-1. Although North Korea agreed to dismantle this facility in 2018, they announced in December 2019 that they'll resume operations at the launch pad and at the nearby engine test facility.

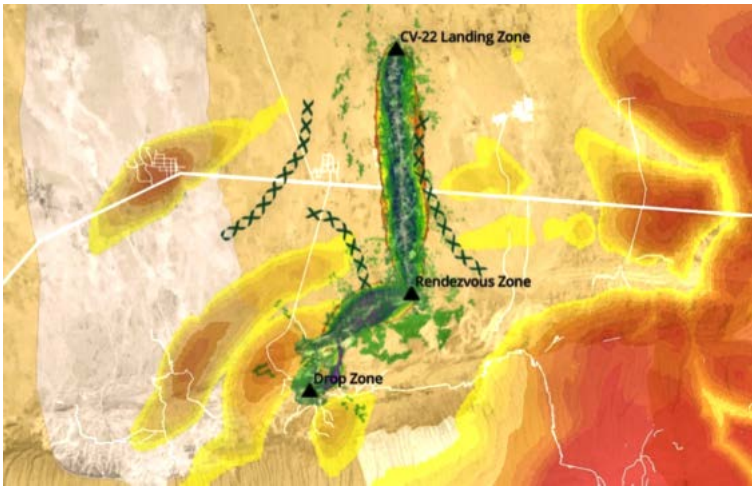
Military Mapping for Mission Support

Planning military operations in remote regions or poorly mapped environments presents unique challenges and risks. It is critical that operators and allies have the latest geospatial information including maps and visualization tools, to plan, rehearse and execute missions.

The addition of WorldView Legion's agile satellites and expanded capacity will improve the currency and scale of Maxar's three-dimensional elevation datasets, mosaics and other mapping products that will help enhance situational awareness and minimize risks and errors in mission planning.

Maritime Domain Awareness

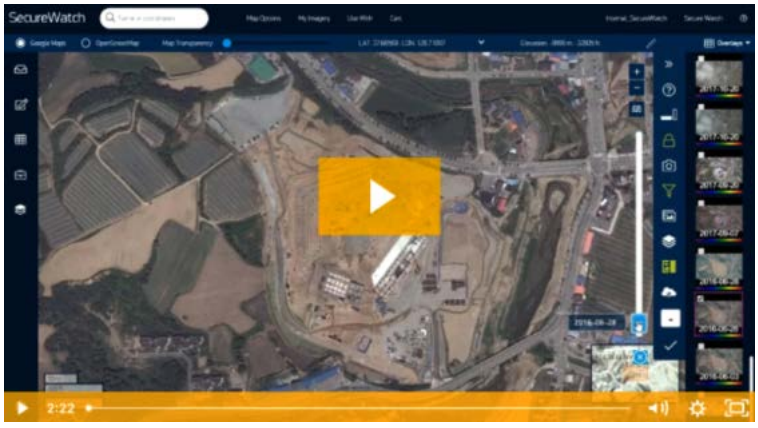
Nations need to focus their maritime security efforts for challenges such as illegal fishing, pollution, piracy, smuggling, and human and drug trafficking. Maxar Vessel Detection Services (VDS) delivers actionable intelligence for monitoring maritime activities and identifying traffic over broad areas. By leveraging WorldView Legion, coordination across our entire constellation and existing VDS capabilities, Maxar will help maritime agencies address the myriad of challenges in the maritime domain.



This operational planning map displays multiple layers of information including mission points, secondary roads, viewshed and Human Landscape data.

By helping focus resources through systematically detecting and identifying suspicious maritime activities, Maxar enhances its customers' ability to evaluate, prioritize and respond faster than ever before.

Maxar has decades of experience providing our mission partners with indispensable geospatial intelligence created with cutting-edging technologies. WorldView Legion will shape the next evolution of the type of national security support Maxar provides to its defense and intelligence partners. Learn more about WorldView Legion's capabilities via the company's information video ***at this direct link***.



Access to GEOINT when and where you need it with Maxar's SecureWatch. Request an evaluation account: ***at this direct infolink...***

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HOW WILL LEO IMPACT MILSATCOM?

By Helen Weedon, Managing Director, Satcoms Innovation Group (SIG)

Over recent months, Low Earth Orbit (LEO) has dominated the headlines, with a number of launches already taking place and many more planned. As more and more smallsats are launched in LEO, the rest of the satellite industry has been raising concerns about how these will impact the space environment, spectrum, and safety of flight in all orbital regimes.

What does this mean for the military, with its reliance on satellite communications for critical operations?

The MILSATCOM Market

The military already relies heavily on satellite for a number of applications, including keeping personnel connected during critical operations. In many cases, there are no alternatives to satellite given the nature and environment of those operations. At the same time, keeping communications lines open can often be a question of life and death for military personnel.

No wonder, then, that the military communications market is set to grow significantly over the coming years. Recent stats from ***Fortune Business Insights*** suggest that the military communications market will reach a value of $62.96 billion by 2026. In particular, this growth will be driven by a demand for SATCOM technology.

Similarly, a recent report from ***MarketsandMarkets*** estimates that the global airborne SATCOM market will grow from $5.8 billion in 2019 to $7.8 billion by 2025, at a CAGR of 5.1 percent from 2019 to 2025. This is partly driven by the commercial sector however a growing fleet of combat aircrafts and increasing demand for SATCOM On-The-Move (SOTM) solutions is having an impact here.

Space (and Spectrum) Situational Awareness

In order to keep the space environment clean and operating efficiently, it is important to have a good level of situational awareness. However, that shouldn't just apply to the physical location of satellites, but also to the spectrum itself. Knowing that spectrum is not being interfered with from an erroneous carrier is just as important for keeping services on air.

The situation in the Geosynchronous (GEO) arc is far from perfect. We know even in the past few months that there have been debris-causing collisions and the satellite operators are constantly dealing with challenges relating to interference. While it is clear that we need to get better at tracking objects and ensuring collision avoidance, incidents are currently few and far between.

On a spectrum front, the satellite operators do have the right tools at their fingertips to quickly and efficiently locate the source of interference. This means that in the majority of cases, interference can now be resolved very quickly.

With the onset of mega constellations however, could that all be about to change?

Debris

It has often been cited that the sheer volume of objects due to launch is likely to increase the risk of collision. Indeed, a recent article by the ***Space Data Association*** in ***MilsatMagazine*** stated that, as of January 1st 2020, the volume of debris in Earth's orbit exceeded ***8,000 tons***.

The same article stated that the total number of objects is estimated at around 500,000 with only around 1,200 of those operational satellites. That means a lot of uncontrollable objects are already in space. If we add in the huge quantities due to be launched in LEO, that is going to obviously get a whole lot worse.

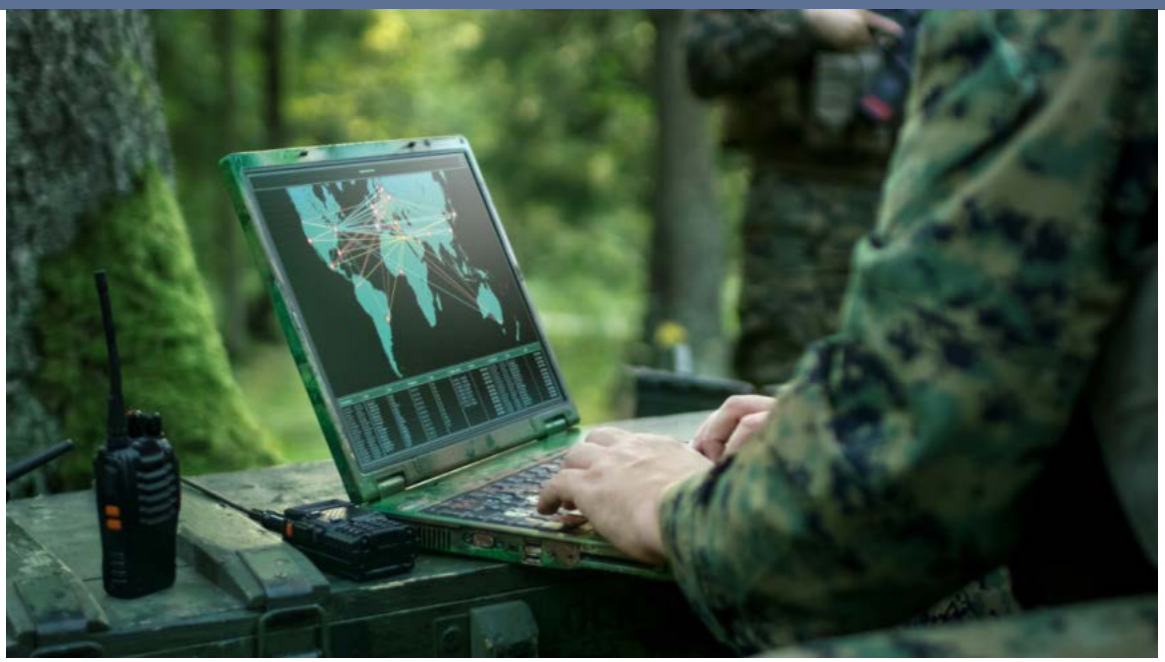
What is particularly concerning is the end of life procedures. In LEO, the ***International Standard Organization*** (ISO) guidelines require operators to ensure satellites re-enter the Earth's atmosphere within 25 years. However, only 15 to 25 percent of payloads reaching end of live in LEO over the past 10 years attempted to comply with these guidelines and only 5 to 15 percent have done so successfully. As numbers increase, if those percentages don't increase, it will, of course, lead to far more debris.

Interference

Just as a large number of new satellites will cause a risk of collision, it will also make the spectrum more crowded and may lead to more instances of interference from mis-pointing.

LEO is also more challenging due to the fact you need to constantly point and re-point, which could well lead to errors. In GEO, the satellite operators are mostly accustomed to dealing with interference. Also, because SIG has delivered a platform for the technical leads from the various global operators to get together,

they often know who to call at other operators when there is an incident. It may seem like a simple thing, but it is vitally important for reducing time to resolution. This is not yet the case for much of the LEO operators.



LEO also operates differently, meaning that some of the tools developed to solve errors in GEO won't translate to LEO. The manufacturers and solution providers need to find new ways to ensure quick and efficient error resolution in LEO otherwise they could even start to interfere with the GEO satellites, causing issues for the entire spectrum.

Eclipsing GEO

The other concern raised by many in GEO is that the sheer volume of LEO satellites could cause an eclipsing effect whereby the view to GEO satellites is masked. Naturally should this happen it will have a significant impact for all satellite users in GEO and will seriously impact services. It is vitally important that this is properly monitored and that LEO satellites follow proper guidelines to ensure that GEO retains its line of sight.

