

*SATCOM for Net-Centric Warfare*

# ***MilsatMagazine***

**INNOVATION** September 2019



The U.S. Air Force's AEHF-5 satellite lifts off from Cape Canaveral, Florida, via a United Launch Alliance Atlas V 551 rocket. Image is courtesy of the company.

# DISPATCHES

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## United States Space Command is formally established

**President Donald J. Trump, Vice President Mike R. Pence, Secretary of Defense Dr. Mark T. Esper, and U.S. Air Force General John W. "Jay" Raymond formally established the United States Space Command during a ceremony held on August 29 at the White House.**



At the direction of the President of the United States, the Department of Defense (DoD) established U.S. Space Command today as the 11th Unified Combatant Command, with Raymond as its congressionally confirmed commander. Establishing USSPACECOM is a critical step that underscores the importance of the space domain and its strategic contributions to U.S. national security. The USSPACECOM establishment will accelerate the United States' space capabilities to address rapidly evolving threats to U.S. space assets and the importance of deterring potential adversaries from putting critical U.S. space systems at risk.

The president's National Security Strategy and the National Strategy for Space highlight space as a strategic domain, and the United States must earn and maintain space superiority. USSPACECOM's establishment will modernize and enhance our approach to space from a domain of an unchallenged environment to one of a warfighting domain.

The USSPACECOM mission is to deter aggression and conflict, defend U.S. and allied freedom of action, deliver space combat power for the Joint/Combined force, and develop joint warfighters to advance U.S. and allied interests in, from, and through the space domain. The command will be postured to protect and defend, while increasing joint warfighter lethality by executing two primary missions

focused on 1) unifying and leading space capabilities for the Combined Force, and 2) maintaining U.S. and Allied advantages in space through protection and defense.

USSPACECOM is a Geographic Combatant Command with a global Area of Responsibility defined as the area surrounding the earth at altitudes equal to or greater than 100 kilometers above mean (average) sea level. The new command is globally integrated with the other geographic combatant commands and prepared to support its partners to meet today's threat on a global scale.

From establishment to full operational capability, General Raymond will remain dual-hatted as the commander of Air Force Space Command and U.S. Space Command.

General Raymond said that the scope, scale and complexity of today's threat is real and it is concerning. The establishment of a Combatant Command solely focused on the space domain, demonstrates the United States' commitment to protecting and defending its space assets against that threat. He added that space capabilities underpin the security of the U.S., enable the nation's economic prosperity, provide for the nation's way of life, and secures the U.S. way of war. By establishing the United States Space Command, which is singularly focused on that warfighting domain, a very clear message has been sent to the world that the United States and the nation's allies will not assume away space superiority.

[www.spacecom.mil](http://www.spacecom.mil)

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**DISPATCHES** *USAF's AEHF-5 satellite successfully launched by United Launch Alliance*

**The United Launch Alliance Atlas V 551 rocket lifted off at 6:13 a.m. EDT (1013 UTC) on August 8 carrying the fifth Advanced Extremely High Frequency (AEHF-5) communications satellite for the U.S. Air Force Space and Missile Systems Center from Cape Canaveral, Florida.**

United Launch Alliance used an Atlas V 551 rocket to launch the fifth communications satellite in the Lockheed Martin-built Advanced Extremely High Frequency (AEHF) series for the U.S. Air Force Space and Missile Systems Center.

AEHF satellites provide highly-secure, jam-proof connectivity between U.S. national leadership and deployed military forces. Atlas V rockets successfully launched the first four AEHF satellites in 2010, 2012, 2013 and 2018.



*Photo of the United Launch Alliance liftoff of the USAF's AEHF-5 satellite. Image is courtesy of the company.*





The AEHF-5 satellite. Photo is courtesy of Lockheed Martin.

The countdown began on August 7 at 10:54 p.m. EDT under the guidance of ULA Launch Conductor Scott Barney.

The rocket was powered up and underwent standard day-of-launch testing while crews finished configuring the launch pad.

The “go” for fueling was given by ULA Launch Director Lou Mangieri at 3:27 a.m. on August 8.

Tanking operations were successfully performed as 66,000 gallons of liquid oxygen and liquid hydrogen were placed into the rocket’s tanks.

The clear to launch was given at 6:07 a.m. EDT by Air Force Mission Director Colonel Shane Clark.

Following the first stage of flight, the Centaur upper stage performed an initial burn that achieved a parking orbit.

A second burn then injected the rocket and payload into a standard geosynchronous transfer orbit. The cubesat secondary payload was then deployed.

At 1 hour, 40 minutes into the launch Centaur continued to coast away from the Earth. In this stage systems were reported nominal as the rocket performed a slow roll to keep the solar heating evenly distributed on all surfaces.

At two hours into the launch a typical rocket ascends to geosynchronous transfer orbit. This is the standard dropoff point for communications satellites, using just two firings by the upper stage to achieve the highly elliptical orbit

to deploy the payloads. From there, the satellites use their own engines in the subsequent days to fly into the operational locations 22,300 miles above the equator.

The Atlas V is enhancing the AEHF-5 satellite’s trip to space by using all of the vehicle’s performance to deliver the payload with a much higher perigee, or low point of the transfer orbit, and substantially reducing inclination relative to the equator.

Those actions by the launch vehicle will benefit the satellite and conserve its onboard fuel supply by getting AEHF-5 closer to geosynchronous orbit.

ULA and the AEHF program produced this ascent profile to maximize mission flexibility over the satellite’s lifetime.

After 2 hours, 37 minutes Centaur telemetry showed nominal tank pressures, bus and battery voltages, and good body rates in the roll.

The vehicle continues in this quiescent coast away from Earth, heading to a point nearly 22,000 statute miles in altitude before the third and final engine firing is planned.

A further update at 3 hours, 6 minutes indicated that this launch successfully added one more to the total count making this the 251st flight of the Centaur.

This venerable, U.S. upper stage is the high-energy, hydrogen-fueled rocket that has unlocked access to the moon and every planet in the solar system for robotic explorer spacecraft.





The first operational payloads launched by Centaur were Surveyor missions that sent landers to touch the lunar surface.

Mariner missions went to Mars, Venus and Mercury, Pioneer 10 went by Jupiter, and Pioneer 11 visited both Jupiter and Saturn. Vikings 1 and 2 launched to Mars, Voyagers 1 and 2 explored the gas giants in our outer solar system, Cassini orbited Saturn, New Horizons flew by Pluto, and more recently the Mars

Reconnaissance Orbiter, Curiosity rover, MAVEN orbiter and InSight lander all departed Earth for the red planet thanks to Centaur.

The stage has evolved considerably from its early days, becoming more capable, more powerful and more accurate. It has flown on numerous Atlas and Titan rocket configurations.

In addition to planetary exploration, Centaur has served as a linchpin in launching communications, weather



and military satellites to various Earth orbits for decades.

After a five-hour coast away from Earth to reach apogee, or the high point of the orbit, the Centaur performed a third and final burn to benefit AEHF-5 significantly by raising perigee, or the low point of the orbit, and reduced inclination relative to the equator. It is advantageous for the satellite to use the remaining performance of Centaur to put AEHF-5 closer to its final orbit as is possible.

The U.S. Air Force's 4th Space Operations Squadron at Schriever Air Force Base is now "talking" with the fifth Advanced Extremely High Frequency (AEHF-5) protected communication satellite after this successful launch.

Additionally, the Lockheed Martin-built AEHF-5 satellite is now responding to the squadron's commands, as planned.

The squadron began "flying" the satellite shortly after it separated from its United Launch Alliance Atlas V 551 rocket, approximately 5 hours and 40 minutes after the rocket's successful 6:13 a.m. ET liftoff.

AEHF-5 completed a geostationary ring of five satellites delivering global coverage for survivable, highly secure and protected communications for strategic command and tactical warfighters operating on ground, sea and air platforms.

In addition to U.S. forces, AEHF also serves international partners including Canada, the Netherlands and the United Kingdom.

AEHF-5, with its advanced Extended Data Rate (XDR) waveform technology, adds to the constellation's high-bandwidth network. One AEHF satellite provides greater total capacity than the entire legacy five-satellite Milstar communications constellation.

Lockheed Martin designed, processed and manufactured all five on-orbit AEHF satellites at its advanced satellite manufacturing facility in Sunnyvale, California. The next AEHF satellite, AEHF-6, is currently in full production in

Silicon Valley and is expected to launch in 2020.



The AEHF team includes the U.S. Air Force Military Satellite Communications Systems Directorate at the Space and Missile Systems Center, Los Angeles Air Force Base, California. Lockheed Martin Space, Sunnyvale, California, is the AEHF prime contractor, space and ground segments provider as well as system integrator, with Northrop Grumman Aerospace Systems, Redondo Beach, California, as the payload provider.

Mike Cacheiro, VP for Protected Communications at Lockheed Martin Space, said this fifth satellite adds an additional layer of flexibility for critical strategic and tactical protected communications serving the warfighter. This added resilience to the existing constellation will help ensure warfighters can connect globally to communicate and transmit data at all times.

He added that in the weeks ahead, AEHF-5 will move toward its operational orbit, deploy all of its solar arrays and antennas, and turn on its powerful communications payload for a rigorous testing phase prior to hand over to the U.S. Air Force. Cacheiro added that individual data rates increase five-fold compared to Milstar, permitting transmission of tactical military communications, such as real-time video, battlefield maps and targeting data.

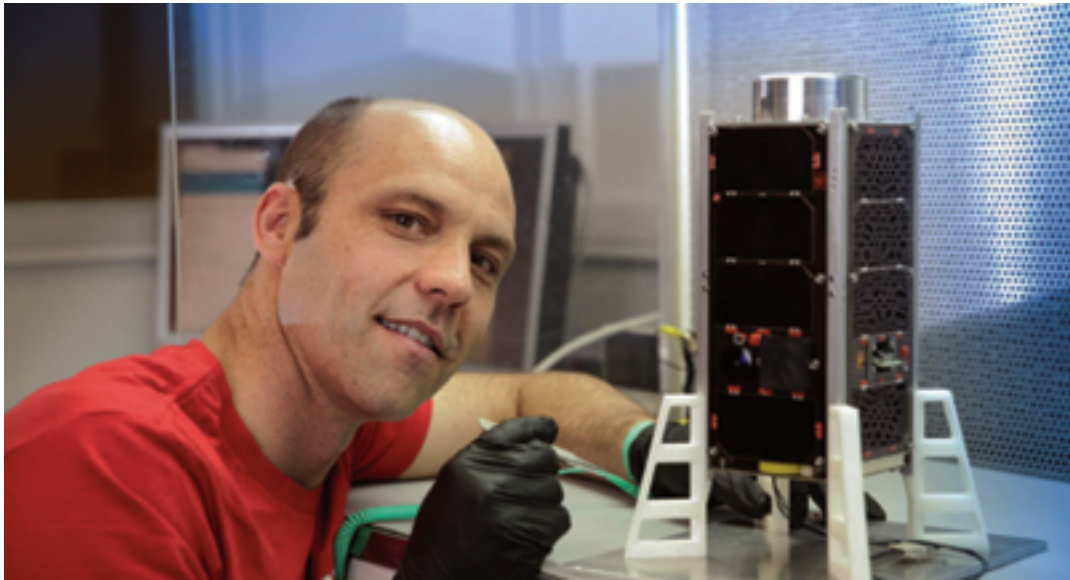
Cacheiro concluded by stating AEHF affords national leaders anti-jam, always-on connectivity during all levels of conflict and enables both strategic and tactical users to communicate globally across a high-speed network that delivers protected communications in any environment.

[www.ulalaunch.com](http://www.ulalaunch.com)

[www.lockheedmartin.com](http://www.lockheedmartin.com)



## DISPATCHES: South Australian SMEs win defense industry contracts



Dr. Matthew Tetlow of Inovor Technologies, based at Lot 14 in Adelaide, South Australia.

### Defense industry SMEs from South Australia have won more than \$8 million in contracts to provide the Australian Defence Force with a capability edge.

Of the 15 contracts valued at more than \$28 million awarded to Australian small businesses developing cutting-edge defense technologies, four are based in South Australia.

Australian Minister for Defence Industry *Melissa Price* said this tranche of investments from the Defence Innovation Hub included initial concept exploration and technology demonstration, through to prototyping and integrated capability demonstration and evaluation.

The South Australian companies are Inovor Technologies, Solinnov and Consunet, while QinetiQ, an international company with offices in Adelaide, was awarded \$280,000 to develop an alternative electrical power micro-grid solution for deployed forces.

Inovor Technologies was awarded a \$5.7 million contract to deliver a prototype smallsat to enhance space situational awareness (SSA), which is aimed at growing Australia's space capability and could contribute to the global space surveillance network.

Inovor designs and integrates smallsats, including their own InoSat nanosatellite, a turnkey surveillance pod to protect satellites from space junk.

The InoSat is a less expensive alternative to directing space traffic and can also be used to study climate change, natural disasters and general agriculture on Earth.

In April of this year, Inovor won a \$272,000 Defence Innovation Hub grant to prove the company's algorithm can stabilize control systems to keep satellites fixed on specific positions.

*"The stabilizing technology enables very fine pointing with as little jitter as possible, focusing on stars for long periods of time,"* Inovor CEO Dr. Tetlow said.

Electronics engineering company Solinnov was awarded \$2.3 million to develop a software defined radio (SDR) system with applications across electronic warfare, communications and sensing domains.