Frequency Bandwidth

Frequency bandwidth for terrestrial comms is normally dedicated to one entity per country. This means that any conflict of spectrum usage is normally around borders and coordination usually mitigates interference.

With GEO satellite, there is normally one entity in a frequency band per orbital slot, which means that the equivalent of border issues is satellites in adjacent slots. Again, coordination mitigates interference.

With LEO, however, we have potentially multiple constellations using the same frequency bandwidth. Each constellation is in multiple orbits and orbit heights. We now have potential of valid transmissions from authorized satellites causing interference at any given spot on the earth with the interference being intermittent and different at any given location.

The LEO Opportunity for Military

Although mega constellations in LEO could impact the current space environment, they do also represent an opportunity for military satellite communications and that shouldn't be ignored.

The promise of huge amounts of bandwidth and lower latency could prove invaluable; however, the military has not yet signed up to LEO and for good reason. Until it can be sure that LEO can deliver on its promises without vast amounts of errors or the risk of collision, the military will not want to move into the LEO camp.

Keeping Spectrum Clean

At the same time, in order to keep the space environment and spectrum clean for all satellite operators and users, we need LEO operators to ensure they follow best practices in the same way that has been become the norm in GEO.

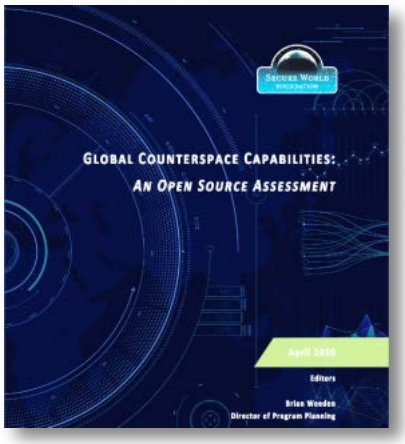
Some of that may be driven by the operators themselves or by industry-wide engagement to ensure they have both the tools and understanding to do that. Many of the larger operators are already showing some level of commitment to keeping space clean, but more needs to be done.

It may well be that better and tighter regulation is the only way to ensure that the entire industry adheres to best practices. It is also clear that better technology designed for LEO fleets and ground stations will be critical in ensuring those operators are able to monitor, spot, and resolve issues quickly and efficiently.

satig.space/

The author, Helen Weedon, is the Managing Director of the Satcoms Innovation Group (SIG)

SWF PUBLISHES THEIR GLOBAL COUNTER SPACE CAPABILITES ANALYSIS AND REPORT



Space security has become an increasingly salient policy issue. Over the last several years, there has been growing concern from multiple governments over the reliance on vulnerable space capabilities for national security, and the corresponding proliferation of offensive counterspace capabilities that could be used to disrupt, deny, degrade, or destroy space systems. This in turn has led to increased rhetoric from some countries about the need to prepare for future conflicts on Earth to extend into space, and calls from some corners to increase the development of offensive counterspace capabilities and put in place more aggressive policies and postures.

The Secure World Foundation feels strongly that a more open and public debate on these issues is urgently needed. Space is not the sole domain of militaries and intelligence services.

Our global society and economy is increasingly dependent on space capabilities, and a future conflict in space could have massive, long-term negative repercussions that are felt here on Earth. Even testing of these capabilities could have long-lasting negative repercussions for the space environment, and all who operate there. *The public should be as aware of the developing threats and risks of different policy options as would be the case for other national security issues in the air, land, and sea domains.*

Report authors Dr. Brian Weeden and Ms. Victoria Samson

Highlights from the 2020 Report

China

Conducted additional rendezvous and proximity operations (RPO) of their SJ-17 to inspect a potential anomaly with Chinasat 5C in GEO Reports of widespread GPS jamming near port of Shanghai Additional details on Chinese ground-based directed energy facilities.

Russia:

New research suggesting tho have two separate programs, Burevestnik and Nivelir, which may correspond to a co-orbital ASAT program and a surveillance / tracking program, respectively Conducted additional RPO activities in LEO and GEO, including shadowing of a NRO imagery satellite Evidence of a new program called Ekipazh to develop nuclear-powered space-based electronic warfare capability Widespread PNT jamming and spoofing in Crimea, Syria, and Russia

United States

Conducted covert release of cubesats from X-37B OTV-5 More public details on the RPO activities of GSSAP and Mycroft Widespread GPS jamming for naval exercises in the southeastern U.S. Re-establishment of the United States Space Command and creation of the United States Space Force

France

Overview of the new French Space Defense Strategy and plans for ground-based lasers and guardian satellites

India

Updated information on March 2019 ASAT test Information on the establishment of the Defence Space Agency and the Defence Space Research Organization

Iran

Information on attempted Iranian satellite launches in August 2019 and February 2020 Reports of Iranian GNSS jamming occurring near the Straits of Hormuz

Japan

Information on their exploration of counterspace capabilities

For more information or media inquiries, please contact SWF Director of Program Planning Dr. ***Brian Weeden*** *at* ***bweeden@swfound.org*** *or Washington Office Director Ms.* ***Victoria Samson*** *at* ***vsamson@swfound.org****. The full report is available* ***at this direct link****...*

THE NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY PUBLISHES THEIR TECH STRATEGIES

The National Geospatial-Intelligence Agency (NGA) has published their technology strategy that highlights the agency's path to continued GEOINT dominance through improving internal processes and leveraging industry-leading technology.

The NGA Technology Strategy outlines the current technology environment, the vision for tomorrow and how the agency and the geospatial ecosystem can reach this desired end state. The way ahead incorporates a number of key initiatives...

- *Enable builders and makers*
- *Transform digital work spaces*
- *Build with customers*
- *Treat data as a strategic asset*
- *Build artificial intelligence, cloud and high performance computing into GEOINT mainstream*

The NGA Technology Strategy was developed concurrently with the 2020 NGA Tech Focus Areas that detail current and enduring agency technology needs.

Rear Admiral Robert Sharp engaged in a presentation.

NGA Director Vice Admiral ***Robert Sharp*** said that maintaining the agency's advantage as the world leader in geospatial intelligence requires a sound digital enterprise. The NGA depends on this system of systems to provide speed, accuracy and precision in the missions to show the way – either physically from point A to point B on land, sea and air, or logically in making national security decisions.

NGA CTO, ***Mark Munsell***, added that this strategy focus on enabling those who build and make technology to support NGA and the Systems for Geospatial Intelligence. The NAG firmly believes that the most important technology problem is not the adoption of artificial intelligence or quantum computing but fostering a technology workforce steeped in GEOINT and enabling them with an environment to deliver the best applications and services in the world.

Mark Munsell

The NGA Technology Strategy is available for download ***at this direct link...***

MARCH 2020

A REPORT OF
THE CSIS
AEROSPACE
SECURITY
PROJECT

SPACE THREAT ASSESSMENT 2020 (PART TWO)

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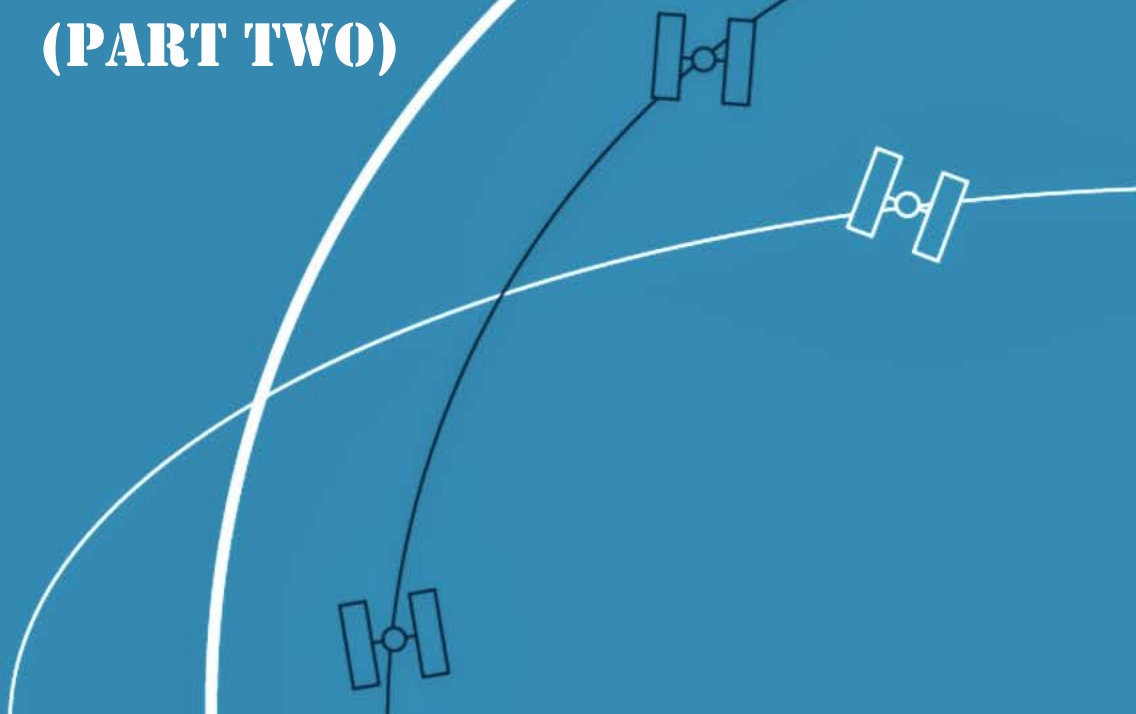


CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

FOREWORD

MUCH IS SAID THESE DAYS about the possibility of conflict in space during, before, or perhaps, instead of conflict on land, at sea, or in the air. Why is this the case?

The subject is discussed as though it emerged in the last 13 years since the Chinese demonstration of a kinetic ASAT in 2007. In fact, the United States was concerned in 1957 that Sputnik represented a precursor to space-based nuclear weapons. An ASAT program started in the United States in 1958, and the Soviets did similarly. Both superpowers deployed several ASAT systems and performed orbital tests.

Nonetheless, fear on both sides of a serious threat of conflict in space did not emerge until recently. Both the Soviets and the United States understood that the satellites of "National Technical Means" were stabilizing and were keys to de-escalation should a conflict occur. This view changed after the First Gulf War, when space systems moved from being primarily strategic systems to tactical ones providing near real-time support to tactical forces. By that time, the satellites of the Department of Defense and of the Intelligence Community operated and reported almost instantly, and the military services developed the equipment and techniques to acquire, analyze, and distribute space system information very quickly.

Following the First Gulf War, a Russian analysis of the rapid American success noted the efficacy of precision weapons and real-time intelligence. Much of this capability depended on space systems and spurred the Russians and Chinese to a sustained program to develop ASAT capabilities--not only those for physical attack but cyber and electronic attacks as well. In recent years, we have read Russian and Chinese doctrine explaining the importance of ASAT capabilities, and we have seen systems deployed to carry them out.

The situation we confront today was inevitable. Capability is always met with counter-capability. In recognition of this need to defend and to increase our space power in the face of such threats, the United States has wisely created the Space Force and the U.S. Space Command. This is where the people who will design, build, and operate our military space systems reside and where personnel will be trained, careers managed, doctrine developed, and a myriad other elements of a military force undertaken.

Several years ago, an Army general gave a speech where he said, "every company commander depends on space, and takes it for granted." What a challenge for our Space Force and Space Command to assure that our military is served at every level of command without failing.

MARTIN C. FAGA

Former Assistant Secretary of the Air Force for Space and Director of the National Reconnaissance Office

Number of Successful Orbital Launches in 2019[319]

0

NORTH KOREA

"North Korea has been building new missiles, new capabilities, new weapons as fast as anybody on the planet,"

GENERAL JOHN E. HYTEN
VICE CHAIRMAN OF THE JOINT CHIEFS OF STAFF, UNITED STATES AIR FORCE[320]

NORTH KOREA SUCCESSFULLY ORBITED ITS FIRST SATELLITE in December 2012 after three failed attempts in July 2006, April 2009, and April 2012. Its fifth attempt, in February 2016, successfully placed a second satellite in orbit. Both successful orbital launches from North Korea have been on the *Unha-3* SLV, whose militarized adaptation is likely the same vehicle outfitted with a reentry vehicle in place of an orbital satellite.[321] Like many other spacefaring nations around the globe, North Korea's space capabilities are closely tied to its ballistic missile development.

A North Korean law journal referenced the close relationship between space capabilities and ballistic missiles, stating "it is an undeniable truth that satellites launched into orbit by many countries around the world were made possible by rocket propulsion." While defending the country's satellite launching program, the article continued to state that the main difference between a peaceful space launch and a ballistic missile is whether the launch vehicle is furnished "with a satellite or a bomb."[322]

Although reaching orbit is a significant achievement, many experts doubt that the two successfully launched satellites perform all of the functions the North Korean government claims.[323] In a 2016 interview with the Associated Press, the head of the North Korean space agency stated his intent

Satellite Imagery of the Sohae Satellite Launching Ground After a Test on December 7, 2019. Differences include scarred vegetation and the moving of equipment. The facility hosted rocket engine tests on December 7 and December 13, 2019.

PLANET / BEYOND PARALLEL

to continue launching Earth observation satellites, and his aspirations to send a mission to the moon around 2026. He was quoted as saying, "Even though the U.S. and its allies try to block our space development, our aerospace scientists will conquer space and definitely plant the flag of the DPRK on the moon."[324]

There is little indication that North Korea is making substantial efforts to build or sustain a space industrial base, but its missile program is advancing. There were 11 separate North Korean missile tests in 2019 alone, which involved as many as 20 rockets in total.[325] Additional satellite footage taken in early 2020 showed increased activity at a known missile launch site, possibly signaling more tests in the near future.[326]

Space Launch Facilities

NORTH KOREA HAS TWO ESTABLISHED LAUNCHING AREAS for space capabilities: the Tonghae Satellite Launching Ground and the Sohae Satellite Launching Ground. The Tonghae Satellite Launching Ground is North Korea's oldest ballistic missile and space launch facility, although a successful orbital launch has never been achieved at the facility. According to December 2019 satellite imagery, there was increased activity at the site, including a group of people and possibly crates, but no sign of major renovations that would have to take place to prepare the facility for a vehicle test. However, North Korea has used mobile launching platforms for all recent land-based ballistic missile tests, which could be conducted in the grounds of Tonghae.[327]

The Sohae Satellite Launching Ground showed initial steps of disassembly in satellite imagery in the summer of 2018, but reassembly began again after U.S - North Korea Summits in Singapore and Hanoi.[328] In late 2019, North Korea conducted two engine tests at the Sohae Satellite Launching ground, believed to be modified liquid-fueled engines for long-range missiles.[329] While the specifics of the tests were unconfirmed, KCNA state media referred to the successful tests as "defence science achievements" that will "have an important effect on changing the strategic position" for the country.[330] Although conducted at a satellite launching pad, experts assess that it was likely another missile test or a step towards ICBM development, rather than a space vehicle launch.[331]

Satellite Imagery of the Tonghae Satellite Launching Ground on December 16, 2019. Analysis shows one launch pad, a second unfinished launch pad, and missile storage for the *No-dong* medium range ballistic missile, and *Taepo-dong* SLV. Both noted missiles are capable of reaching LEO.

AIRBUS / BEYOND PARALLEL

SPACE ORGANIZATION AND DOCTRINE

North Korea keeps its doctrine and operational concepts largely under wraps, including what is released about its counterspace capabilities. The absence of discussion about counterspace capabilities that could threaten the U.S. military is unusual given the aggressive rhetoric used by the regime in touting its nuclear and missile programs.[332] The country continues to advocate internationally for its right to a sovereign space program.[333]

When the regime has spoken about its space program at the United Nations, delegates speak of respect of international norms to maintain peaceful development and use of outer space, including the North Korean space program's right to help the country grow economically.[334] In March 2009, North Korea became a signatory to two major UN space treaties: the Outer Space Treaty of 1967 and the Convention on Registration of Objects Launched into Outer Space of 1974.[335] Four years later, in April 2013, the country's Supreme People's Assembly established the National Aerospace Development Administration (NADA), the official North Korean space agency.[336] Additionally, space has often been included in five-year plans that the regime has put forward.[337]

In October 2017, a delegate to the United Nations was reported in state media as saying "peaceful development of outer space is actively conducted in accordance with the 2016-2020 plan for national outer space development."[338] As reported, this plan included an aim to launch a geostationary satellite—a much more challenging feat which would require a more powerful launch vehicle.[339] State media reported a successful ground test of a new launch vehicle for this purpose, but it has not noted any attempts at an actual launch.[340] The regime hopes to use satellites to monitor crop and forestry growth as well as to improve communication ca-

pabilities.[341] The plan expressed a goal to field a satellite communication system by 2019, though there is no indication that goal was achieved.[342]

COUNTERSPACE WEAPONS

Kinetic Physical

Current space launch vehicles and ballistic missiles demonstrated by North Korea could serve as the basis for a kinetic ASAT capability, but many technological hurdles remain. To date, North Korea has not tested, or indicated that it is attempting to develop, a direct-ascent or co-orbital ASAT capability. It is unlikely that North Korea could quickly gain the technology for an effective direct-ascent or co-orbital ASAT weapon, as it has only succeeded in placing two satellites into orbit, the operation of which are not confirmed outside state media. This additional capability would also require onboard sensors (e.g., optical, infrared, radar) and a guidance system to steer the weapon into a target satellite.

It is conceivable that North Korea could field a crude direct-ascent ASAT capability in the near term in the form of an adapted ballistic missile. This would be possible with the launch of an unguided warhead set to detonate in the vicinity of a target satellite. Rather than directly strike a satellite, it could create a debris field that would complicate future operations for satellites in a similar orbit. For example, the North Korean *No Dong-1* medium-range ballistic missile would likely be able to carry a 1200 kg payload to a maximum altitude of 600 to 750 km—well within the LEO regime.[343] Missiles launched from North Korean territory could more easily be used in a conventional attack on nearby ground stations that support satellite operations, such as the U.S.-operated GPS monitoring station in South Korea and other ground stations as far away as Guam.[344]

Non-Kinetic Physical

The technology necessary to develop directed energy weapons, such as lasers that are able to dazzle or blind the sensors on satellites, requires a level of sophistication that North Korea likely does not possess.[345] It is possible, however, that North Korea could develop a crude EMP weapon for use against space assets. In 2017, North Korea successfully tested a hydrogen bomb underground, a claim that was confirmed by South Korea and Japan.[346] Officials from Pyongyang released a photo of the hydrogen bomb and asserted that the bomb is able to fit on an ICBM.[347] Kim Jong-un has called for further improvements in nuclear bombs similar to this test in the "Songun" spirit, which places the military first.[348] In January 2020, KCNA reported that Kim Jong-un declared the world would soon see a new strategic weapon, adding that there will never be denuclearization on the Korean peninsula.[349]

A nuclear weapon on a long range missile would theoretically give North Korea the capability to create a high-altitude EMP effect.[350] In 2018, The Daily NK—a South Korean news site—obtained North Korean internal propaganda documents aimed to inform citizens that the country has the capability to damage enemies' military and civilian electronic systems beyond repair as a result of a nuclear EMP attack.[351] North Korea is not a signatory of the 1963 Partial Test Ban Treaty, and the country has not tested a nuclear weapon at high altitudes.[352]

Electronic

North Korea has acquired and is constantly using electronic forms of attack against varying space systems. In 2010, South Korean Defense Minister Kim Tae-young said in a speech to parliament that "North Korea has imported vehicle-mountable devices capable of jamming GPS signals from Russia." These downlink jamming systems reportedly have an effective radius of 50 to 100 km. North Korea began using this jamming equipment against

NORTH KOREA HAS BEEN CARRYING OUT CYBERATTACKS BY PLACING INDIVIDUALS IN SCATTERED FOREIGN COUNTRIES IN AN ATTEMPT TO DISGUISE THE ORIGIN OF THE ATTACKS.

South Korea in August 2010, but South Korean forces could not pinpoint the location of the jammers at that time because the jamming lasted just 10 minutes in each instance.[353]

In the decade since, North Korea has repeatedly used its GPS jamming capabilities against South Korea. More GPS jamming occurred in December 2010 and again in March 2011, which coincided with a U.S.-South Korean military exercise. Jamming occurred again in April 2012, disrupting air traffic at Incheon and Gimpo international airports, forcing flights to use alternative navigation systems.[354] In March and April 2016, over 250 South Korean fishing boats lost access to GPS, forcing them to return to shore.[355] A few days later, South Korea complained to the UN Security Council that North Korea was jamming GPS signals across the border, with the jamming coming from five areas in North Korea: Pyongyang, Kaesong, Haeju, Yonan county, and Mount Kumgang.[356] Documents state that in 2016, 2,143 aircraft disclosed GPS interference, likely due to North Korean jamming operations.[357]

The South Korean Defense Ministry has said it believes the jamming attacks originate from "a regiment-sized electronic warfare unit near the North Korean capital Pyongyang, and battalion-sized units closer to the inter-Korean border."[358] The jammers are mounted on mobile platforms and are operated intermittently, which could be difficult to locate and neutralize in a conflict. North Korea appears to be gaining operational experience using these systems in peacetime. Because the GPS jammers were acquired from Russia, it is possible that North Korea could also have acquired other types of jamming capabilities that can target different satellite systems, such as uplink jammers that can disrupt military satellite communications.