The Australian Defence Force is interested in the technology because of its potential to replace multiple pieces of equipment with a single, lightweight, portable solution.

Solinnov, established in 2010, is based in the in Mawson Lakes Technology Park, north of Adelaide, as well as are many other defense industry companies.

IT company Consunet, based in the Adelaide suburb of Thebarton, was given \$180,000 to develop a software capability to enable

electromagnetic battle management that integrates existing technologies.

*"Each time the Defence Innovation Hub invests in a local company, it supports local jobs and gives Australian companies the opportunity to develop world-class capabilities,"* Minister Price said.

Then there's a device that could soon have Australian farmers looking to the stars, rather than the skies for their weather information following the development of a rain gauge that uses a satellite network to transmit remote rainfall data.

South Australian satellite communications company Myriota and Queensland AgTech business Goanna Ag have partnered to develop the 'everywhere' solution that they say will unlock the power of remote monitoring at a price and scale never seen before.

Myriota's direct-to-orbit satellite network for the Internet of Things (IoT) means data from the devices can be transmitted in remote areas without internet or mobile phone coverage.

Article by *Jim Plouffe*, *The Lead* ([theleadsouthaustralia.com.au/](http://theleadsouthaustralia.com.au/))

[www.inovor.com.au](http://www.inovor.com.au)

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[myriota.com](http://myriota.com)

[www.goannaag.com.au](http://www.goannaag.com.au)



This Goanna Ag rain gauge will use Myriota's direct-to-orbit satellite network to share data with its owner. Photo: Julian Simon Nguyen.



## DISPATCHES: Kleos Space gains USAF SBIR Phase 1 contract



Artistic rendition of a Kleos Space Scouting Mission smallsat.

**Kleos Space S.A. (ASX: KSS, Frankfurt: KS1) has been awarded a United States Air Force Small Business Innovation Research (SBIR) Phase 1 contract with a focus on "Innovative Defense-Related Dual-Purpose Technologies/ Solutions with a Clear Air Force Stakeholder Need."**

The Small Business Innovation Research (SBIR) program is a highly competitive program that encourages small businesses to engage in U.S. Federal Research/ Research and Development (R/R&D) that has the potential for commercialization.

The special U.S. Air Force (USAF) SBIR topics, developed in partnership with the Air Force Research Laboratory, National

Security Innovation Network and AFWERX, are experiments to increase the efficiency, effectiveness, and transition rate of the SBIR program.

Through a competitive awards-based program, SBIR enables small businesses to explore technological potential and provides the incentive to profit from commercialization.

Kleos was successful in its presentation of the Kleos' Scouting Mission under AF192-001 and is participating in Phase I of the program.

Phase 1 is to be completed by October 23, 2019, with delivery of a report including technical feasibility, financial sustainability and meeting defense needs serving as a gateway to a Phase 2.

The multi-satellite Scouting Mission system will form the foundation of a constellation that delivers a global picture of hidden maritime activity, enhancing the intelligence capability of government and commercial entities when AIS (Automatic Identification System) is defeated, imagery is unclear, or targets are out of patrol range.

Kleos' Head of U.S. Strategy, **Karyn Hayes-Ryan**, said that participation by Kleos in the SBIR program is a welcomed opportunity for the company to provide access to numerous Department of Defense entities.

The first scouting mission is made up of 4x smallsats built by GomSpace in Denmark.

[www.kleosglobal.com](http://www.kleosglobal.com)

[gomspace.com](http://gomspace.com)

## DISPATCHES: C-COM debuts their latest, auto-pointing antenna



C-COM's iNetVu@ MP-80-MOT

**During the recent IBC2019 event in Amsterdam, many companies shared their latest and greatest — among those presenting their newest technologies was C-COM and the firm's new, auto-pointing antenna and steerable phased array antenna.**

Highlighting the latest in C-COM design is the iNetVu@ MP-80-MOT, a fully motorized, auto-acquire, 80 cm. carbon fiber one-case backpack antenna.

This sturdy and lightweight system will point to any programmed satellite with just the push of a button on the NEW iNetVu@ 8020 Controller.

Highly portable, the multi-segment manpack can be easily hand-carried by one person and assembled in less than 10 minutes without tools.

Also presented at the show was the company's iNetVu@ Ka-75V Driveaway, the 75cm, auto-deploy, vehicle-mounted antenna, authorized for use on ViaSat Exede@ Enterprise, and on KA-SAT NEWSSPOTTER NEWSGATHERING service by Eutelsat.

The system is fully motorized and configured with the iNetVu@ 7024 Controller to provide fast satellite acquisition within minutes, anytime anywhere.



C-COM's iNetVu@ Ka-75V Driveaway.

The iNetVu@ FLY-981 Flyaway was also on display at the C-COM booth. Paired with the iNetVu@7710 Controller, the fully automatic and transportable 98cm Ku-band flyaway antenna system comes in three robust cases and can be field converted to Ka-band.

[www.c-comsat.com](http://www.c-comsat.com)

## **DISPATCHES:** *Viasat completes NATO SATCOM control stations upgrades*

### **Viasat Inc. (NASDAQ: VSAT has successfully upgraded the North Atlantic Treaty Organization's (NATO) Ultra High Frequency (UHF) satellite communications (SATCOM) control stations to comply with the new Integrated Waveform (IW) baseline.**

Using Viasat's Visual Integrated Satellite communications Information, Operation and Networking (VISION) software platform, NATO gains greater communications interoperability, scalability and flexibility across legacy and next-generation platforms, which it expects will significantly enhance warfighters' situational awareness and operational insights on the battlespace.

Viasat's VISION platform is the first commercially-available software package to simultaneously support all 25-kHz legacy Demand-Assigned Multiple-Access (DAMA) and next-generation IW networks and services. The VISION platform has enabled the following benefits for NATO:

- *Faster communications: VISION reduced time to access software from 90 seconds to 4 seconds*
- *Better reliability: VISION offered greater reliability when compared to previous waveforms*
- *Improved functionality: VISION doubled NATO's channel efficiency*
- *Enhanced bandwidth: VISION gave network operators real-time capabilities to reconfigure UHF satellite networks to meet new mission profiles on-the-fly.*

The Viasat VISION platform (select this direct link to view an informative video) provides a single, user-friendly network management interface for legacy DAMA and IW services, inclusive of the ability to locally or remotely manage and control ground station networks, monitor status and system performance, track event/alarm management situations and add/remove services when missions

change. By enabling interoperability between DAMA and IW platforms, NATO can double its channel efficiency without additional investment in the UHF space segment. This optimization doubles the number of users, giving more warfighters access to reliable, high-quality, resilient voice and data communications.

*Ken Peterman*, President, Government Systems, Viasat, added that this NATO upgrade was fielded on time and under budget — further demonstrating the value of Viasat's agile business models and deep customer knowledge.

Peterman added that by working closely to understand NATO's most urgent needs, Viasat was able to

deliver a cost-effective, scalable and interoperable technology capability needed to support emerging mission demands and help NATO warfighters maintain communications at the tactical edge.

[www.viasat.com](http://www.viasat.com)

[www.nato.int](http://www.nato.int)

**DISPATCHES:** *Get SAT and GRC forge a strategic, cooperation relationship*



**A collaboration of talents has been finalized between Get SAT, a developer of small, lightweight satellite communication terminals for airborne, ground, and maritime applications, and GRC (Global RadioData Communication Ltd.), who specialize in the design and development of mission critical communication and situational awareness systems.**

The companies have created a strategic relationship that will target U.K. security, defense and government markets with Communications-On-The-Move (CoTM) broadband platforms based on Get SAT's terminals.

The companies participated in the DSRI (Defence & Security Equipment International) in London and ushered in a new era of CoTM, powered by direct, high bandwidth, real-time video, audio and data communication.

*Iain Pope*, GRC Chairman, reported that their customers have been consistently impressed by Get SAT terminals and their ability to deliver high-bandwidth communication on-the-move, with relatively low size, weight and power demands.

Pope noted that this has allowed GRC to offer solutions that would previously have proved impossible due to unique vehicle requirements and even lead to them developing their own magnetic mount, for easy walk on fit, allowing terminals to be installed and removed within

minutes. The high-level of terminal efficiency also means they're able to offer their customers great value, effectively delivering more 'bandwidth for your buck' than they're able to offer with other terminals.

*Kfir Benjamin*, CEO of Get SAT, stated that uniting Get SAT's CoTM systems with GRC's mission critical solutions provide the ultimate, flexible and seamless on-the-move answers for a wide range of applications required by U.K. clients such as search and rescue, military and other security assignments. With Get SAT systems already deployed in various missions around the world, we look forward to growth in the U.K.

[www.getsat.com](http://www.getsat.com)

[grcltd.net](http://grcltd.net)



## DISPATCHES: *USSPACOM Commands*

**U.S. Space Command  
Commander General John W.  
"Jay" Raymond, in his first  
official directives, established  
two subordinate commands  
that will jointly provide  
support to the new Unified  
Combatant Command.**



*General John W.  
"Jay" Raymond.*

Combined Force Space Component Command and Joint Task Force Space Defense will focus the planning and execution of global space operations, activities and missions into two areas:

- *Protection and defense from threats to U.S. space capabilities/forces*
- *Maintaining and growing our national security space programs, combat-relevant space capabilities, and space cadre talent to increase warfighter lethality*

General Raymond said that to ensure USSPACECOM can conduct its mission decisively, he is establishing two subordinate commands with distinct and defined mission areas to ensure the command is postured to protect and defend, while also increasing joint warfighter lethality and strengthening partnerships.

The establishment of the Department of Defense's 11th COCOM dedicated to space operations reflects the value of space contributions to national security, the evolution of the threats to U.S. space systems, and the importance of deterring potential adversaries from challenging or attacking U.S. space systems. These subordinate commands will have a direct impact on that mission.

The JTF-SD will be commanded by Brigadier General Thomas L. James, with a mission to conduct space superiority operations in unified action with mission partners to deter aggression, defend space capability, and when directed, defeat adversaries throughout the continuum of conflict. The JTF-SD will execute its protect and defend mission through various operations centers, including National Space Defense Center at Schriever Air Force Base, Colorado; Space Situational Awareness Units; and Emerging Space Defense Units.

The CFSCC will be commanded by Major General Stephen Whiting with a mission to plan, integrate, conduct, and assess global space operations in order to deliver combat relevant space capabilities to Combatant Commanders, Coalition partners, the Joint Force, and the Nation. CFSCC plans and executes space operations through four distinct and geographically dispersed operations centers, including: Combined Space Operations Center at Vandenberg AFB, California; Missile Warning Center at Cheyenne Mountain Air Force Station, Colorado; Joint Overhead Persistent Infrared Center at Buckley AFB, Colorado; and Joint Navigation Warfare Center located at Kirtland AFB, New Mexico. Additionally, CFSCC executes tactical control over a number of Air Force, Army, and Navy space units.

General Raymond added that over the past decade, the great power competitors have developed technologies that threaten this nation's critical national assets in space. The U.S. has no desire to see a conflict in space and the nation is working hard to ensure no country believes they can gain a terrestrial advantage by extending a conflict to space. It's important to understand that, like all nations, the U.S. has the inherent right of self-defense, so purposeful interference with space assets vital to U.S. national security will be met by leveraging the nation's multi-domain capabilities across air, land, sea, cyber and space, and all instruments of national power.



*A Delta IV carrying the GPS III SV2 satellite lifts off from Cape Canaveral Air Force Station's SLC-37, August 22. Photo is courtesy of ULA — photo by Jeff Spotts)*

**The U.S. Air Force and its mission partners successfully launched the second Global Positioning Systems (GPS) III satellite at 9:06 a.m. EDT, August 22 from Space Launch Complex-37 at Cape Canaveral Air Force Station, Florida.**

The Lockheed Martin-built satellite, known as "Magellan" (in honor of Ferdinand Magellan, the Portuguese navigator who led the first expedition to circumnavigate the globe), was carried to orbit aboard a United Launch Alliance Delta IV (4,2) launch vehicle, the final flight for the Delta IV medium launch vehicle.

The USAF Space and Missile Systems Center (SMC) was responsible for Magellan's rigorous Mission Assurance certifications and testing leading to full launch- and mission-readiness. SMC also conducted a rigorous source selection to

ensure the ULA Delta IV rocket met all mission requirements, which included examining every single piece of hardware that built the rocket. This due diligence enabled the satellite to be reliably placed on orbit to meet civilian and warfighter communications needs.

*"A successful launch such as this is always a proud moment for the team and its many members. I can't reiterate how important this second GPS III launch is as we progress toward a modernized fleet and maintain U.S. superiority in space,"* said Lt. Gen. **John F. Thompson**, SMC commander and Air Force program executive officer for Space.

*"The launch of Magellan epitomizes the constant collaborative efforts which exemplify the continual improvements our teams at SMC are making in getting these satellites built and launched at EPIC*

*Speed. With a third GPS launch planned for the end of the year, we continue to provide the "Gold Standard" in positioning, navigation and timing services for our military and for the world."*

GPS III's Magellan separated from its upper stage approximately 1 hour and 56 minutes after launch. Engineers and operators at Lockheed Martin's Waterton facility started on-orbit checkout and tests, which are estimated to be completed within one month. Operational use is expected to start within a year

*"This launch was 7 months in the making. As soon as we launched Vespucci last December, the team got to work on the SV02 campaign to get Magellan into orbit,"* stated said Col. **Edward Byrne**, Medium Earth Orbit (MEO) Spacecraft Production Division chief. *"This isn't*



*the end of our job with Magellan. We now have to carry out on-orbit checkouts, in parallel with preparations to launch SV03; not to mention the continual production effort of SV04. That is why the Production Corps space vehicles division is known as the 'A-Team'."*

Magellan will join the current GPS constellation comprised of 31 operational spacecraft, and will be the 21st M-Code-capable satellite added to the fleet. GPS satellites operate in MEO at an altitude of approximately 20,200 km (12,550 miles) in six planes.

Each satellite circles the Earth twice per day, providing the "Gold Standard" of position, navigation and timing services for billions of users worldwide. GPS III, the newest generation of GPS satellites, brings new capabilities to users, including three times greater accuracy and up to eight times improved anti-jamming capabilities.

*"Having launched a GPS III satellite in December 2018 aboard a Falcon 9 and now today on a Delta IV, the team demonstrated again their commitment and capability to achieve 100 percent mission success,"* said Col. **Robert Bongiovi**, Launch Enterprise director.

SMC's Production Corps, located at Los Angeles Air Force Base in El Segundo, California, leads the GPS III Magellan team. SMC's Launch Enterprise led the launch, which took place at Cape Canaveral Air Force Station.

Lockheed Martin Space Systems Corporation is the prime satellite vehicle contractor. Air Force Space Command's 50th Space Wing and 2nd Space Operations Squadron operate the GPS constellation from Schriever Air Force Base, Colorado.

SMC is the U.S. Air Force's Center of Acquisition Excellence for acquiring and developing military space systems. Its portfolio includes GPS, military satellite communications, defense meteorological satellites, space launch and range systems, satellite control networks, space-based infrared systems and space situational awareness capabilities.



This second successful GPS III launch is an exemplary case of SMC's ongoing transition to the

"SMC 2.0" initiatives, as even more satellites await their ride to orbit.

The U.S. is entering a new era with space as a Warfighting domain, and SMC is leading the way with more significant U.S. acquisition agility initiatives that will birth innovation within the space enterprise and speed the delivery of crucial new capabilities to Warfighters.

SMC 2.0 encompasses the collaborative nature of the space enterprise and embraces the agility of production driving forward.

Another launch of GPS III is planned for later this year.

# STATE OF THE SPACE INDUSTRIAL BASE:

## Threats, Challenges and Actions A Whitepaper Executive Summary

By Dr. Thomas Cooley, Air Force Research Laboratory  
Colonel Eric Felt, Air Force Research Laboratory  
Colonel Steven J. Butow, Defense Innovation Unit

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**The Air Force Research Laboratory's mission is leading the discovery, development, and integration of warfighting technologies for our air, space and cyberspace forces.**

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With its headquarters at Kirtland Air Force Base, New Mexico, the Space Vehicles Directorate serves as the U.S. Air Force's "Center of Excellence" for space research and development.

The Directorate develops and transitions space technologies for more effective, more affordable warfighter missions. The Defense Innovation Unit's mission is to accelerate commercial innovation for national security. It does so by increasing the adoption of commercial technology throughout the military and growing the national security innovation base.

DIU's Space Portfolio facilitates Department of Defense (DoD) partners' ability to access and leverage the growing commercial investment in

**"The United States of America has no intention of finishing second in space. This effort is expensive — but it pays its way for freedom and for America."**  
**President John. F. Kennedy**



*Illustration depicting Spaceflight Industries' successful deployment of 64 satellites on its SSO-A dedicated rideshare mission which launched to LEO on December 3, 2018. Illustration is courtesy of Spaceflight Industries.*

new space to address existing capability gaps, improve decision making, enable a shared common operating picture with allies, and help preserve the United States' superiority in space.

This white paper executive summary is to draw attention to a call to action to address present and emerging challenges and threats to the U.S. space industrial base and space dominance. The full paper summarizes the discussions, conclusions and recommendations from a meeting on March 11 and 12, 2019, of interested parties and experts gathered from across government, academia and industry sponsored by the **Air Force Research Laboratory** (AFRL) and the **Defense Innovation Unit** (DIU).

The meeting was motivated by the recognition that in an ever more global and interconnected world, commercial, civil and national defense space capabilities are increasingly vital to national power.

To preserve and expand that power requires a coordinated national space strategy and a vibrant, competitive and agile U.S. space industrial base to execute that strategy.

The objectives of this meeting were to examine

- *The increasing contribution of space to national economic, political and military power...*
- *The U.S. space industrial base required to ensure and expand that power*
- *Current and emerging challenges and threats to the space industrial base*
- *Potential strategies to address those challenges and threats.*

We define the 'U.S. space industrial base' as the private-sector, industry-suppliers of technology, hardware, software, systems, data and financial and insurance capacities that grow the space economy to serve our nation's civilian, civil and national security interests.

The U.S. space industrial base is presently a relatively small, nascent part of the national and global economy. As such, it remains particularly vulnerable to, and the government must protect it from, manipulation, distortion, penetration and domination by our adversaries, allies and neutral countries.

While the U.S. has long played a dominant role in space and continues to make significant space investments across civil, military and commercial space, the overall domestic effort is insufficiently integrated, focused and leveraged to address the challenges and threats to our Nation's dominant position.

Creating and maintaining the required space industrial base faces external and internal threats and challenges. Externally, our present and potential adversaries and rivals recognize the growing importance of assured space capabilities. For this reason, they have developed and are executing comprehensive national space strategies aimed at actively competing with, complementing, and, in certain respects, displacing, the United States as 'the 'or 'one of the' dominant space powers.

While this increased international attention poses significant, overarching challenges, China's approach in terms of means, methods and effects presents particular threats to the U.S. space industrial base. We are here to underscore the urgency with which all of us must focus our actions to maintain our technological and military dominance.

The breadth and depth of Chinese malfeasance with regard not only to our technology, but also to our larger economy and our nation is significant and intentional.<sup>1</sup>

The key threatening elements of the Chinese strategy include

- *Theft of intellectual property combined with a concerted and effective drive to create organic, national expertise across key space science and technology areas*
- *Direct integration of state-owned corporations and their technologies with commercial, space startup-companies*
- *Penetration of American companies to obtain and further exploit U.S. technology or to influence those companies in a direction that serves China's domestic space priorities*
- *Investment in the U.S. space industrial base via front companies and multi-level off-shore accounts to facilitate early venture technology surveillance, infrastructure access and control of developing space capabilities and intellectual property*
- *Obtaining vertical control of the key space capabilities 'supply chains or control of sufficient elements of those supply chains so as to influence space capabilities development in their favor*
- *Predatory pricing of space capabilities or elements of key space supply chains to control or dominate the market*
- *Use of state-sponsored venture capital, finance and market control mechanisms to surveil U.S. technology, interdependencies, business model innovations and other advanced concepts.*

Chinese industrial policies of economic aggression, such as investment-driven technology transfer and illegal intellectual property theft, pose a multifaceted threat to our entire national security innovation base.<sup>2</sup>

Internally, the challenge is developing an industrial base that outpaces our inter-national adversaries and competitors in speed and innovation in developing new space capabilities and in continually upgrading existing ones. This requires

Upgrade of our own methodologies such as shared, trusted supply chains and interoperable technology standards that accelerate viable commercialization of the space economy

The development of more flexible, U.S.-led markets for space capabilities that spread the risk, increase the pool of investors and establishes our Nation's leadership role in setting the inter

Changes in U.S. government procurement and licensing processes and other regulations to eliminate unnecessary delays and micromanagement of the space industrial base's ability to deliver next generation space capabilities and to enable early U.S. investment in emerging capabilities.

For the United States to be a dominant force in the future space economy during peacetime and to monitor and engage decisively in space when national security is threatened, we require a unified and comprehensive national strategy that builds and continually refreshes a strong space industrial base.

The group recommends urgent attention to the development of this strategy as detailed in the Conclusions and Recommendations section of the entire white paper, which is accessible **at this direct infolink:**

## References

<sup>1</sup>Testimony of USD(R&E) Mike Griffin to House Armed Services Committee's Military Personnel Subcommittee (June 2018). *State of the Space Industrial Base: Threats, Challenges & Actions* AFRL-DIU | May 20193

<sup>2</sup>Testimony of DASD Eric Chewning to House Armed Services Committee's Military Personnel Subcommittee (June 2018).

# BRIEFING: **NOW SPACE**

## **Normalizing, Optimizing and Winning in the space domain**

By David J. Buck, Lieutenant General, USAF (Ret.), former Commander, 14th Air Force, Air Force Space Command, Joint Functional Component Command for Space — U.S. President and CEO, Buck Consulting Group

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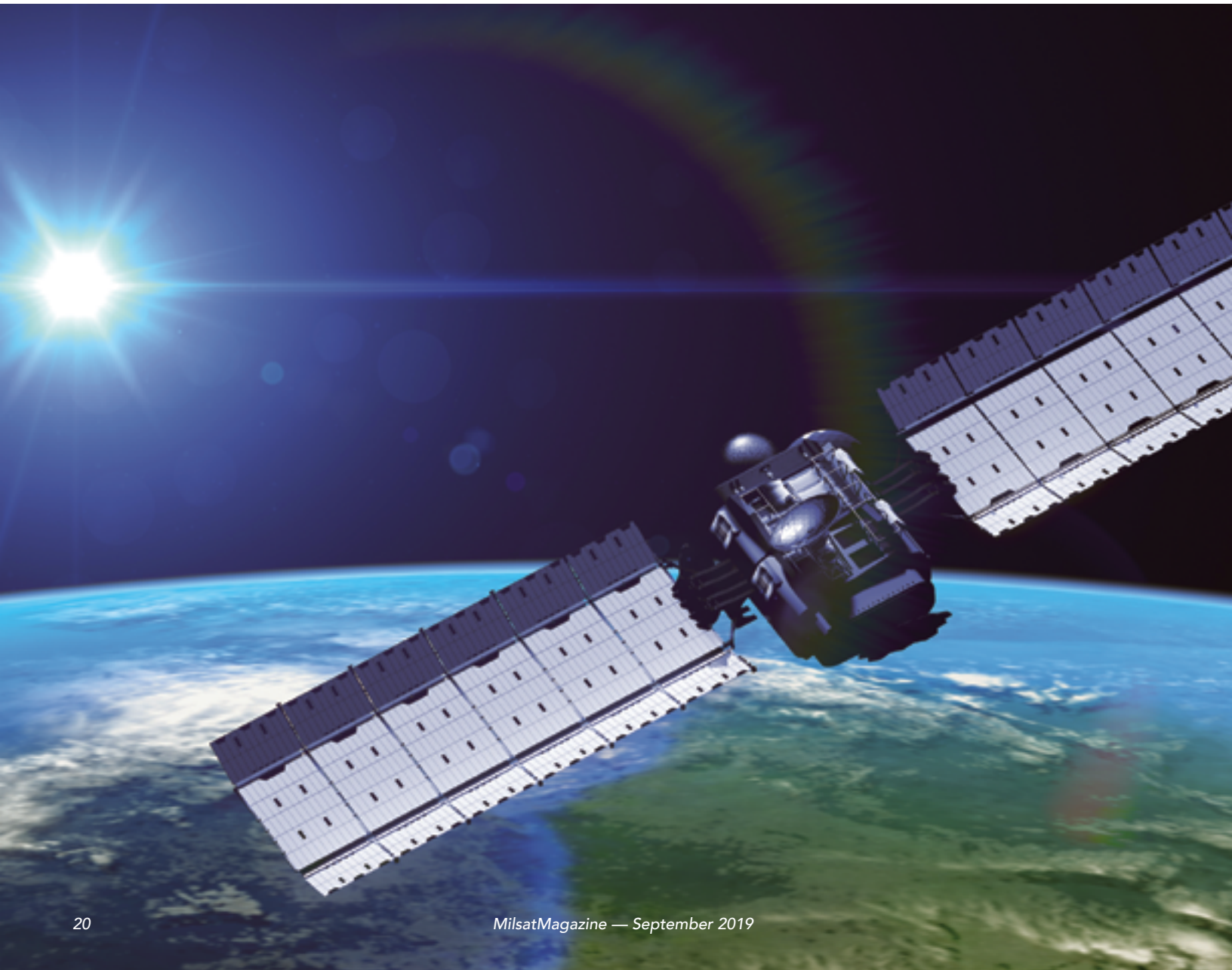
**Before I launch into this article, I want to recognize those leaders in the Department of Defense (DoD), Civil and Commercial sectors who are leading the charge to normalize and optimize the space domain.**

*Kudos especially to the Commercial sector because commercial space has morphed into a powerful force and willing ally for both the National Security and the scientific community.*

*It's heartening to see government agencies and commercial companies driving the space industry forward today. The space industry is on the cusp of great progress with respect to growth, exploitation and partnerships in the space domain to the extent we have not experienced in decades.*



That's a big statement and there is reason to be cautious. In the early 1990s, industry analysts projected massive growth in the space industry.





Many analysts, including the Commercial Space Transportation Advisory Committee, predicted an era where large rockets would launch 20 to 30 times a year with profit-generating satellites for telecommunication companies. The fervor drove the government and many companies to invest in infrastructure, equipment and capabilities that were either never used or underutilized.

What's different this time? I'm more optimistic about substantial growth in the commercial space sector because over the past two decades we acknowledged and educated the American public that space is no longer exclusively linked to science or the DoD.