Additionally, AIS spoofing has been used in shipping vessels during 2019 likely in an attempt to hide what is assumed to be coal smuggling operations. A report details the suspicious behavior of one of North Korea's largest bulk ships, the *Tae Yang*, which North Korea relies on for imported goods and revenue. The *Tae Yang* consistently broadcasted a unique identification number assigned to another vessel to disguise its own illicit movements, while still transmitting AIS data. Another report by the UN Panel of Experts has uncovered additional examples of AIS spoofing techniques used by North Korean ships to avoid sanctions.[359]

According to minutes from a 2008 meeting about network surveillance capabilities, North Korean officials inquired about a satellite jamming system to two groups of internationally contracted engineers. The meeting ended with an agreement that "the number of jamming systems that prevents interception by satellite should be increased." However, analysts believe it is possible that the inquiry was an excuse to get imported German cellular detection equipment, which was subsequently used to catch North Korean citizens with Chinese cell phones.[360]

Cyber

Under the Kim Jong-un regime, North Korea has used its cyber forces frequently, first launching attacks on South Korea and the United States, then branching out to others. According to CrowdStrike, North Korean hackers have the second-fastest breakout time (the time needed for hackers to achieve their objectives in an attack) of any hacking organization in the world, behind Russia. North Korea's malicious cyber activity tends to focus on financial targets or inter-Korea issues. A majority of the cyberattacks stemming from North Korea are "linked to currency generation and economy-bolstering efforts for the Kim regime."[361]

Experts believe there are around 6,000 - 7,500 military personnel conducting cyber warfare for the North Korean state. Cybersecurity defector and founder of North Korea Intellectuals Solidarity, Kim Hueng-kwang, said most cyber operations in the country are organized in a unit directly under North Korea's main overseas intelligence agency, the Reconnaissance General Bureau (RGB).[362] He emphasized that North Korea was "inspired by the Chinese cyberwar units and learned from them."[363] According to Kim,

members of an elite North Korean hacking group go on covert missions overseas, generally to places with better internet than the notoriously shielded country, to lower the risk of being caught. South Korea's vice foreign minister confirmed this report, telling Reuters that North Korea has been carrying out cyberattacks by placing individuals in scattered foreign countries in an attempt to disguise the origin of the attacks. [364]

A leaked report sent to the UN Security Council's North Korea sanctions committee stated that through 35 separate cyberattacks, North Korea has stolen over $2 billion, which has likely been used to fund weapons development.[365] Subsequently, the U.S. Department of the Treasury announced sanctions for three state-sponsored cyber groups from the country, naming them responsible for malicious cyber activity on critical infrastructure.[366]

North Korean hackers have also been tied to a nuclear power plant in India and possibly the Indian Space Research Organization during its Chandrayaan-2 mission, although Indian space authorities deny they were compromised. [367] They are also suspected to have hacked an Israeli aerospace and defense company.[368] Given its demonstrated cyber capabilities, it is conceivable that North Korea could initiate a cyberattack against U.S. space systems or ground stations, although there is no publicly available information to suggest this has happened to date.

SUMMARY

North Korea has demonstrated growing capabilities in two counterspace weapons categories: electronic and cyber. It is also developing some of the necessary technologies to field a non-kinetic physical nuclear EMP counterspace weapon through its nuclear program, but this does not appear to be the intent of those activities.

Although North Korea has demonstrated its dedication to increasing the range of its ICBM-class missiles, its limited number of successful orbital launches suggest that the country is far from developing the capabilities needed to pose a significant kinetic physical threat to foreign satellite systems. The only significant risk of non-kinetic physical attack from North Korea is high altitude nuclear detonation, a devastating, irreversible counterspace attack that would indiscriminately affect systems in the target satellite's orbital regime. Importantly, North Korea is improving its electronic warfare capabilities, as demonstrated in continued GPS jamming and spoofing operations, and is continuing to use cyberattacks against a variety of targets worldwide.

Number of Successful Orbital Launches in 2019[369]

6

INDIA

"When India celebrates [its] 75th year of Independence in 2022, and if possible even before, an Indian son or daughter will undertake a manned space mission on board 'Gaganyaan' carrying the national flag."

PRIME MINISTER NARENDRA MODI[370]

INDIA JOINED THE WORLD STAGE AS A RISING SPACE POWER by launching its first satellite from the Satish Dhawan Space Center in 1980. India has since developed highly successful launch vehicles, a range of communications, imaging, and other critical satellites, and is beginning serious development of counterspace capabilities. While India has no overarching national space policy yet, the government of India is in the process of creating one.[371] Currently, it does have various organizations dedicated to the space domain in both the military and civil sectors, each with supporting policies and doctrine. Among these organizations is the principal space organization in India, the Indian Space Research Organization (ISRO), which is responsible for maintaining the SLVs and spaceports of India.

Currently, India has two operational orbital launch vehicles, the Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV). These two vehicles launched six times in 2019, representing only a small portion of the 67 total Indian launches since 1980 from the Satish Dhawan Space Centre.[372] India made history in 2017 with the largest number of satellites on any single mission, launching 104 satellites with one PSLV, breaking the previous record of 37 satellites held by Russia since 2014. All but three of these satellites were foreign owned.[373]

INDIA

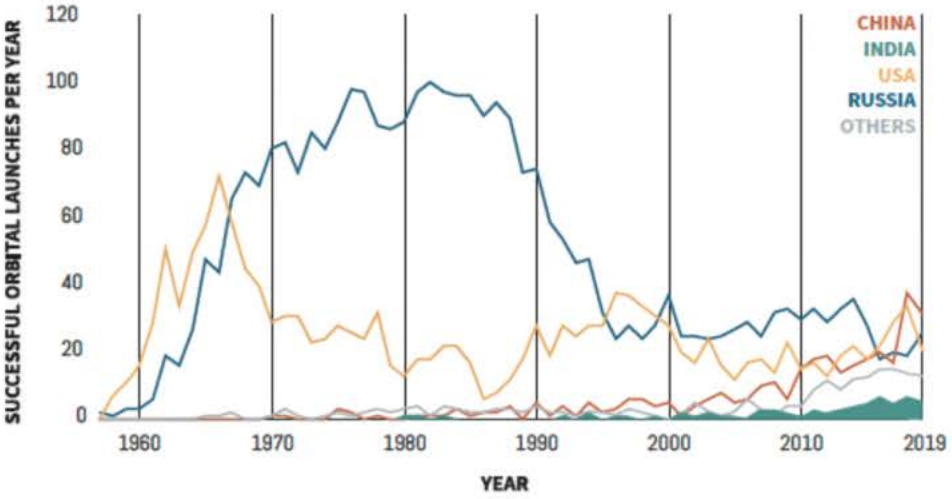


Figure 12: Indian Orbital Space Launches (1957 - 2019).

SPACETRACK.ORG / CSIS AEROSPACE SECURITY[374]

The Satish Dhawan Space Center has been India's only major spaceport since it began launching in 1980. However, due to the anticipated increase in demand for national and commercial space launch in the coming years, the Indian government has begun the land acquisition process for the construction of a new spaceport.[375] The proposed spaceport, to be located in the southern state of Tamil Nadu, is planned to mainly service India's newest launch vehicle, the Small Satellite Launch Vehicle (SSLV).[376] A derivative of the PSLV, this new Indian launch vehicle is rated to carry "up to 500 kilograms to mid-inclination low Earth orbits and 300 kilograms to [sun-synchronous orbit (SSO)]."[377] The location of the proposed spaceport will allow for launching southward into a polar or near-polar orbit, which is difficult from the Satish Dhawan Space Center due to the need to maneuver around Sri Lanka.

Only three countries—China, the Soviet Union, and the United States—have ever "soft-landed" on the lunar surface.[378] In 2009, India successfully launched the *Chandrayaan-1* spacecraft, which was designed to orbit the moon and conduct a hard-landing for the purpose of targeting and practicing a future soft-landing.[379] In 2019, the *Chandrayaan-2* spacecraft was placed on a GSLV and launched into lunar orbit. While on approach to the lunar surface to attempt a soft-landing, the Vikram Lander lost contact with the ISRO and crashed into the lunar surface.[380] After about a month of attempting to re-establish contact with the lunar lander, the Indian government made an official announcement that they had lost contact and were unable to recover the spacecraft.[381] However, this failure has only reinvigorated the Indian space program and public.

In an announcement on January 1, 2020, Chief Kailasavadivoo Sivan, head of the ISRO, stated that the top priorities for the ISRO in 2020 are a *Chandrayaan-3* mission to the lunar surface and the *Gaganyaan* human spaceflight program, though it is unlikely that either will launch before 2021.[382] The *Chandrayaan-3* mission will similarly attempt to conduct a soft-landing on the lunar surface. When asked if a crewed mission to the moon was in the near future for India, Sivan said, "definitely, but not im-

THE TOP PRIORITIES FOR THE ISRO IN 2020 ARE A CHANDRAYAAN-3 MISSION TO THE LUNAR SURFACE AND THE GAGANYAAN HUMAN SPACEFLIGHT PROGRAM, THOUGH IT IS UNLIKELY THAT EITHER WILL LAUNCH BEFORE 2021.

Vikram Lander and Pragyan Rover. The Vikram lander was launched on the *Chandrayaan-2* mission, but it did not achieve a successful soft landing on the lunar surface.

ISRO

mediately."[383] Four Indian astronauts will be sent to Russia for 11 months to receive training in preparation for the *Gaganyaan* program. Additional program-specific training will also take place in India.[384]

ORGANIZATION AND DOCTRINE

India does not have an official military department focused on space. It instead created a separate agency, the Defence Space Agency (DSA), to coordinate between and command the space assets of the Indian Army, Navy, and Air Force, including India's new direct-ascent ASAT capabilities.[385] According to the two-star general appointed to head the DSA, "the agency will eventually grow into a full-fledged Space Command in the years ahead."[386] To date, however, there is no confirmed timeline for this growth. Within the DSA, India established the Defence Space Research Organization (DSRO) in late 2019 to further develop and test counterspace systems and related technologies.[387]

In late July 2019, India's top strategic planners from several agencies gathered to begin to establish new policies and doctrine for future military and non-military uses for space. Called IndSpaceEx, the strategic planners were led through a wargaming simulation that was meant to assess military assets of other leading space powers—namely the United States, China, and Russia—to better assess the level to which India must counter international space threats.[388] The session's conclusion was that future wars may be dominated by activities in the cyber and space domains,

leading to asymmetric advantages or disadvantages.[389]

A 2019-2020 annual report released by the Government of India's Department of Space detailed initial steps of an official space policy for the country. This policy will "support the pursuance of space activities by various agencies in India including private sector and start-up companies in the aerospace sector."[390] It is clear through India's military space reorganization, renewed focus on commercial partners, and it's test of a direct-ascent ASAT in March 2019 that the Indian leadership views space as a key operational domain.