We had to change this mindset before there was a business case for commercial entities because space did not relate (in their minds) to the everyday needs of John Q. Public. Today, we have business and political leaders who are not afraid to take risks in space to benefit the public good. We have disruptive technologies, innovative satellite buses, and lower cost launch access capable of bringing logistics and business to space.

### **Assuming Risk and Partnering**

Failure *is* an option. We go faster when leadership, both in government and industry, embrace a culture of risk tolerance. Don't get me wrong, we shouldn't celebrate failure; however, incremental setbacks oftentimes lead to monumental success. We can learn and advance from failure.

For the DoD, partnering with commercial companies is not only smart, it's a must-do in order to move fast with cost-efficient and cutting-edge capabilities. The new sound bite across both commercial and DoD sectors is that space can be cheaper, faster and better.

In space, GEO used to be the coveted piece of real estate. Now, LEO is the new GEO. We have the commercial world to thank for that as small satellites (smallsats) are big business.

We are witnessing a movement toward resiliency and augmentation through swarms of small, micro, or nano satellites that are less expensive, easier to launch, simpler to update and harder to defeat.

These platforms are no longer simply demonstrators on orbit. As a result, LEO is now very lucrative for the DoD and commercial alike. It's not a stretch to say that we are on the cusp of a LEO space race. For all the following reasons:

- *Cost to orbit is down through:*
  - ◊ *Multi-mission manifesting*
  - ◊ *Dedicated small launch vehicles becoming operational*
  - ◊ *Large launch vehicles competing for business*
- *New spaceports with geographic diversity are coming online*
- *LEO brings resiliency through orbital speed, numbers and size*
- *Greater persistence through:*
  - ◊ *Redundancy*
  - ◊ *Reduced latency*
  - ◊ *Ease of replenishment*
  - ◊ *Ease of tech refresh*

## Technology Enables Growth

Nearly all great endeavors start with government funding... crossing continents, exploring new lands, sending humans to the moon, developing the internet, etc. At some point, financial profit is viable and private companies capitalize from new-found resources, technology or human expense.

That's where we are today with space. Private companies and startups are bringing innovative ways to drive down the cost of space access. New technologies such as additive manufacturing, augmented reality, machine learning and digital twins are rapidly advancing industries and none faster than in the space industry. Space is a domain where human-to-machine, machine-to-machine and artificial intelligence (AI) should be the norm not the exception.

Whoever masters AI will move to the next plateau in dominance, decision making and influence. Today, and in the future, strategists must understand competitors will leverage AI and machine learning capabilities. In conflict or competition, the winning side will be the one with the most secure, networked and autonomous systems capitalizing on machine learning applications. LEO satellite networks will be the key to leveraging AI.

## Logistics in Space

Logistics are foundational to all operations — civilian and military alike. *"Beans, Bullets, and Bandages"* must be forward deployed to support the operation and provide the right equipment at the right time. In today's space environment, the focus is on rapid launch and constellation replenishment either with long planning intervals or only after an event (e.g., failure) has occurred.

Rarely discussed are logistics requirements associated with the space domain. To normalize, optimize and win space, this must change. Logistics prepares the domain, first in and last out, in the air, land and sea domains; however, this fundamental tenet is not mature yet in the space domain.

We wouldn't think of conducting an operation in any other domain without prepositioning assets for sustainment, replenishment or refurbishment. We need the same mentality and capability in space.

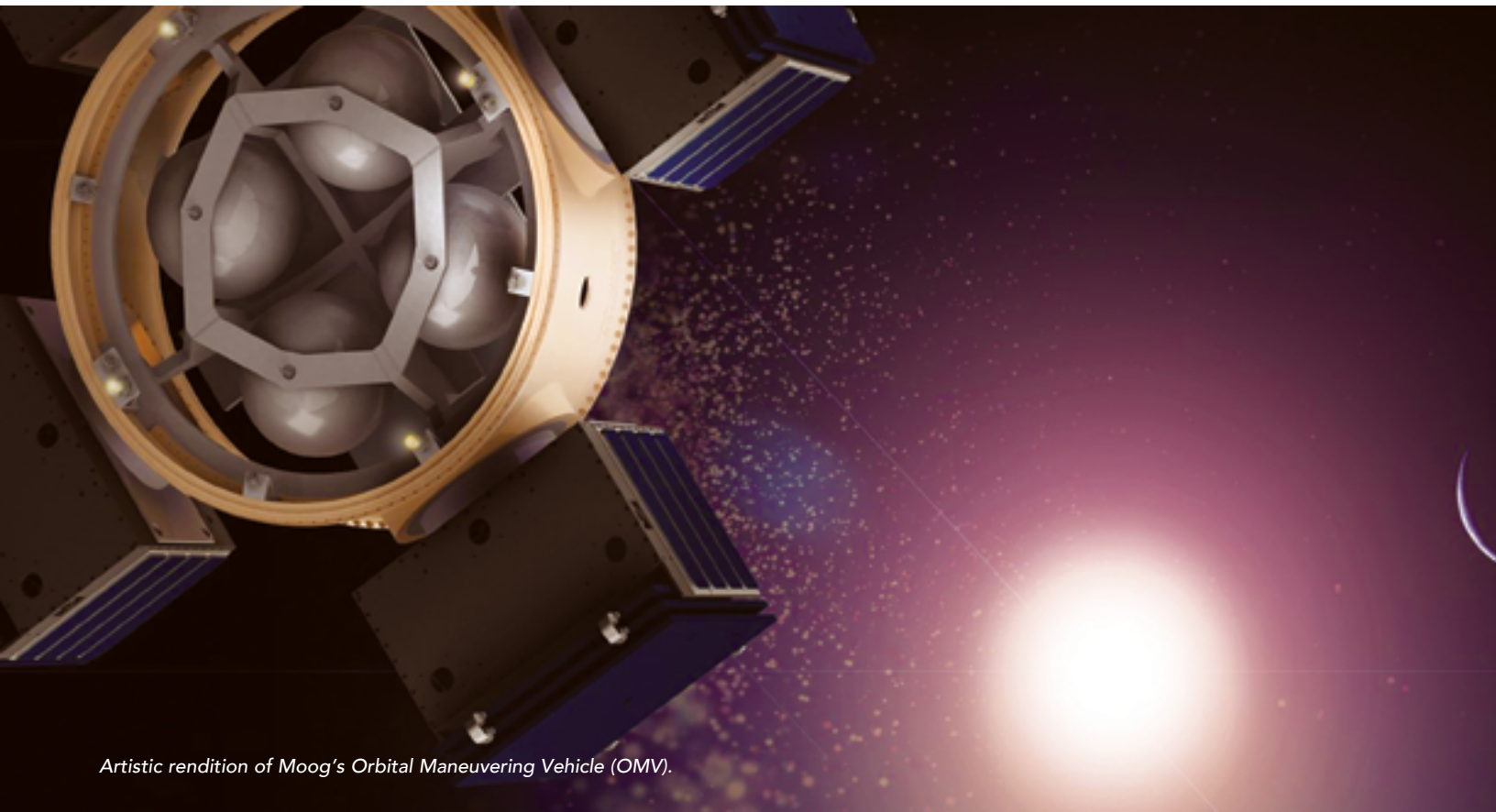
Many new agencies and startups are focusing on smaller satellites ranging from 50 to 500 kg. With new technology and better subsystem components, the push for low cost, high production satellites is the new norm, especially satellite busses with open architectures. This allows multiple payloads to leverage commercial capabilities quickly and use known bus capabilities with sufficient power, standardized payload

mounting areas and easy application of telemetry, tracking and command (TT&C) through flexible ground stations.

Given my heritage as an operator and space normalization proponent, I'm enamored with Moog's Orbital Maneuvering Vehicle (OMV) family of spacecraft and would place its revolutionizing capabilities as one of the top game changers of this decade. The OMV can serve as a "third stage" kick motor or operate as a fully capable long-duration satellite bus, a mother ship, etcetera... the space applications are nearly limitless.

In my book, nothing to date is as flexible or adaptable for launch. Once in space, the OMV has stunning on-orbit flexibility and performance that places it at the top of my list. Prior to launch, it is positioned in the load path of the rocket directly beneath the primary payload at nominal cost because the rocket is already carrying the primary payload. It is highly secure because it is integrated in a Payload Processing Facility and the payload fairing encapsulates both the primary spacecraft and the OMV, down to the Payload Attach Fitting.

Once on-orbit, it can maneuver to an entirely new orbit, change planes or completely leave Earth's gravitational pull providing unseen maneuvering flexibility for mission requirements. It can serve as a spacecraft bus providing all the health, TT&C and payload monitoring as a traditional bus with proven performance. When payloads are



Artistic rendition of Moog's Orbital Maneuvering Vehicle (OMV).

attached, they can be separable or non-separable allowing for easier mission design, deployment, disinformation and proliferation capabilities.

Finally, an OMV equipped satellite with Moog's own BRE-440 processor is capable of handling large amounts of radiation and can operate in the harshest environments.

The simplicity, reliability and industry-recognized interfaces also make the OMV a tremendously capable satellite bus. The spacecraft is built from the ESPA ring that has already been used on many government and commercial missions where small satellites are integrated. There is inherent integration flexibility that permits stacking ESPA rings to create large constellations on short order. Each port can carry satellites from 180 up to 700 kg., based on configuration.

Moog's OMV can host satellites, provide power, battery conditioning, and carry payloads designed to separate or be hosted for their complete mission life. The five-year orbital life allows payloads to be placed on the ports to wait to be dispensed at a time and place of the customer's choosing.

The baseline ESPA structure is modular with a set of "building-block" subsystem components that can be upgraded to meet tighter mission requirements. The OMV is comprised of an integrated avionics unit for both Command and Data Handling, Electrical Power System, and Guidance and Navigation Control sensors. It allows for a variety of propulsion systems, such as green, monopropellant or bipropellant. Other on-board functions can be tailored to specific missions to take advantage of lower launch costs through multi-manifesting.

The Moog BRE-440 CPU is a fully radiation hardened processor and is in a true System-On-a-Chip design, including floating point unit. The flexibility OMV allows for multi-manifest missions with civil, intelligence, and DoD. It is possible to have a single OMV act as a secondary adapter to deploy commercial payloads, act as a tug to deploy additional payloads at varied orbital parameters, and remain on-orbit as a hosted payload platform for a third customer.

### **Changes in Agencies**

The need to go fast and innovate at a quicker cycle than traditional acquisition timelines has created new agencies, contract mechanisms and partnerships. There are consortiums which use Other Transaction Authority (OTA), there are new offices which apply commercial capabilities to military applications, there are innovative campuses which invite teams to understand government challenges and offer unique solutions, and there are new agencies being formed to solve some of the toughest space vulnerabilities to protect our nation.

In October of 2017, the Space and Missile Systems Center (SMC) formed the Space Enterprise Consortium (SpEC) to use OTAs as a means for rapid prototyping. Now SpEC members from large companies to small companies can assist the Government in identifying challenges, prioritizing which challenges get solicited, and select the highest priority project submitted through the SpEC.

Constant innovation and rapid technology delivery will be deployed to improve system responsiveness and survivability on more frequent, regularly scheduled launches.

Also, in 2017 Defense Innovation Unit Experimental (DIUx) dropped its "x" mark showing it has an official permanence in DoD acquisitions. DIU uses a unique approach to strengthen national security by accelerating the adoption of commercial technology. It takes commercial solutions and rapidly developing prototypes to fit them in a military application solving some great challenges with a commercial off the shelf mindset. This approach allows nontraditional government contractors to partner with the DoD by lowering the barrier to entry and seeking out commercial companies to do business with the government.

Another game changer is the Catalyst Campus in Colorado Springs. This innovative campus is challenging typical acquisition approaches to bring about maximum flexibility, cutting-edge technology and open brainstorming collaboration to a new level of creativity and problem solving.

I call the Catalyst Campus an idea incubator; startups and small businesses can interact with government program offices on a whole new level of transparency and candor. The campus has plenty of meeting rooms, collaborative workspaces, an auditorium, and a Space Operations Control Center where orbiting satellites can be commanded and monitored.

In 2018, the National Defense Authorization Act established the Space Rapid Capability Office (RCO) to push the boundaries of performance for rapid capability delivery. The mission of the SpRCO has three main focuses. They seek to develop low-cost, rapid reaction payloads, busses, and launch systems; speed up planning, acquisition, and operations; and to rapidly develop and field space capabilities.



Over the next few months we will see the Space Development Agency (SDA) finding their stride. On July 1, 2019, they released their first RFI outlining their proposed architecture for eight essential capabilities. In their RFI, and as presented at the SDA Industry Day on July 23, 2019, they used the terms "proliferation", "global persistence" and "distributed" to describe the goals of their notional architecture.

The SDA's work will develop an architecture with high technology refresh, multiple global sensors at different altitudes, maintain custody of time sensitive targets, and develop a better deterrence capability; changing the calculus of any adversary. This system will require machine learning, hybrid networking, crosslink capabilities and space logistics.

### **NOW is the Time**

I am excited to be a part of the design, transformation and creation of a new norm for space operations. The technologies embraced by multiple industries to drive competition and gain market growth can and need to be applied in space acquisitions and operations.

Our predecessors had the right stuff; they understood that failure is an option. It's important to capitalize on systems like the OMV to change how we manage and sustain on-orbit capabilities and to use logistics as a foundation for space superiority.

Ambitious agencies are motivated to make a difference, go faster and drive change. This enthusiasm, along with unique contract mechanisms and a fresh approach to source selections will help the DoD, Commercial Space and the Scientific Community move faster, evolve and maintain dominance in a once-stagnant industry.

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# THE IMPROVING WORLD OF MILITARY SOTM

## Boosting critical mission success

By Raz Cohen, Vice President, Products, Get SAT

**Global communications are driven by high-bandwidth applications needing high data rate connections. On the battlefield it is no different; however, the delta between civilian life and the limitations and challenges of the military loom large.**

Today, high bandwidth connections are becoming essential for providing optimal conditions to boost critical mission success on the battlefield. High bandwidth data is mandatory. Decisions based on miscommunication or limited access to data made by commanders, officers and soldiers can literally change a person's life, whether combatant or civilian.

To tilt the fulcrum toward better decision making, militaries, defense services, HLS and security agencies are seeking the best high bandwidth communication tools that enable instantaneous access to more information and even more so, to real-time communications.

Delivering real-time intelligence data, maps, live videos, mission information, enemy profiles and movement in an on-the-move situation requires communications capabilities of the highest order. Decisions impacting life and death need to be predicated on as close to full knowledge as possible.

High speed SOTM improvement not only impacts the military. Various HLS and security missions, such as search and rescue operations, disaster recovery and relief, coastal security and other Communications-On-The-Move (COTM) operations, will also greatly benefit.

### What are High Bandwidth Communications?

High bandwidth is today's reality — try a day without using your smartphone and its applications and see how frustrating such an experience will be for you.

Having data flow with low latency — as close to instantaneous communication as possible — is another real need. In the civilian world, this is currently at the LTE as well as 5G stages that provide data speeds between 5 and 12 Mbps and upload speeds between 2 and 5 Mbps. The same is needed for the military's on-the-move requirements.

As soldiers in the field, vehicles, vessels or airborne platforms are constantly in dynamic mode, they need these capabilities in a secure and rugged instrument in an on-the-move format.

**No longer does a soldier need to rendezvous with a mobile communication vehicle. No longer do warfighters have to visit a frontline HQ tent to obtain new maps or upload mission results or to view the next mission.**



UAV with Get SAT's Nano SAT-H terminal aboard. Image is courtesy of the company.

Satellites are the answer for soldiers in the field requiring MILCOM COTM. Satellite beams are fast, reliable and reachable and offer a major advantage with unparalleled Beyond-Line-Of-Sight (BLOS) reach. The only answer while in the field to receive from, and transmit to, a satellite are technologically advanced, small, lightweight satellite communication SOTM (SATCOM-On-The-Move) terminals.

These terminals ability to attain seamless on-the-move communications furthers flexible tactical and strategic decision-making processes on constantly changing battlefields, war zones, disaster areas, behind enemy lines and elsewhere. These terminals enable decision makers in the field, in front-line command posts as well as BLOS rear HQ to see, hear and communicate in real time. This means that a full comms link package located within the confines of a 'man-pack' is usable for a far longer period of time over the horizon — plus, such capabilities are here and now.

This new era of real-time video, audio and data flow comes via the development of an ultra-portable lightweight, only 3.6 kg., low-profile terminal optimized for 'on-the-move' applications: the Nano SAT-H. This is the first manpack in the world, based on SATCOM, that realizes the desire for high data rates.

Forty years ago, battlefield comms for an individual soldier or small unit was voice only. Today, comms capabilities are quite different.

The Nano SAT-H provides live feeds, live human data interfaces (such as email and chat), instant data applications for downloading or uploading maps, enemy profiles and changing mission tasks. Both in the field and at command posts, intel information can be relayed for 3D modeling of buildings, tunnels and other infrastructure, varied maps such as heat, Elint, Search and Rescue, population density. Additional data types can be loaded or changed to reflect new and refreshed knowledge and provide updated information in the field and for HQ.

With secure, high bandwidth communications 'man-pack,' the field of action changes. The Nano SAT-H quickens the process of providing and delivering information.

No longer does a soldier need to rendezvous with a mobile communication vehicle. No longer do warfighters have to visit a frontline HQ tent to obtain new maps or upload mission results or to view the next mission. Now this all comes in through the soldier's Nano SAT-H 'man-pack' unit. Imagine the time and effort saving this provides for the warfighter and the unit. Now they can focus on the mission — this is a win-win for all.



Get SAT's Nano SAT-H antenna. Top, without radome. Below, with radome. Images are courtesy of the company.

Think of the soldier having a ruggedized 'smartphone' connected to the Nano SAT-H. Now, that is progress. This competitive advantage changes the field, improving mission success rates.

Nano SAT-H terminal provides autonomous operation for transmission and reception of high bandwidth data rates at 4 Mbps between ground forces and headquarters. To meet milspecs, the terminal is fully ruggedized to withstand the harshest blows and atmospheric changes. With integrated BUC, LNB and ACU within the terminal, the SAT-H terminal offers a single point of contact without having to add equipment.

Based on highly miniaturized technologies, that together create a small profile unit that fits into a small backpack, the terminal literally replaces equipment that previously would have filled a mobile communications truck.

The next exciting story behind the creation of the Nano SAT-H is its applications for UAVs. Suffice it to say: **Size and Weight do matter.**

The terminal's 3.6 kg. weight for a full broadband comms package, including an integrated BUC, allows the UAV a longer ride in the air and the unit's size enables builders and integrators to add more systems and technologies within the UAV. Additional time in the air, plus greater

technological efficiencies, augment mission goals and enable greater horizons for UAV deployments. Looking at the evolution of UAV technologies, especially including Class variations, the dilemma of length versus size versus capabilities has always been how to fit more technologies into a smaller size, or how to fit more technologies into a standard size. Creating UAVs that stay aloft for longer periods of time creates a delicate tug between fuel, mobility and capabilities. Giving up in one area leads to gains in another facet. This means matching the payload to the mission has been a critical consideration. However, this does not need to be the case.

Nano SAT-H's mini size provides a small SATCOM package that literally makes it a micro-comm but with the power of something far larger in size. With this power in a small package, the need to allocate resources to either enhance mission goals or payload capabilities can be eliminated. As the terminal's size is only 21 x 23 cm. (8.2 x 9 inches), it is the smallest miniature terminal that is capable of handling high bandwidth requirements.

Today a small Class III tactical UAV, those in which the Nano SAT-H are deployed, deliver 4K UHD video feeds from five different cameras. Only two decades ago, video feed was black and white with low definition. Times have changed and UAV capabilities have grown exponentially.

[www.getsat.com](http://www.getsat.com)

Get SAT, the developer of the Nano SAT-H, is a pioneer in small, lightweight satellite communication terminals. Focusing on micronizing SATCOM antenna technologies, the company targets SOTM applications: in the air; on the ground; and on the seas.

Get SAT's technologies are based on the firm's patented, fully-interlaced, Inter-FLAT panel technology: a single antenna panel that provides full transmission and reception. InterFLAT's dual capabilities significantly decrease antenna and thus terminal size, bulk and weight as compared to traditional antennas utilizing different panels for Tx and Rx.

With less weight and size, the Nano SAT-H is optimized for mobility and man carried portability. Pulled together, its technologies increase power efficiency, reduce electrical interference and enhance capabilities. Each small step creates a better product that outdistances earlier technologies.

SATCOM terminal miniaturization is heading in the correct direction. GetSAT is fulfilling the vision with small, mobile, rugged and robust SOTM terminals. The company is empowering HLS, security and defense agencies to push their operations further, faster and smarter. Hand-held SATCOM communicators will be realized far sooner than many might believe to be the case.

# POWERED BY SATELLITE...

## A boost for Link 16 military radio

By Alex Miller, Editor, Inside Viasat

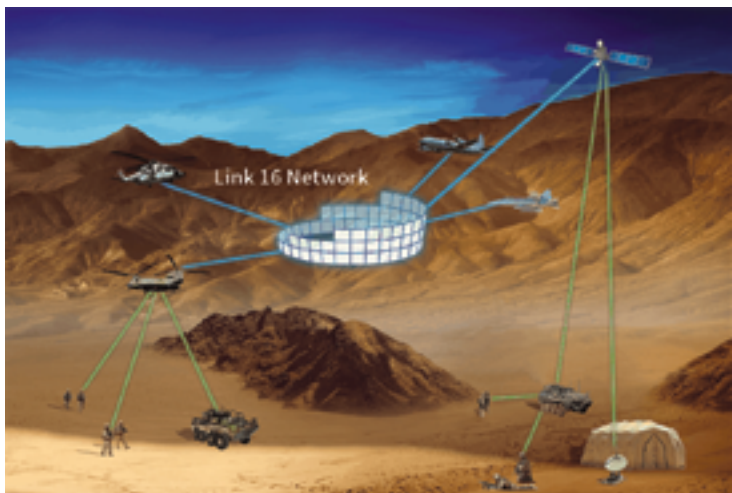
**The recent announcement that Viasat is developing a Low Earth Orbit (LEO) satellite for Link 16 military communications is a perfect illustration of how the company is able to connect core competencies. In this case, Viasat's expertise in satellite technology, tactical data links and network encryption will come together in the XVI program to vastly improve the ability of warfighters to communicate on the battlefield.**

For the past five years, Viasat has been working to enhance the capabilities of Link 16 — a common and critical communications protocol for the U.S. military. Viasat has put more than 1,000 handheld Link 16 radios in service, enabling warfighters on the ground to better communicate with aircraft for close air support.

To make Link 16 even more effective with Viasat's expansive portfolio of Link 16 products, the company is looking to expand satellite connectivity for Beyond Line-Of-Sight (BLOS) missions. As Viasat's main fleet of satellites are in high geostationary orbit beyond the reach of traditional Link 16 terminals, the company's XVI prototype spacecraft sets the stage for a potential constellation of LEO military satellites within range of the Link 16 network.

*"This is the first-ever Link 16-capable LEO satellite to be built," said Ken Peterman, President of Viasat's Government Systems business. "The primary goal of the XVI program is to prove the feasibility of Link 16 on a LEO satellite system—which has significant value and potential because Link 16 is a widely used system by the U.S. military and our allies."*

Viasat's Craig Miller, Viasat's Vice President and Chief Technology officer for Government Services, described a simple scenario of how the XVI would work.



Adding satellite connectivity to the Link 16 network enables BLOS capabilities.

# MAKING MILCOM BETTER

## The Link 16 evolution

By Kim Hampson, Marketing Director, Viasat

**Link 16 is a secure system protocol that allows different military users to share data over the same network.**

However, like any good thing, everybody wants a piece of the action. As the popularity of Link 16 grows to include more platforms (ships, aircraft, vehicles, drones, etc.) and individual users, it will be important to expand Link 16 capabilities to help U.S. and coalition military forces adjust to new mission needs, enhance situational awareness, adapt to new technologies and improve warfighter safety.

The U.S. military has expressed strong interest in expanding Link 16 capabilities to maintain the tactical advantage needed to succeed across today's data-driven, contested battlespace. One solution is Concurrent Multiple Reception (CMR) in which a radio can demodulate and decrypt multiple messages from multiple users simultaneously.

*"Imagine that instead of a single FM or satellite radio station, your car radio could pick up three or four stations simultaneously," said Andy Kessler, Vice President and Business Area Director for Viasat's Next Generation Tactical Data Links (NGTDL) systems.*

One example is with positional data, where CMR enables more frequent, secure updates on the location of friendly and enemy forces. The data from multiple messages received simultaneously is fused into a common picture.

*"This picture that you are seeing on your tactical situational awareness display is more robust," Kessler said. "The tracks are getting updated more frequently due to reduced latency so the locations are more precise."*

Multi-message capability also allows CMR devices to share data between specific users while still receiving information from the broader network, all in a single timeslot. This is expected to increase the overall network efficiency and capacity because multiple networks can operate in the



*"Now, a soldier on the ground with a Link 16 radio can communicate with another person on the ground or with an aircraft they can 'see' — within a range of a few hundred miles. With XVI, the range is greatly extended, with the satellite connection enabling that warfighter on the ground to see someone or something, say, on the other side of a mountain."*

## **Dissipating the Fog of War**

The ability to have BLOS connectivity is a huge advance, but as Miller explained, it's just the beginning of what extending the range of Link 16 with satellite can accomplish. When Viasat's global constellation, ViaSat-3, is in place in a few years, it will be able to provide internet connectivity almost anywhere in the world. If a full constellation is developed, the XVI satellites in LEO could connect to the ViaSat-3 satellites in geostationary orbit (GEO) to link the warfighter on the ground to broadband.

*"It's a powerful capability," Miller added. "Linking to broadband gives you the ability to access a common operational picture. There's an operations center with all of this intel, and that's sent up over the satellite network and finished over the Link 16. It tells that warfighter on the ground about threats or conditions they need to know — if there's a tank behind that bush or a group of adversaries on the other side of a mountain, for example."*

The interoperability between LEO and GEO satellites is a capability Miller said Viasat is eager to explore. LEO satellites can only cover a small portion of the Earth, due to their low orbit, but connect them to a constellation of GEO satellites and that limitation vanishes. Meanwhile, the lower orbit enables connection to handheld terminals on the ground.

## **Testing in 2020**

Viasat is at work building the first satellite to start testing in 2020. Ultimately, Viasat looks to develop a constellation of Link 16 LEO satellites that will enable coverage of most of the earth.