COUNTERSPACE WEAPONS

Kinetic Physical

The Indian government took notice of China's successful 2007 direct-ascent ASAT, causing it to shift focus to protecting its vulnerable space assets from a Chinese threat. As one scholar noted, "It suddenly reminded them that their diverse space assets were now at risk,

Mission Shakti

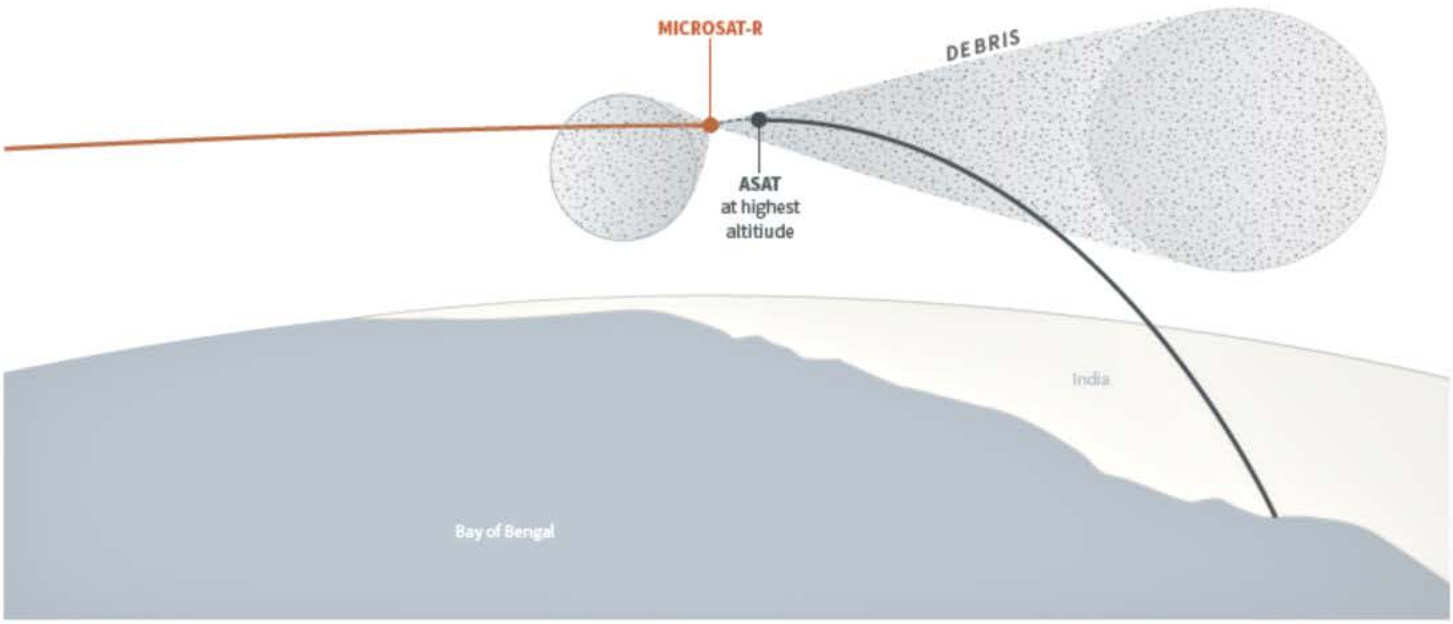
ON MARCH 27, 2019, India successfully launched a Prithvi Delivery Vehicle Mark-II (PDV MK-II) missile defense interceptor at one of its own satellites. Launched in late January 2019, the target satellite, *Microsat-R*, was specifically placed in a low-altitude sun-synchronous orbit as the target for an ASAT test. After the successful test in March, independent analysts realized that an earlier attempt to intercept the satellite on February 12 of the same year failed.[391]

What was perhaps most notable about the Indian ASAT test was the muted international outcry that occurred afterward. This was likely due in part to the minimal amount of orbital debris created—only about 400 pieces remained in orbit immediately after the test, compared to the over 3,000 pieces of debris created during the 2007 Chinese ASAT test. The Indian ASAT test took place at a relatively low altitude, and at the time of impact, the interceptor was on a downward trajectory. This resulted in much of the debris having a downward trajectory, allowing it to be more quickly deorbited. Given these factors, it is likely that the Indian government was attempting to limit the potential for long-lasting orbital debris.[392] Since the test, a majority of the debris has deorbited, and by the end 2019, just 18 pieces of debris large enough to track remained in orbit.[393]

The Indian ASAT test did not receive the same level of international outcry as the Chinese ASAT test, in part because it produced much less orbital debris. The United States, for example, only had one government official speak out against the test. NASA Administrator Jim Bridenstine decried the test because some pieces of debris were pushed to a higher altitude, threatening the astronauts on the International Space Station.[394] While public international outcry was minimal, Pakistan was one of few states to openly denounce the test, urging all countries to "condemn India's action and strengthen international laws regarding the militarization of space."[395] Additionally, the Union of Concerned Scientists denounced the test, expressing that this test harmed international efforts to prevent further weaponization of outer space.[396]

Figure 13: Depiction of Kinetic Physical ASAT Test by India in 2019. Muted international outcry in response to this ASAT test was, in part, due to the low amount of debris created because of the slight downward trajectory of the missile on impact.

AEROSPACE SECURITY PROJECT / EMILY TIEMEYER



hostage to the dangers emanating from their most formidable regional threat." For years, defense planners debated the merits of conducting a similar kinetic ASAT test to signal to China and other nations that India had the ability to retaliate in kind if its space assets were attacked.[397] The government eventually concluded that India should pursue kinetic ASAT weapons.

On March 27, 2019, India became the fourth country—behind the United States, China, and Russia—to successfully test a direct-ascent ASAT missile. Named Mission Shakti, meaning "strength" in Hindi, the test was conducted with an Indian-produced ballistic missile which intercepted a small target satellite in LEO.[398] In a tweet, Prime Minister Narendra Modi said this test will "have a historic impact on generations to come."[399]

"In the journey of every nation there are moments that bring utmost pride and have a historic impact on generations to come."

PRIME MINISTER NARENDRA MODI[400]

India does not have any publicly known co-orbital ASAT capabilities. However, Defence Research and Development Organization Chief G. Satheesh Reddy announced in April 2019—less than a month after the success of Mission Shakti—that India was developing co-orbital ASAT capabilities and that the details remained classified.[401] India is developing, in partnership with France, the technical capabilities to conduct RPO on orbit as part of its efforts to develop a national space station.[402] RPO proficiency is a key step toward the fundamental capabilities of building some types of co-orbital counterspace weapons.

The Indian military also has the ability to directly attack satellite ground stations. Indian special operations units are specially trained to "to carry out crippling attacks against critical enemy targets miles away."[403] The newly created Armed Forces Special Operations Division is designed and modeled off of the United States Joint Special Operations Command (JSOC).[404]

Non-Kinetic Physical

Thus far, India does not appear to have developed and tested non-kinetic physical counterspace weapons. However, the 2010 *Technology Perspective and Roadmap* released by the Ministry of Defense detailed that ASAT weapons "for electronic or physical destruction of satellites (2,000 km altitude above earth's surface) and geosynchronous orbits" are a key area of future focus.[405] Following this, a new *Technology Perspective and Capability Roadmap* in 2013 noted a focus on developments in electronic weapons, specifically miniaturization of EW elements as payloads on satellites.[406]

PDV-MK II Missile Lifting Off on Track to Intercept *Microsat-R* on March 27, 2019. The missile used by India during its first ASAT test was an indigenously manufactured missile.[409]

GOVERNMENT OF INDIA

In its 2018 *Technology Perspective and Capability Roadmap*, India detailed investments in a two-phase Tactical High Energy Laser System. The second phase of this system is intended to play an "anti-satellite role from ground & aerial platform."[407] Following the Mission Shakti test, DRDO Chief Satheesh Reddy stated that India was in the process of developing different ASAT technologies, including directed-energy weapons, lasers, and electromagnetic pulses.[408] However, beyond these general statements and reports, the government of India has not divulged any details of these activities.

As a nuclear-armed state, India has the ability to launch a nuclear warhead into space as a counterspace weapon. Theoretically, in addition to the kinetic properties of the nuclear weapon, India could use the EMP effect from a high-altitude nuclear detonation to disable satellites. However, there is no publicly available indication that India is pursuing a nuclear EMP space weapon.

Electronic

India's 2018 *Technology Perspective and Capability Roadmap* also shows investment in an integrated EW system with requirements to "detect, monitor, locate and jam enemy cellular receivers and satellite communication receivers."[411] Another planned system has similar requirements as the integrated system and is intended to also be able to "carry out jamming & spoofing of satellite based positioning systems."[412] However, India has not yet publicly demonstrated its jamming or spoofing capabilities.

Cyber

In 2019, the government of India set up the Defence Cyber Agency (DCA). Similar to the Defence Space Agency, the DCA is meant "to control and coordinate joint cyber operations."[413] There have been questions as to whether India may have some kind of cyber deterrence against enemy satellites with both space- and land-based systems; however, Union Minister Shripad Naik has stated that such information is sensitive and therefore is unable to be confirmed or denied.[414]

"India has always been opposed to the weaponization of space and an arms race in outer space, and this test does not in any way change this position."