*"These are really cool innovations to extend the range of Link 16," Miller said. "And the other important innovation is a modification we've already made to the satellite payload allowing the Link 16 signal to work at much longer distances."*

This also enables the XVI system to work with all of the existing Link 16 devices already in the field — an important consideration both financially and for getting the system in place more quickly.

All of it adds up to the potential creation of a new system of communication that Viasat is uniquely positioned to implement.

*"The XVI award highlights Viasat technology leadership in Link 16 and space-borne tactical communications," Peterman added. "Our innovative spacecraft design and development coupled with expertise in next-generation tactical data links and cybersecurity places Viasat in a unique position to address the Department of Defense's urgent need for a fast-to-market, cost-effective, space-based Link 16 solution to maintain a technological edge in contested environments."*



Alex Miller is the is editor of Inside Viasat, the official corporate blog for Viasat Inc.

same theater of operation. Seeing the need to enhance communications capabilities, the U.S. military recently identified CMR as an emerging need for Link 16 products.

## **Successful Integration**

Viasat recently took a proactive approach to develop and implement CMR capabilities to fulfill a need from the U.S. military ahead of future requirements. In April, Viasat announced it successfully integrated CMR advancements into the company's extensive line of next-generation Link 16 products. CMR advancements are now available in the latest versions of Viasat's AN/PRC-161 Battlefield Awareness and Targeting System – Dismounted (BATS-D) handheld Link 16 radio, as well as its KOR-24A Small Tactical Terminal. One of the key attributes of Viasat's growing portfolio of NGTDL products is the forward compatibility that is built-in from day one.

Viasat's proactive approach to its NGTDL product portfolio has already generated significant interest from both U.S. and international customers. In fact, Viasat recently announced its Small Tactical Terminal (STT) has been fielded by more than 1,400 U.S. and international customers. In April, the company also announced over 1,000 of its BATS-D radios are now in use by U.S. military customers.

Ken Peterman, President of Viasat's Government Systems business. "The flexibility of our architectures allows Viasat to add new NGTDL capabilities, like CMR, in near real-time to keep pace with today's rapidly evolving digital battlespace and meet the unique needs of each mission."

## **A Real-World Solution**

CMR strengthens modern military operations: the coordination of multiple land, sea and air platforms over vast distances.

*"This leverages the more robust network infrastructure in a way that previously wasn't possible because of the limitations of communications," Kessler said and he recalled his military service as a Navy F/A-18 pilot, when "you spent your time looking out your cockpit to see where your wingman was. Now you look down at your situational display and see where he's showing up on your moving map."*

CMR enables more frequent positional updates that enhance flight safety as well as air operations. That's also why CMR will be vital for manned-unmanned teaming, where manned platforms operate in conjunction with autonomous systems. More than ever, human operators will need to be in constant contact with drones and artificial intelligence-based systems at all times.

*"We are proud to advance the industry in the tactical data link market," Peterman added. "Innovations like CMR are just one of the ways we're providing the connectivity needed to significantly enhance mission effectiveness and improve warfighter safety across today's battlespace. We're looking forward to making what's next."*

# MAKING A WAY IN THE UNIVERSE

By Ricardo Gonzalez, Director of Space Systems, BAE Systems

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**Whether it is helping to connect the world through satellite communications, monitoring of the proliferation of weapons of mass destruction, tracking international terrorists and drug traffickers, supporting international peacekeeping and humanitarian relief operations, enabling deep space exploration, or assessing the impact of natural disasters, the company's space products have been reliably processing data on the ground and in all satellite domains for nearly 30 years. Every day, BAE Systems' space products are on the job performing national security, civil, and commercial missions.**

In fact, BAE Systems' radiation-hardened electronics recently reached an unprecedented milestone marking 10,000 cumulative years on-orbit with 100 percent mission success.

In addition to developing the processors that have powered every NASA Mars rover, the company's space products and processing play an integral role in assisting many of the products and services most Americans enjoy every day, including satellite TV and radio, broadband service, secure banking, and GPS. BAE Systems support missions such as the Commercial Resupply Service, which provides cargo resupply and waste disposal for the International Space Station. Plus, the firm's systems are used by U.S. armed forces every single day to help keep our nation safe.

## **The Space Environment**

For years, space assets have played a role in protecting national security — by providing our nation and our allies with strategic indications and warning, assured communication capabilities, reconnaissance, and precision positioning, navigation, and timing data.

However, as more nations leverage the benefits of space missions, the space domain has become increasingly more congested, contested, and competitive — all while it remains operationally challenging due to radiation and extreme temperature cycles.

**BAE Systems' space organization is focused on providing operational agility to the space security community.**



In this evolving environment, the ability to adapt, maneuver, defend, and protect assets is essential and requires systems that can detect threats and then quickly do something about them.

Leveraging BAE Systems' expertise in areas such as radio frequency systems, radiation-hardened electronics, secure communications, and ground mission processing capabilities, the company has developed a large portfolio of trusted, high-reliability, radiation-hardened products designed to operate successfully in these harsh environments and enable its customers to command, control, and communicate with spacecraft.

In fact, the company's space single board computer products, operating on more than 300 satellites, act much like the main motherboard does in personal computers, providing the intelligent connection between the operator on Earth and the satellite on-orbit. They process and interpret all commands and communications, ultimately converting the operator's intent into action.

The type of computer the company produces can be seen in the movie *'The Martian.'* When Matt Damon's character retrieves the Pathfinder Rover and opens the side, a computer can be seen. On the actual platform, that's BAE Systems' RAD6000® computer. While Hollywood took a few liberties, the likeness is extremely close to the real device.

Between the RAD6000 and the follow-on RAD750® computer, BAE Systems has provided the space industry's general-purpose computing workhorses and have also developed the next generation of processing, the RAD5545™ computer, which is built using RH45® technology, the most advanced space-qualified semiconductor technology available today.

The RAD5545 computer delivers exponential improvements in size, speed, and power-efficiency over its proven predecessors in the unforgiving space environment. Also offered by the company is a suite of radiation-hardened Serial RapidIO® network products, including the

RADNET™ 1848-PS, an 18-Port RapidIO Packet Switch, and the RADNET 1616-XP Crosspoint, a protocol agnostic SerDes signal circuit switch and replicator. These networking devices complement the RAD5545 single board computer, and allow the user to efficiently manage and route data through the system.

### Ground Processing

On the ground processing side, BAE Systems focuses on applying resiliency and analytics know-how for mission data processing and mission control systems. The company's team is migrating techniques it created for the geospatial-intelligence market to enable multi-intelligence data fusion and battle management command and control.

Also provided by BAE Systems is leading-edge software frameworks and applications that scale to process mission data of a rapidly expanding persistent collection architecture and enable decision making at the speed of today's compressed mission timelines.

Ground processing continues to be a critical component of the overall space landscape and, combined with on-board processing capabilities, BAE Systems makes missions more effective. These products increase the ability for on-orbit, real-time interaction and decision making.

Sensors on the platform are collecting a lot more data and, at times, the satellite may have to take immediate action. Some of that data has to be processed at the source instead of coming back to the ground.

The company's products do more of that data processing, sending both the processed information and the raw data back to the ground. The RAD5545 computer is ideal for that mission as it provides ten times the performance of prior-generation processors for the missions that demand higher levels of processing.

### Mission Payloads

BAE Systems is also a leading mission payload provider in the airborne market and is strategically migrating airborne platform protection technologies to enable space protection and resiliency. These transformational mission payloads assure access to challenging targets and provide rapid delivery of mission-critical collection solutions for military and civil customers.

Satellite payloads are progressing in the more heavily congested, contested space environment and BAE Systems is leveraging increased, on-board processing performance with advanced capabilities such as the firm's RH45® technology

offering. RH45 technology is a space-qualified 45nm integrated circuit technology that is a great example of innovative electronics that are advancing the "art of the possible" for satellite payloads through more advanced computers, network components, and ASICs.

BAE Systems' space organization is focused on providing operational agility to the space security community. The company's Analytics Framework and visualization expertise in Activity Based Intelligence and Object Based Production allows simplicity of integration of multi-data types and sources, allowing users to quickly see and understand things others don't, giving context to data in ways others can't, bringing a more complete, integrated picture to anticipate and assess what is happening.

The BAE Systems' history of excellence in space technology makes this kind of innovation attractive to customers. A company's products don't rack up 10,000 cumulative years' time on-orbit without a perfect performance track record.

The biggest reward for BAE Systems is the sense of achievement that everyone shares when one of the company's systems starts its journey of discovery on a planet nearly 500 million kilometers away, or provides a critical capability supporting national security.

[www.baesystems.com](http://www.baesystems.com)

*Ricardo Gonzalez is the director of the Space Systems product line within the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Systems business area of BAE Systems*



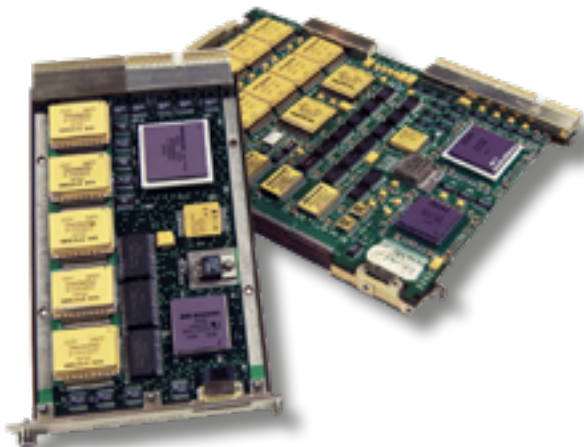
*Ricardo previously served as engineering director for Space Systems, operating across five different geographical locations. He joined the company in 1997 and has served in a wide variety of leadership roles in engineering, program management, and new business capture.*

*He received a bachelor's degree with honors in electrical engineering from the University of Puerto Rico and a master's degree with honors in electrical engineering from The Catholic University of America.*

*He is a graduate of the Armed Forces Communications and Electronics Association Leadership Forum and is also a graduate of BAE Systems' Leadership Enhancement and Accelerated Development program.*

*Prior to joining BAE Systems, he held a project leadership position managing an Advanced Technology Demonstration Program at the Night Vision Laboratories in Fort Belvoir, Virginia.*

*Ricardo serves on the George Mason University ECE Department Advisory Board. He also co-chaired BAE Systems' 2012 Diversity & Inclusion Symposium and was a member of the BAE Systems, Inc. D&I Advisory Council to the CEO.*



BAE Systems single board computer.

# LACK OF INTEROPERABILITY INHIBITS MISSION-CRITICAL COMMS ACROSS AGENCIES

By Henrik Nørrelykke, Vice President, Land Mobile, Cobham SATCOM

**During the most serious of emergency situations, it's long been acknowledged that two-way communications between state (or local), and federal (or national) agencies can save more lives.**

As an example scenario, a hurricane situation in Dade County, Florida, U.S. will require support from different types of first responders; fire, police and ambulance services that are under state jurisdiction. However, when a disaster escalates, they do not always have the resources to handle the situation alone and are supported by nearby state agencies as well as the Federal Emergency Management Agency (FEMA).

Typically, until recently, the exchange of information 'on the ground' between these agencies collectively would have been siloed and quite limited, resulting in operations being far more strained and uncoordinated. This becomes a possible factor in adding numbers to lives and property losses.

Acknowledging this serious issue, many countries have taken steps to upgrade their radio systems, transitioning from traditional digital mobile radio (DMR) and land mobile radio (LMR) to Long Term Evolution (LTE) based radio systems. This has brought huge advantages to first responders and homeland security agencies, thanks to the addition of network capacity and speed to mobile device users. However, 4G is restricted in its coverage to mainly urban areas, much like we are all used to when using 4G on our mobile phones. This is a huge paradox anomaly for first responders and homeland security agencies, which must provide vital support in any location, no matter how remote, at any time.

Despite these limitations, many countries have put considerable investment into LTE Mission-critical-push-to-talk (MCPTT) systems. In the U.S. this technology underpins the country's FirstNet system, the new emergency network designed *to develop, build and operate a nationwide broadband network that equips first responders to save lives and protect U.S. communities.*

FirstNet has been widely lauded and is commendable in terms of driving interoperability and encouraging the use of MCPTT systems. However, it will fall short of its mission to deliver nationwide coverage unless additional provisions can be made to address "white spots" in remote areas which have little or no LTE coverage.

widely lauded and in terms of driving encouraging the use of MCPTT systems. However, it will fall short of its mission to deliver nationwide coverage unless additional provisions can be made to address "white spots" in remote areas which have little or no LTE coverage.

**First responders, homeland security agencies and military personnel are subject to some of the most daunting scenarios in the extreme regions on Earth.**



This issue is universal and is being experienced by other LTE MCPTT first mover programs. If other countries also decide to invest in new LTE MCPTT systems, then their first responders operating in far-flung locations will experience similar issues. Areas including Australia, New Zealand, Canada, parts of Europe and the Middle East with large rural and remote communities are likely to be particularly exposed.

Returning to the Florida hurricane example, FirstNet would only be available to those communicating via LTE. And, even in areas where LTE is available, challenges remain since every agency must be equipped with LTE enabled radios in order for interoperability to make sense.

For users lacking LTE enabled equipment, radio systems have to be set up before individuals can communicate. This means, at best, that radios have to be re-programmed and, at worse, that communication is not possible between incompatible systems. This problem is particularly acute between first responders from different locations, who may attend the scene equipped with radio systems that do not function outside their usual 'patch'.

### First Movers in Interagency Communications

Have any solutions to these challenges been developed and tested to date? The answer is yes. In fact, in the U.S. and Canada, organizations have been enjoying interagency communications for more than a decade and ways before FirstNet.

Satellite based push-to-talk was introduced 15 years ago, offering cross agency communications between local and national agencies. Agencies were offered the possibility to interconnect between them using SMART (Satellite Mutual Aid Radio Talkgroup Program). While a strong concept, the system became an "island" separated from the LMR/DMR networks and, as a result, did not find its way as a means of communication that is used daily.

A further issue that early pioneers of interagency communications were not able to address was agility, the need for a system that first responders and other agencies could turn to in all scenarios, both routine and exceptional.

Fortunately, this issue has now been addressed through a new solution that offers seamless and continuous connectivity between DMR, LMR, LTE and MCPTT systems. It works by harnessing L-band satellite technology to provide uninterrupted connectivity regardless of geographical location. In addition, it operates seamlessly with LTE MCPTT, LMR or DMR, consistently ensuring that the public service purse is getting the most cost value for its connectivity investment.

Applying a combined L-band satellite and LTE communications systems to MCPTT also delivers a continuous interface between the user's data device (computer, tablet or mobile data terminal) back to the central IT systems.

First responders and homeland security agencies can access this technology by integrating their existing radio systems with satellite push-to-talk (PTT) solutions, such as Cobham's PRISM PTT+. The combination of radio, LTE and satellite provides users with Beyond Line-of-Sight (BLOS) voice and data communication that systematically routes communications between the most reliable terrestrial (2G/3G/LTE) and satellite (L-band) networks. This network's agnostic, user-friendly solution provides a failsafe solution that enables users to make mission critical and often life-saving voice calls, as well as sending and receiving important data, in all conditions.

Since LMR/DMR as well as mobile data terminals already found in emergency vehicles are brought into the IP world by means of sophisticated voice handling algorithms, interagency communications is handled exactly as easily as communication between two vehicles in a talk group — all managed centrally. As all traffic is handled as IP data, integrity is insured by applying AES-256 encryption to all voice and data streams, thus ensuring the highest possible level of data protection operationally when aiming to integrate very disparate communications platforms.

### Military Applications

From a military perspective, the technology available today would enable military personnel to use safe and secure interoperable communication over multiple networks at the same time. Such a system would use whichever network is available and deliver the necessary information back to users, giving them the experience of a singular network. There are no geographical boundaries to the technology, which means that international communications can be facilitated with ease, even in the remotest areas.

Indeed, applying a combined L-band satellite and LTE communications systems to MCPTT could at last provide an answer to the 'swing' in military spending with regards to proprietary systems versus COTS (Commercial-Off-The-Shelf) systems that offer a less expensive off the shelf application. As the military sector is faced with the dual challenge of cutting costs, while increasing standards, L-band satellite systems accessed via network agnostic PTT solutions systems could provide a cost system with many of the benefits of a proprietary system.

### Enabling Critical Decision Making

First responders, homeland security agencies and military personnel are subject to some of the most daunting scenarios in the extreme regions on Earth. While they are trained and well prepared to work in such conditions, lack of consistent communications severely restricts the ability of all these agencies to act as swiftly and efficiently as they could with improved Interoperable communication.

At Cobham SATCOM, the firm's vision is to enable a scenario where all providers of vital services can communicate seamlessly, talking and listening as much as they want, while working in the most remote and inaccessible areas.

This is now possible with PRISM PTT whether they are connected to FirstNet, another LTE MCPTT system or any alternative radio system. Furthermore, the provision of interagency communications offers a further 'step up,' enabling critical decision-making across all relevant agencies in the most challenging of circumstances.

[www.cobham.com](http://www.cobham.com)

Henrik Nørrelykke is the Vice President, Land Mobile, with Cobham SATCOM.



Cobham SATCOM's EXPLORER Mobile Gateway (Push-To-Talk Unit).

# RF COMPONENTS ARE THE KEYS...

...for good military satellite applications

By Dr. Esen Bayer, Managing Director, Atlantic Microwave

**There is no denying the military's dependence on satellite applications. Satellite is relied upon for all-important radar operations, from anti-missile and air-defense systems to enabling land and ocean surveillance.**

Satellite communications are also especially crucial for maintaining communication links with operatives in the field, often in remote areas where other links are simply not available. In those instances, satellites literally provide a lifeline.

**The selection of the most suitable RF products requires a good understanding of their specifications and intended applications.**

However, this functionality doesn't come without challenges. RF components are often overlooked as simply something that need to be purchased; however, getting it right can be key to ensuring resilience throughout the satellite networks.

## Challenges

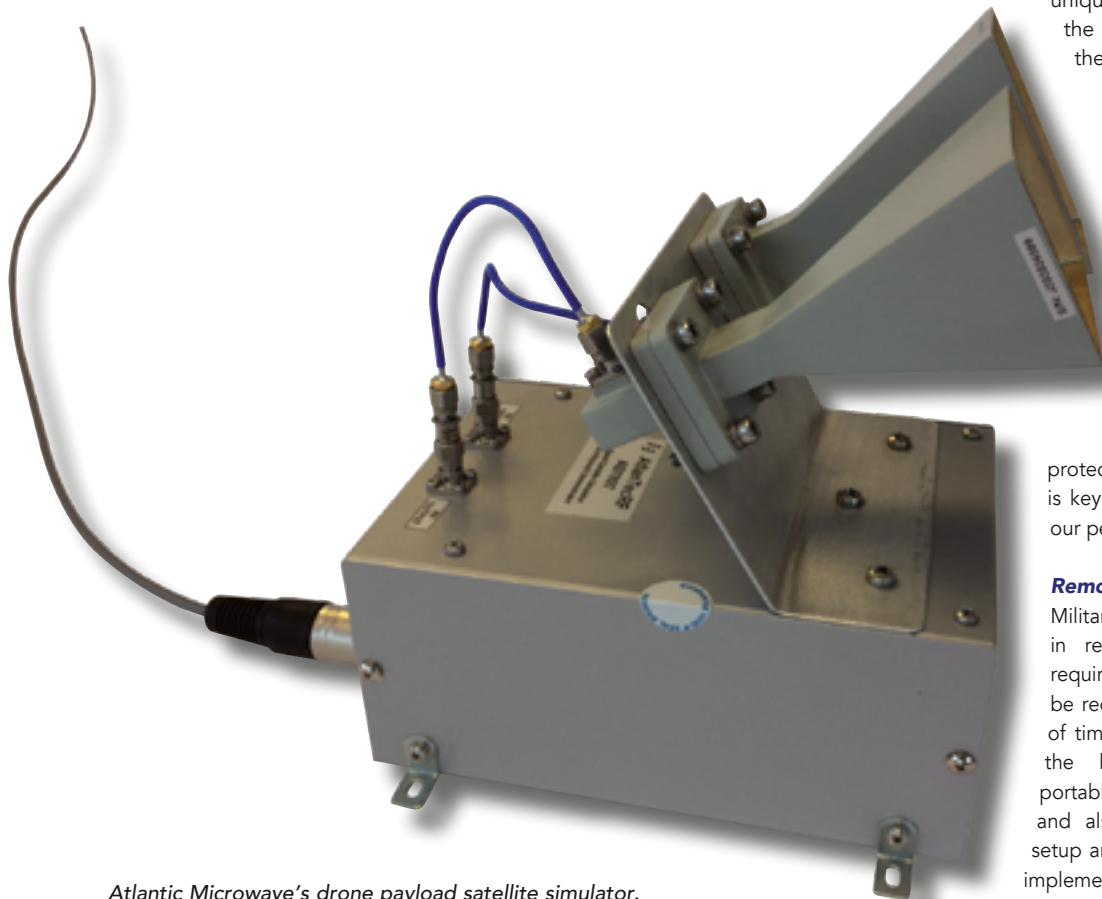
Military satellite operations, as well as experiencing the challenges associated with any satellite network, have their own unique challenges. Here are some of the most significant difficulties for the military today:

### Cyber Attacks

As the world becomes more connected, cyber-attacks are becoming a serious threat to pretty much everyone, from huge companies to the man on the street. The military is a significant target for potential cyber criminals in view of its importance to our protection. While communication is key, the security and safety of our people is paramount.

### Remote Operations

Military operations often occur in remote locations and may require substantial hardware to be redeployed in a short periods of time. For effective operations, the hardware needs to be portable, compact and resilient and also needs to be quick to setup and operate as well as easily implemented into an existing system.



Atlantic Microwave's drone payload satellite simulator.

### Extremes of Weather

Military operations require global access and quick deployment across the globe. In many locations, there can be extremes of temperature and weather that require products that are designed to operate across such extreme conditions without performance degradation. In some cases, operational temperatures span from -20°C to +65°C or beyond. All products need to pass well controlled test regimes to ensure resilience across harsh operational or storage conditions.

### Interference

Interference is a challenge for the entire satellite industry. Interference free operation is fundamental for the functioning of any satellite link. This requires well planned frequency allocation, antenna pointing and expertise in the field of communications.

For effective and compliant performance, RF components with good spectral purity are required.

Interference of any kind can cause degradation of signal or even downtime. In many military situations, that is simply not an option and, therefore, military operators need to be able to mitigate interference before the crucial service is negatively impacted. RF Products should provide very low spurious characteristics and filters to limit or restrict interference.

### COTS

In an attempt to reduce costs and increase speed of delivery, many defense companies are looking for Commercial-Off-The-Shelf (COTS) products.

It is important for all mission critical applications that reputable companies

with proven track records are selected as the equipment suppliers.

The expected life cycle of such equipment is typically 10 years or more. This requires programs where product cycles and the subsequent replacements are well planned. When it comes to end of life it is vital that the services are maintained, and new products are backward compatible. These schemes are required to deliver desired solutions quickly and to maintain COTS provisions.

### The Role of RF Components

RF components are fundamental in determining the performance and resilience of any satellite link. For this reason, the specifications and performance parameters need to be clearly defined. In doing so, RF system analysis and link budgets are essential tools which determine the performance of the entire satellite communication network.

In addition to performance, there are several key factors to be considered as outlined below:

#### Reliability

RF components need to be extremely resilient for military applications. Reliability is critical in ensuring no downtime and therefore it is important that the products perform to their specifications without any deviation.

Additionally, products designed for high reliability applications need to pass strict requirements complying to EMC (Electromagnetic Compatibility), vibration and extreme operational and non-operational environmental conditions. These are captured by internationally recognized military standards.

### Cost versus Specifications

While the industry is under pressure to deliver products to a tight time scale and budget, this needs to be done without compromise to the technical specifications and reliability. The desired solution should involve an interactive exchange of ideas between the supplier and end-user to deliver to the requirements.

### Compact

The designs need to be compact to facilitate mobility and ease of deployment. Miniaturized devices, multilayer PCB boards, effective thermal dissipation and smart HMI (Human Machine Interface) all enable light weight and reliable product solutions.

### Life cycle

Products developed for high reliability applications require a well-planned life cycle and obsolescence management. The industry requires support beyond the nominal life cycle of 10 years. The new products need to be backwards compatible and introduce enhancements over their preceding products at the same time as producing new and superior products to ensure advancements without compromising on the products' longevity.

### Testing

In applications where resilience and reliability are critical, extensive testing is extremely important. This should apply to relatively simple products such as coaxial cables and cable assemblies, as well as to the more sophisticated products such as frequency synthesizers, test loop translators and satellite simulators.

### Selecting RF Components

The selection of the most suitable RF products requires a good understanding of their specifications and intended applications. Selecting a supplier that offers a broad range of RF components, modules and equipment, as well as custom solutions, will save investment in time and money.

[www.atlanticmicrowave.com](http://www.atlanticmicrowave.com)

Esen Bayar has 30 years of experience in satellite communication systems. He joined ETL Systems in 2003 and has been pivotal in transforming the firm into a world leading RF company. Esen is now actively engaged with Atlantic Microwave following its acquisition by ETL. Prior to ETL, he worked for BAE Systems, Matra Marconi Space Systems (now Airbus), Com Dev and Radiant Networks.



# MANTA+: DYNAMIC SATELLITE COTM IS A REALITY

By Lyuda Promyshlyayeva, Director of Marketing, Lepton Global Solutions

**“Always-connected” could certainly be the motto of this generation. Whether on a plane, in a car, at the office, or on vacation, Internet access for digital devices is no longer a wish, but an expectation.**

Cellular connectivity has moved forward quickly, with new technologies emerging every two to three years. Remember 3G? Now 5G is a new reality that is adopted in major cellular markets and Gigabit connections are leaving current broadband speeds in the dust.

With every step, hand-held devices have become more robust, on-the-move access more essential and data transfers more extensive. User dependency on continuous connectivity is at its peak.

These same phenomena apply to soldiers, and none more so than the Special Operations Forces (SOF) community. The wars they fight today are decidedly “fourth generation”: the enemies are un-uniformed, networked, non-state actors that are highly mobile, highly connected and technologically savvy. These American adversaries are not operating from behind fortifications and operate in urban and rural environments.

In order to maintain an advantage in such fluid, operational theaters, SOF users must have flat-panel access to low-profile Communications-On-The-Move (COTM) capabilities.