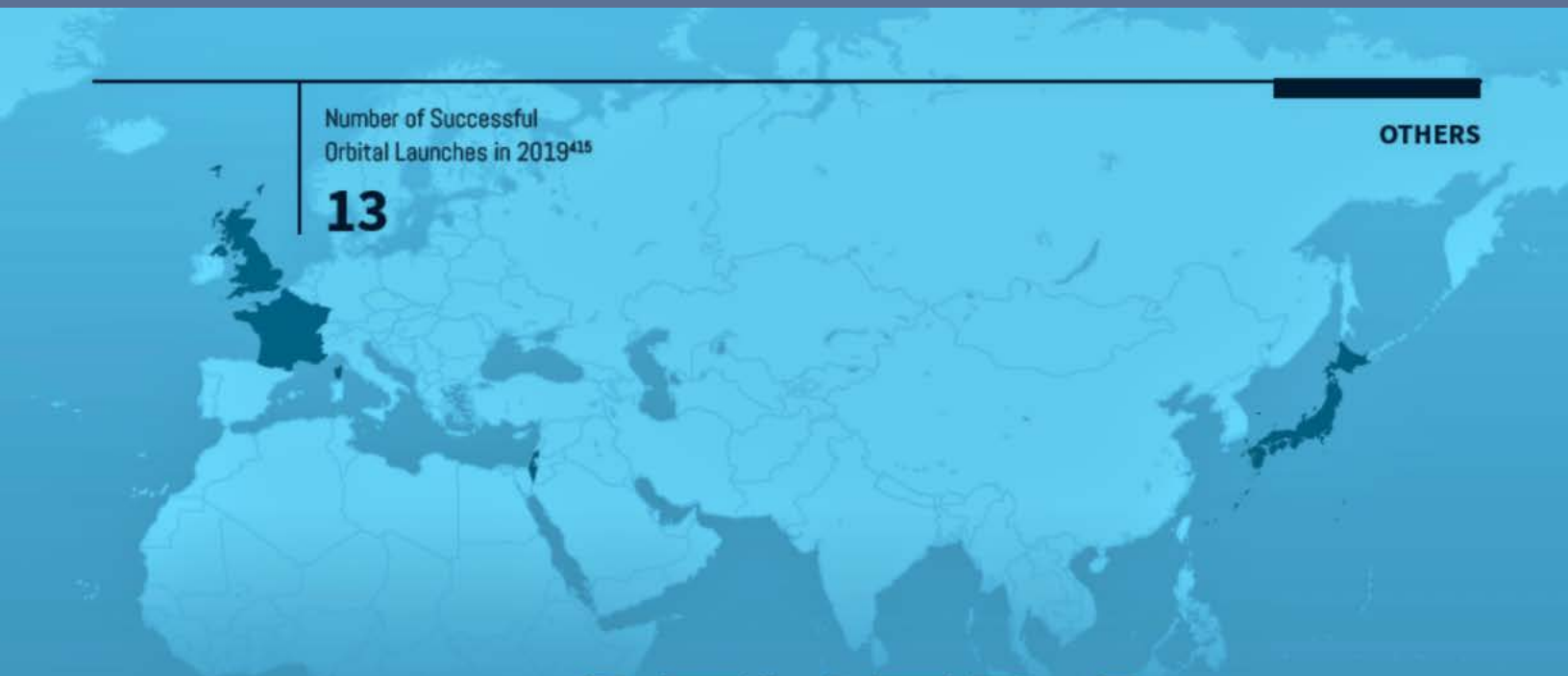
PRIME MINISTER NARENDRA MODI [410]

SUMMARY

Although India has had a recent successful direct-ascent ASAT test, other types of counterspace weapons are far from developed. As India focuses more on building out its space assets, as well as its counterspace assets, subsequent counterspace weapons tests may occur. While the 2019 ASAT test has certainly caused great debate in the international space community, the muted official international response sets a different precedence from the Chinese 2007 test. With little to no repercussions, India demonstrated that a lower-altitude ASAT test may be accepted by the international community.

Number of Successful Orbital Launches in 2019[415]

13



OTHERS

"I'm convinced that in the future, if we were to get into a conflict with a peer or near-peer competitor, we're going to have to fight for space superiority."

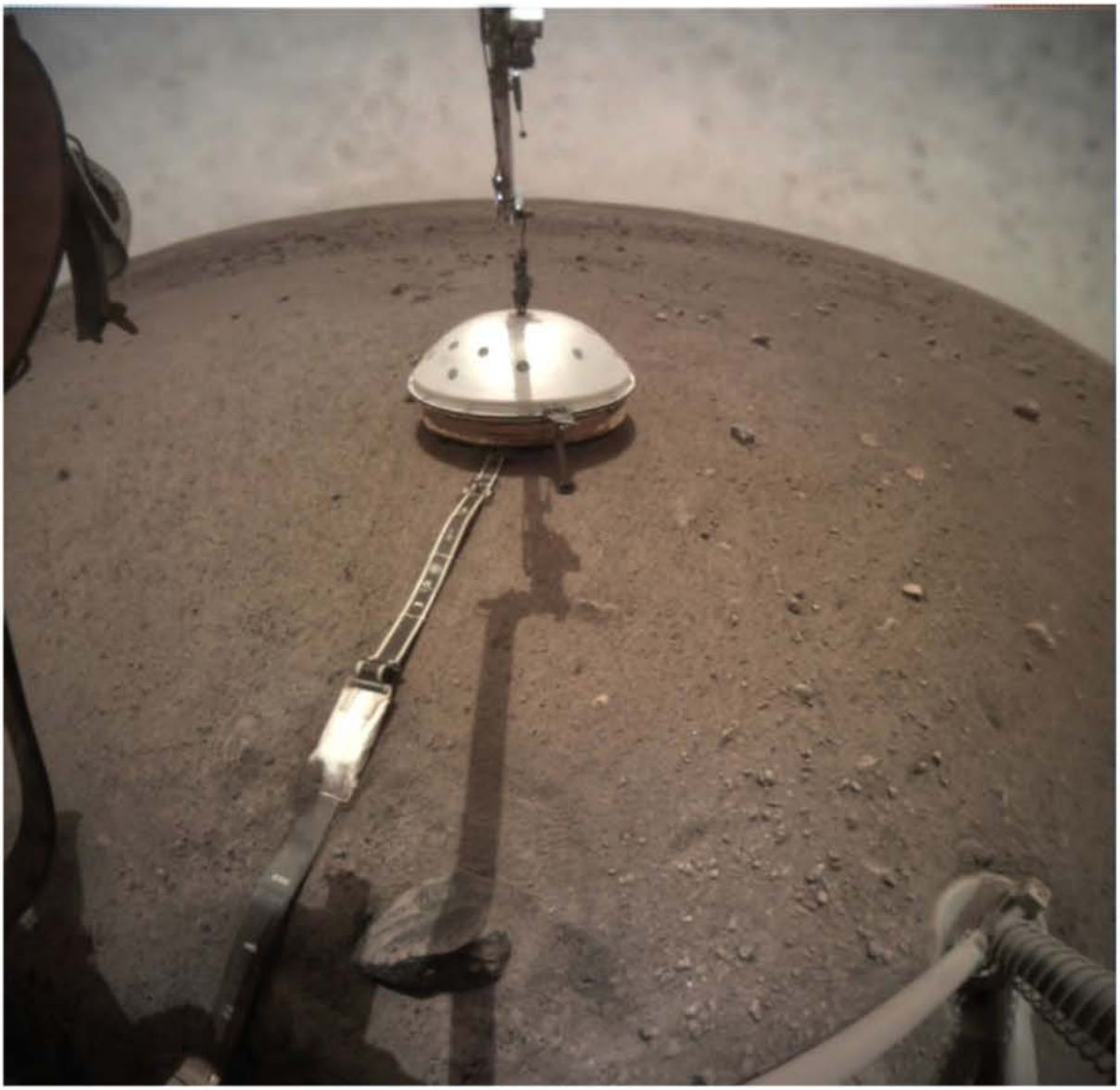
GENERAL JOHN RAYMOND, CHIEF OF SPACE OPERATIONS AND COMMANDER OF U.S. SPACE COMMAND[416]

WHILE THE PREVIOUS CHAPTERS HAVE BEEN DEDICATED to the countries making the largest strides in counterspace capabilities—China, Russia, Iran, North Korea, and India—they are not the only ones thinking strategically about the changing space environment. This chapter includes significant discussion and developments related to counterspace capabilities in other countries and non-state actors.

FRANCE

AS THE THIRD OLDEST SPACE PROGRAM IN THE WORLD, France has accomplished much since it first established its national space agency, the Centre national d'études spatiales (CNES), in 1961. France launched its first satellite in 1965, led the development of the Ariane family of launch vehicles, and became one of the foremost European space powers through its strong relationship with the European Space Agency (ESA).[417]

In 2018, the CNES was a key partner of NASA's Mars Discovery Program, providing the InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission. InSight deployed a seismometer, named SEIS (Seismic Experiment for Interior Structures), which measures "Mars' tectonic activity to learn more about its structure, for example the size of its core and the thickness of its mantle."[418] InSight landed on Mars in 2018 for its planned two-year mission, and in April 2019, the SEIS seismometer detected and recorded the first "Marsquake," allowing scientists to study the slight tremors detected on the Martian surface.[419]



Deployment of the SEIS Protection Dome on Mars.
NASA / JPL-CALTECH

Recent events have triggered changes in France's overall space policy. In September 2018, France publicly charged Russia with interfering with the operation of one of its satellites in GEO. The *Athena-Fidus*, a jointly operated French-Italian military satellite, provides broadband military communications. France alleged that the Russian satellite, known as *Luch* or *Olymp-K*, maneuvered close enough to *Athena-Fidus* in 2017 to intercept military communications.[420]

Following this public denunciation of Russian space activities, France issued a new Space Defense Strategy in 2019. Among other things, the French strategy calls for the creation of a Space Command under the Air Force and renaming the Air Force to the Air and Space Force. The strategy notes that "renewed analysis of the space environment and its threats, risks and opportunities, as well as the recognition of the strategic nature of the space assets for France force our country to revisit its model in order to remain a leading space power." The Space Defense Strategy further declares that France will establish a "space defense capacity" in order to "enable the armed forces to

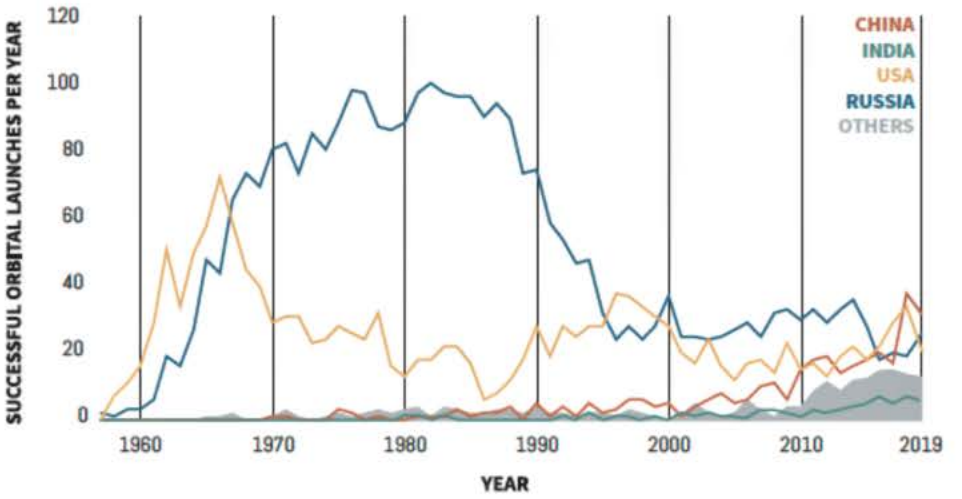


Figure 14: Space Orbital Launches from Other Nations (1957 - 2019). This figure includes orbital launches from nations such as New Zealand and Japan, as well as the European Space Agency.

SPACETRACK.ORG / CSIS AEROSPACE SECURITY[421]

impose a peaceful use of space, deter unfriendly or hostile acts against our space assets, and be able, as the case may be, to defend our space-based interests."[422] France has also committed to increasing its military space budget by 700 million euros between 2019 and 2025 to support the creation of Space Command and pursue "active defense" satellite technologies.[423] The defense of space assets appears to be in response to the interference France felt was caused by *Luch*.

In a speech announcing the new strategy, French Minister of the Armed Forces Florecne Parly spoke at length about the changes. In some of the most direct and specific language by a government official from any nation on space defense, the defense minister said, "I want to be precise: active defence is not an offensive strategy, what it is about is self-defence." She went on to add that, "If our satellites are threatened, we will consider dazzling those of our opponents. We reserve the time and means of the response: this may involve the use of high-power lasers deployed from our satellites or from our patrol nano-satellites."[424] Through these remarks Parly sheds further light on France's plans to develop and deploy "bodyguard" or "patrol" satellites to protect its space assets, as well as its plans to mount lasers on satellites in order to dazzle or blind satellites that may be threatening French assets.

A laser mounted on satellites is theoretically possible but faces some technological hurdles. Laura Grego from the Union of Concerned Scientists explained that "dazzling from accompanying satellites (probably not 'nano' satellites unless that definition is very generous) or onboard might stop other slow moving proximity operations satellites from observing their satellite [targets] or to make it hard for them to use lidar for getting really close." Dr. Grego went on to assert that it would be hard to use lasers on cross-orbit attacks or direct-ascent ASAT weapons.[425]

France's public posture toward protecting its space capabilities is shifting. The country's leaders are indicating a move toward active defense in space, which has contributed to a broader public debate on the proper use and development of counterspace weapons. While countries like China and Russia have been extensively developing offensive counterspace weapons, such as jamming and spoofing capabilities, France seems to be considering a different strategy: defensive capabilities on orbit. However, the country's policies appear to be in flux, and there is little public indication of how quickly France plans to pursue this new direction.

ISRAEL

In July 2019, the United States and Israel jointly tested the Arrow-3 missile interceptor. While not publicly listed as a direct-ascent ASAT weapon, "the Arrow-3 interceptor successfully demonstrated an engagement capability against the exo-atmospheric target during the test."[426] Speculation of the Arrow-3 system being used as an ASAT weapon began in 2009 when leading space military experts pointed out that "Israel's planned Arrow-3 high-altitude ballistic missile defense system could relatively easily be adapted to destroy Iranian spy satellites if and when Tehran manages to deploy high-resolution orbiting vehicles."[427]

The Israeli company Regulus claims to have spoofed a Tesla Model 3 using the Navigate on Autopilot (NOA) system.[428] The purpose of the NOA system is to follow a predetermined route maintained by using GPS and Google Maps technology. The spoofing targeted the relationship between the Tesla Model 3's NOA system and the GPS it relied on to maintain autopilot. The test itself took place on an interstate and made the car believe it was further along on the route, causing it to make an incorrect turn into a rest stop instead of the planned exit further down the road.[429] In response to these claims, Tesla stated that the test was only a promotional stunt and that they have no safety concerns with the Tesla-3's NOA.[430]

Israel has also begun development of a ground-based and plane-mounted high-energy laser defense system designed to target threats in the air. Currently it has no stated counterspace implications, but the technology could be adapted to perform some counterspace operations. With a power level of 50-100kW, this airborne laser could be capable of dazzling or even blinding satellites in LEO.[433]

Israeli Missile Interceptor, Arrow-3, was tested July 2019 out of the Pacific Spaceport in Alaska.[431] Designed to intercept medium-range ballistic missiles, the Arrow-3 system has been speculated to also be capable of performing direct-ascent anti-satellite operations.[432]

MISSILE DEFENSE AGENCY

JAPAN

In the past year, Japan has made progress toward setting up a new Space Domain Mission Unit, a military organization meant to protect Japanese space assets as more countries are moving to further weaponize space through the testing and development of kinetic and non-kinetic weapons.[434] Citing Japan's need "to protect itself from potential threats as rivals develop missiles and other technology," Prime Minister Shinzo Abe said this new organization will work closely with its American counterpart, the United States Space Force. The Space Domain Mission Unit will also cooperate with the newly re-established U.S. Space Command and Japan's own civil space agency, the Japan Aerospace Exploration Agency (JAXA).[435] With a small core established in 2020, the Space Domain Mission Unit plans to be fully operational in 2022 to "bolster capability and system[s] in order to secure space superiority."[436] After its establishment, the Space Domain Mission Unit will be responsible for operating the ground stations necessary to conduct these defense operations.[437]

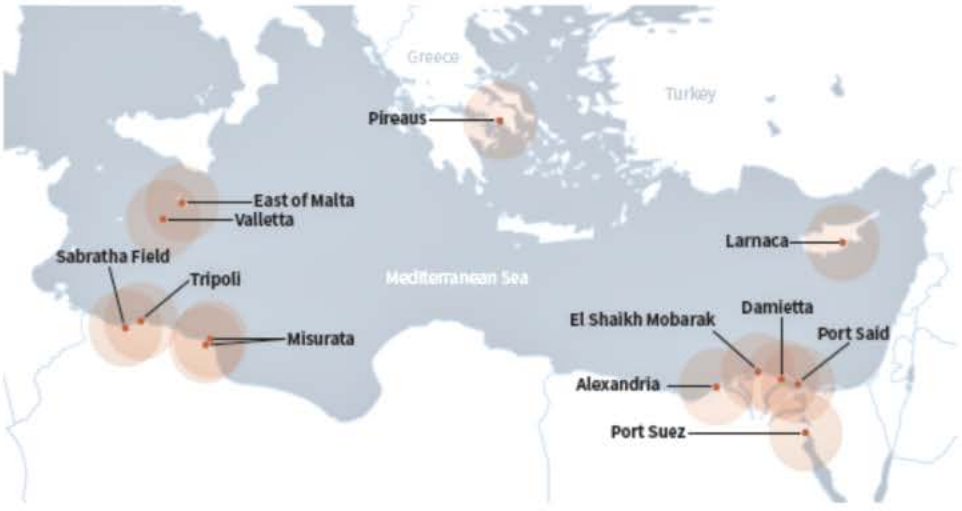
Japan is also reportedly considering the development of active defenses to protect its space systems. Using robotic arm technology developed by JAXA, the Japanese government is debating options to develop a co-orbital satellite defense system to deter attacks on Japanese satellites. This system, which would intercept an attacking satellite in order to defend another Japanese space asset, could be launched as early as the mid-2020s.[438] The government is also reportedly considering options to disable hostile satellites through electronic and cyber means.[439]

In April of 2019, Japan deployed a *Hayabusa-2* probe system to an asteroid, Ryugu, which contained a small carry-on impactor (SCI). The SCI is an explosive projectile able to be launched at the asteroid to form an artificial crater. This explosive, which created rubble for Hayabusa-2 to collect and bring back to Earth as samples, could be placed on a satellite and be used as a co-orbital anti-satellite weapon.[440]

THE JAPANESE GOVERNMENT IS DEBATING OPTIONS TO DEVELOP A CO-ORBITAL SATELLITE DEFENSE SYSTEM.

Spoofing in the Mediterranean Sea

CIVIL AND COMMERCIAL MARINE GPS USERS reported consistent loss of GPS signal in the Mediterranean Sea and surrounding areas throughout 2019. These outages ranged from the coast of Libya to Greece and Egypt's Suez Canal. The U.S. Maritime Administration issued alerts that specifically mention the possibility of GPS interference in the Eastern and Central Mediterranean regions.[441] The increased instances of GPS jamming have led captains to suppress their AIS data and switch to receive only. This has led to a decrease in situational awareness on the sea.[442]



U.S. COAST GUARD NAVIGATION CENTER / EMILY TIEMEYER

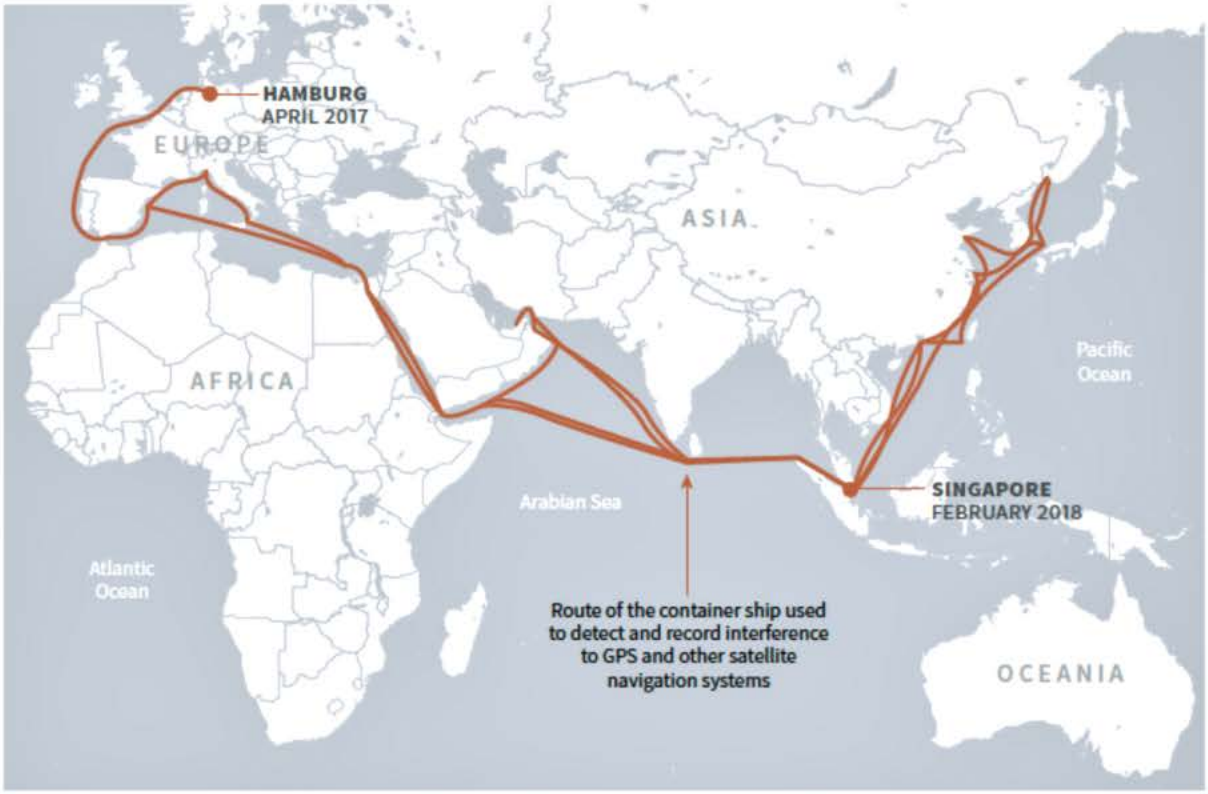


Figure 15: The Journey of the Basle Express. The Basle Express was a cargo ship outfitted with GPS receivers designed to track and collect GPS interference. The ship travelled from Germany to Singapore tracking and detailing many instances of GPS interference.

GERMAN AEROSPACE CENTER

UNITED KINGDOM

The United Kingdom has begun restructuring its military space organization, although it does not plan to create a separate military service for space. The current restructuring effort should result in a two-star major general becoming the director of Space within the Ministry of Defence, supported by policy and capabilities teams.[443] This comes after the U.K. government declared space as part of its critical national infrastructure in 2015 and more recently as a warfighting domain.[444] While the UK has not explicitly endorsed the development of space defense systems and counterspace weapons, the requisite technology is within its reach. For example, the United Kingdom is developing its own high-energy laser for anti-drone and missile defense. These lasers, while not directly cited as counterspace weapons, have the potential to be further developed into counterspace capabilities.[445]

NON-STATE ACTORS

In 2019, reports emerged of position, navigation, and timing (PNT) jamming in northeastern China, disrupting civilian aircraft flying over the area. Authorities were able to trace the jamming origin to a farm in Heilongjiang province near the city of Harbin. Frustrated by a local gang's hijinks of using drones to supposedly infect local farmers' pigs with African swine fever—a disease deadly to pigs, but harmless to humans—the farmer used PNT signal jamming to protect his herd. The gangs were infecting local pigs to force farmers to lower the prices and then would resell the pork to the public as "healthy" for the full price.[446]

In 2018, at Hong Kong's 10-year celebration of the Wine and Dine Festival, a drone light show over Victoria Harbor was disrupted by GPS jamming, which caused 46 drones to fall from the sky, resulting in $127,500 in damages.[447] In response to questions about the incident, the board's executive director, Anthony Lau Chun-hon, said that "the [jamming] signals were so strong that many of them just dropped from the air."[448]

In April of 2017, a commercial container ship, the *Basle Express*, left Hamburg, Germany on a research mission equipped with receivers designed to pick up on interference. The *Basle Express* mission was designed to sense levels of jamming and spoofing in different areas of the world.[449] While travelling around Europe, the Middle East, Africa, and Asia, the ship's crew detected strong interference "at some of the world's largest seaports, including Jeddah in Saudi Arabia, Singapore, Hong Kong, and Shanghai, and less often, on the open sea."[450] With many commercial vessels poorly suited to operating in a world where GPS is not guaranteed, some experts are recommending that new anti-jamming systems will need to be created to ensure that commercial shipping can continue unthreatened in an increasingly technology-dependent world.[451]

SUMMARY

In the last year, more states are considering the development of offensive and defensive counterspace capabilities to protect space systems from attacks. Nations are moving to reorganize their national security space enterprise, as the United States did in 2019, to better address the growing uncertainty and threats in the space domain. Jamming and spoofing technologies are also being used around the world by non-state actors in both conflict zones and thriving seaports, to gain military and economic advantage. Collectively, these developments are making the space environment more dynamic and uncertain—a trend that is likely to continue in the coming years.

WHAT TO WATCH

THIS YEAR'S EDITION OF THE CSIS SPACE THREAT ASSESSMENT finds that threats to space systems are growing as more countries and non-state actors acquire counterspace capabilities and, in some cases, employ them in more ways. While this report primarily details the developments in counterspace weapons that have occured in the last year, some of these developments have been ongoing for several years. This section highlights the types of threats and counterspace activities where more developments are expected to occur in the coming months and years.

Electronic counterspace weapons continue to proliferate at a rapid pace in both how they are used and who is using them. Satellite jamming and spoofing devices are becoming part of the every-day arsenal for countries that want to operate in the gray zone—i.e., below the threshold of overt conflict. The jamming and spoofing of satellites has become somewhat common, and without strong repercussions these adverse activities could gradually become normalized. The fact that Russian President Vladimir Putin appears to travel with GPS jamming devices in his motorcade and that China appears to be spoofing GPS signals to conceal illicit activities in its own ports demonstrate how important and integrated these capabilities have become at all levels. One should expect that the rate of satellite jamming and spoofing incidents will only increase as these capabilities continue to proliferate and become more sophisticated in the coming years.

One of the most significant counterspace developments in the past year was the Indian test of a direct-ascent ASAT weapon. This incident proved that a kinetic test done in a way that minimizes orbital debris may not generate the same degree of diplomatic backlash as the Chinese ASAT test in 2007. Moreover, the Indian test and how it was received could incentivize other nations, such as Pakistan, to develop and demonstrate ASAT capabilities of their own.

Russia also continued to step up its co-orbital activities in the past year. The Russian *Luch* satellite continued its close inspection of satellites in geostationary orbit, despite international denunciation of its activities. Russia also placed a widely-reported inspector around a classified U.S. Government satellite in low Earth orbit. Both the Indian ASAT test and Russia's co-orbital activities may provide further incentive for nations to develop and deploy defensive counterspace capabilities of their own, as France announced it intends to do. Nations may also seek to draw distinctions between offensive and defensive counterspace weapons in order to justify the latter while delegitimizing the former.

As nations reevaluate the threats to their space systems, some have moved to reorganize existing space organizations or create new military organizations to better focus on space as a warfighting domain. France is creating a Space Command within its military and renaming its Air Force the Air and Space Force, while the United Kingdom may not be far behind in reorganizing its space forces. In the coming years, more nations may continue to reorganize and elevate space forces within their militaries both to focus attention internally and to signal externally.

A final area to watch in the coming year is how the United States continues to adapt to face threats in the space domain. The U.S. military is in the midst of what is arguably the most significant reorganization since the Goldwater-Nichols Act of 1986. With the re-establishment of United States Space Command as a geographic combatant command for space and the new establishment of the Space Force as an independent military service for space, many things are in flux within the military space community. While there is great opportunity in this reorganization process, there are many risks as well. A chief concern is that an excessive focus on building bureaucracy (and attempts to limit bureaucracy) could distract senior leaders' attention from the evolving threats to space systems and the U.S. military's efforts to counter these threats. Key developments to watch within the United States are updates to space doctrine, strategy, and policy and investments in new space capabilities and missions. Developments in these areas would be a clear indication that the reorganization efforts put in place in 2019 are part of a fundamental shift in the U.S. military's overall approach to making space more defendable.

ENDNOTES

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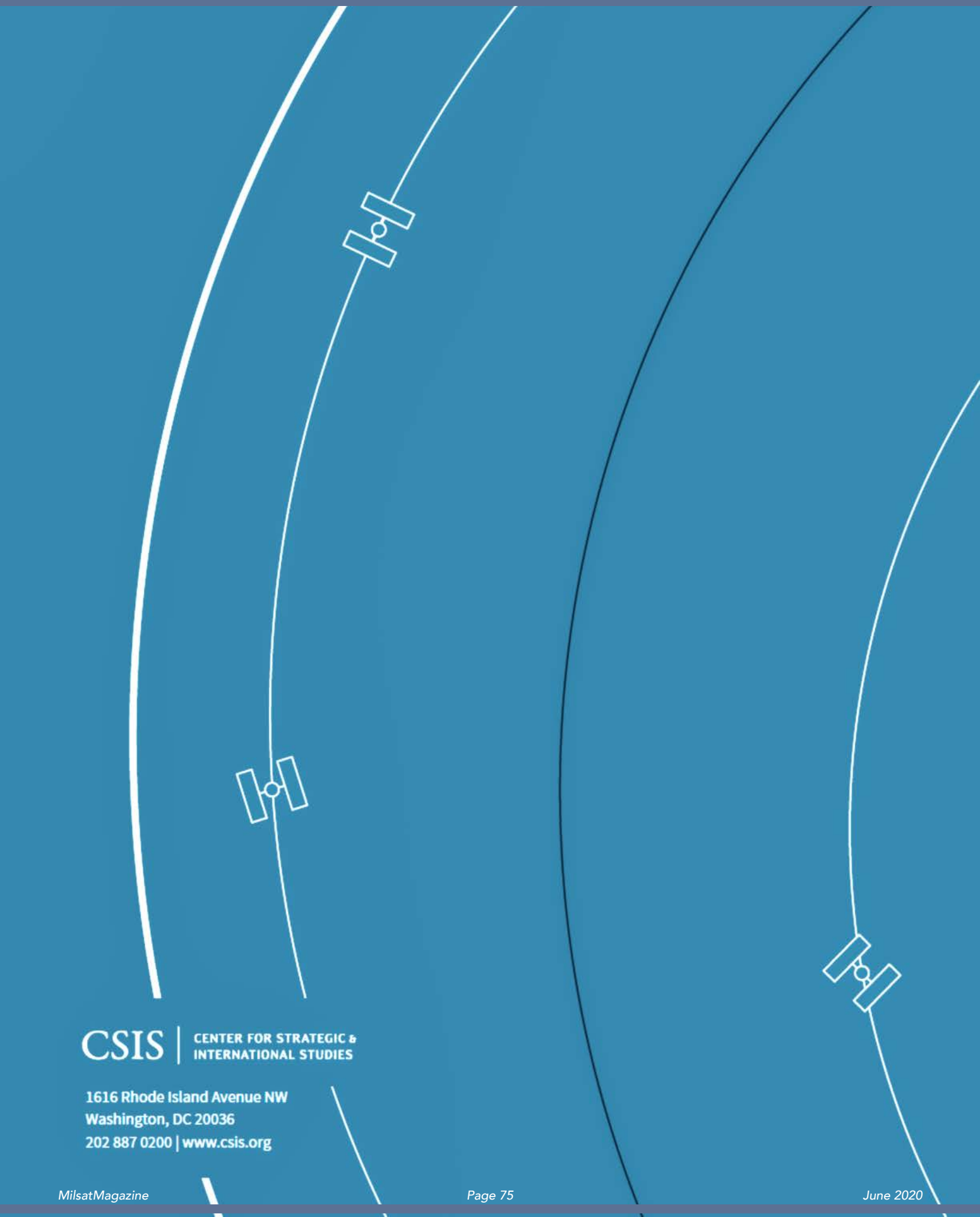

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