## From the Ground Up

As global connectivity demand grows, mobile operators are upgrading and expanding infrastructure to match user needs. This expansion includes extending networks to more rural areas and improving failover and backhaul frameworks.

At the same time, the “new space” industry, financed by technology-focused investors and led by major players in the tech arena such as SpaceX, Facebook and Alphabet, is focused on expanding broadband connectivity around the world. New towers and satellite constellations are being hurriedly designed and built and they are frequently in competition with each other for tomorrow’s users.

This investment-heavy economic environment presents significant opportunity for improving military connectivity options, particularly for vehicle-based COTM offerings.

## Satellite-Based COTM Antennas

Unless a user is willing to install a maritime antenna on the roof of their vehicle, BGAN terminals have long been the only viable, mobile, satellite-based, COTM solution.

A limited number of BGAN hardware options can be used for true COTM connectivity with a maximum achievable (and never guaranteed) speed of less than 500 Kbps., and service comes at eye-popping prices. For anyone trying to maintain a low profile, a BGAN terminal, universally recognizable as an antenna, is a poor option.

Cellular antennas are certainly viable where mobile coverage exists. In the age of connected, self-driving cars, and those that run on

**For SOF users, cellular capabilities in the field present threats and opportunities and the ideal scenario is to be able to harness or avoid cellular networks as needed.**





MANTA+ and PIM interior control panel.



software requiring a remote connection to the manufacturer, satellite integration is a must.

For SOF users, cellular capabilities in the field present threats and opportunities and the ideal scenario is to be able to harness or avoid cellular networks as needed.

Satellite connectivity provides a much more secure, if more limited, alternative. The flat panel revolution was started more than a decade ago, with Boeing leading the way. Since then, a few other players have joined the race to blend efficiency with affordability, and Kymeta is now at the forefront of such movement. These companies have attracted serious investment as the technology of tomorrow, with plans to remake entire industries.

For example, using metamaterials, the Kymeta flat-panel antenna can replace a typical L-band offering with higher-throughput, lower-profile Ku-band options, heralding a major step forward in the connected car movement.

After producing a working VSAT flat-panel antenna, Kymeta set out to develop their product into a fully-integrated, satellite communications (SATCOM) terminal. The Seattle-based company teamed with Paradigm Communications Ltd., a U.K. manufacturer and integrator of VSAT terminals with their trademark integration component, the Paradigm Interface Module, or PIM®.

The PIM terminal controller was designed to provide a common terminal interface for a range

of fixed and quick deploy terminals operating on all major satellite networks.

The PIM provides the modem, baseband switching, and assisted pointing and setup functions, and presents users with a quick and simple acquisition process. Paradigm took the Kymeta antenna and turned it into the MANTA®: a fully integrated, flat-panel system inclusive of all electronics, housing, and easy-to-use operator interfaces.

The PIM uses advanced pointing technology to search and lock onto satellites faster and with higher precision than other solutions. When compared with Kymeta's basic antenna unit with non-integrated electronics, the MANTA was able to acquire satellites at a faster rate and significantly improve re-acquisition times after encountering blockage.

The MANTA has since been successfully fielded in the SOF community and has heralded a powerful new communications capability to operators downrange. The same technology could be critical in myriad non-military applications, including disaster response and public safety.

### The Next Iteration

In late 2018, during a demonstration with a SOF user at Ft. Bragg, Lepton Global's Rob Weitendorf asked what else the SOF community needed from a COTM VSAT perspective, now that MANTAs were in use. This soldier's suggestion was to add an integrated cellular capability to the MANTA terminal, a natural marriage of today's diverse and growing telecommunications solutions. While some users had experimented with rudimentary plug-in cellular connections, his request was for a sophisticated terminal system that could offer users complete autonomy over the backhaul method from a ruggedized, single user interface with smart routing and a VPN capability.

In response, Lepton Global worked with Paradigm and

Kymeta to develop the MANTA®+, the first flat-panel COTM VSAT system with a fully integrated 3G/4G/LTE cellular capability. The resulting terminal is a discreet, plug-and-play unit that provides seamless network switching between cellular and satellite. The complete terminal comes in one ruggedized case, contains no moving parts, supports 10+ modem technologies, and can be ordered with BUCs from 8 to 40 Watts.

In June, the initial shipment of MANTA+ terminals was delivered to the SOF community and they have already been deployed for use overseas. In its first iteration, the MANTA+ solution revolutionizes comms-on-the-move capabilities for its SOF users by harnessing the best of both worlds in mobile connectivity.

With the integrated Cradlepoint router, a local SIM card is all that is required for cellular capabilities anywhere in the world. Combined with a satellite network, the PIM can instantly support whichever connectivity platform the user needs. Users interface with the PIM's simple GUI inside their vehicle, ensuring discreet operations and total security.

As a highly customizable product designed to meet end-users' nuanced requirements, the design and optionality are likely to grow; and as Kymeta's antenna technology improves, the number of High Throughput Satellite (HTS) networks increase and cellular coverage expands, the MANTA+ will act as a force multiplier for the U.S. military community.

See MANTA+ at Lepton Global's exhibitor table 10 at the Satellite Innovation Symposium, October 8 to 10.

[leptonglobal.com](http://leptonglobal.com)

[MANTA+ brochure download](#)

Ms. Promyshlyayeva has experience in B2B and B2G business environments. She previously worked for manufacturing and distribution companies and joined Lepton Global in early 2016.



Border Patrol Vehicle outfitted with a Kymeta Terminal  
Photo is courtesy of Kymeta.

# THE GOVERNMENT SATELLITE REPORT (GSR)

## SES & O3b mPOWER

By Ryan Schradin, Executive Editor, Government Satellite Report

**In 2021 SES will be launching its next-generation MEO (Medium Earth Orbit) satellite system called O3b mPOWER – a powerful, flexible, and scalable satellite-based system capable of delivering multiple terabits of throughput with extremely low latency. O3b mPOWER comprises advanced communication satellites, innovative ground infrastructure and intelligent software to deliver exceptionally high bandwidth connectivity to nearly 80 percent of the Earth's surface.**

O3b mPOWER will complement the existing multi-orbit fleet of Medium Earth Orbit (MEO) and Geostationary Earth Orbit (GEO) satellites that SES already operates. It will give the U.S. Department of Defense customers a new tool in enabling digital and network-connected platforms.

In fact, the O3b mPOWER capabilities provide an advantage for a number of use cases across practically every domain of operation — including land, sea and air.

Within the air domain, there are multiple, disparate platforms of operation that all have unique requirements. Each of these three platforms — unmanned aerial vehicles (UAVs), transport aircraft and manned aircraft — can benefit from the advanced capabilities that will be enabled by O3b mPOWER.



*Eric Gunzelman, top, and Mike Blefko, bottom.*

To learn more about the requirements of these platforms and how O3b mPOWER could benefit them each, individually, GSR sat down with two members of the SES Government Solutions team, *Eric Gunzelman* (Project Manager at SES Government Solutions) and *Mike Blefko* (Vice President of Business Development, SES Government Solutions). The conversation began with one of the military's most recent and relied

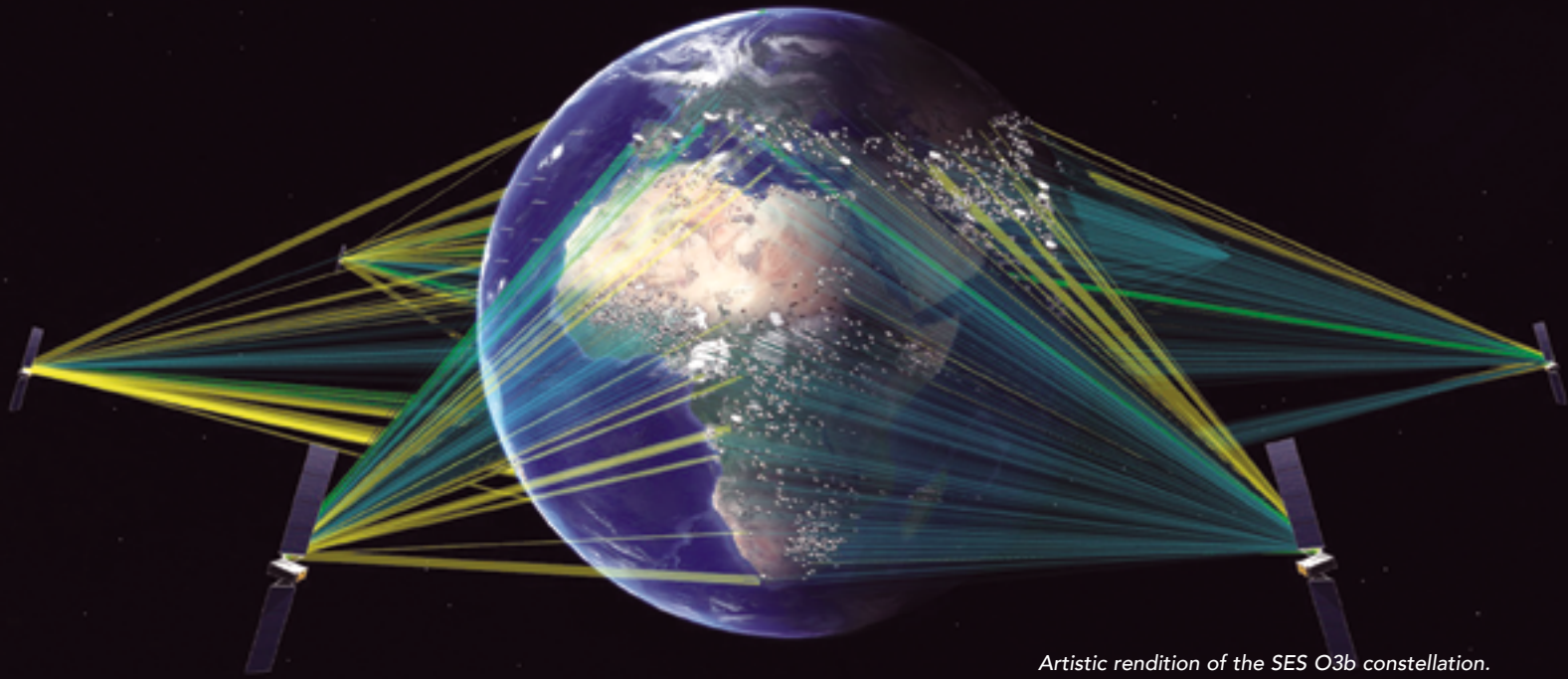
upon platforms — UAVs. Here is what they had to say...

### *Government Satellite Report (GSR)*

*What process is currently in place for getting ISR data from UAVs? Can the data be collected and delivered in real-time?*

**When compared to traditional satellite constellations at Geostationary Orbit (GEO), just the physical proximity of a MEO constellation to Earth reduces the overall latency.**





Artistic rendition of the SES O3b constellation. Image is courtesy of the company.

**Eric Gunzelman (EG)**

There are currently multiple methods for uploading data from a UAV that range in sophistication and speed. There are sophisticated, point-to-point links via air-to-ground or air-to-satellite-to-ground. There are also less sophisticated methods that involve landing the plane in order to access and subsequently ship a hard drive.

**Mike Blefko (MB)**

When it comes to ISR data, timely delivery is of the utmost importance. The more recent the intelligence information is, the more accurate it is, and the better it is for situational awareness, mission planning and mission command. Ideally, decision makers would get access to quality ISR data — such as HD video — in real-time so that it is up-to-date and reliable.

That's why the process that Eric described of landing a UAV and physically shipping a hard drive is not ideal — since the data — much of which is comprised of multiple large files — needs to be accessed in real-time.

**GSR**

*What types of sensors are found on ISR UAVs? How much data do they produce? How has this changed in recent history?*

**MB**

There are numerous sensors on UAV platforms. The number of sensors has increased over the years as electronics have miniaturized. These sensors can include visual, infrared, optical and other airframe state-of-health sensors.

**EG**

That's something that I think is important to realize: sophisticated ISR sensors have exponentially increased the amount of data that needs to be offloaded from the UAV.

When you combine the data generated from airframe sensors and the data generated by ISR sensors, it's easy to see why the amount of bandwidth needed to and from the aircraft has jumped significantly.

In fact, I recently read an Avascent industry briefing that showed the total number of UAVs and the total data rate from those UAVs will both double between 2015 and 2025. That's going to require a lot more bandwidth.

**GSR**

*How are the connectivity requirements of UAVs different from other aircraft?*

**MB**

While many aircraft are strictly being pushed information, UAVs are typically collecting data locally and then sending it via the uplink path back to the base. They need just as much uplink capacity as they need downlink capacity.

This is why O3b mPOWER is such an effective solution for UAVs, specifically. Unlike other satellite networks, O3b mPOWER provides a significant upload path to address these types of applications.

**GSR**

*Aside from the larger uplink capacity, what else about O3b mPOWER makes it a good solution for UAVs?*

**EG**

O3b mPOWER is a Medium Earth Orbit (MEO) constellation. When compared to traditional satellite constellations at Geostationary Orbit (GEO), just the physical proximity of a MEO constellation to Earth reduces the overall latency.

This means that large file transfers and voice communications will experience less than 150 milliseconds of latency roundtrip. Low latency coupled with high throughput and O3b mPOWER's ability to dynamically allocate bandwidth and power in near-real-time while flying a mission enables mission planners to decide to use all of the sensors, part of the payload or reconfigure sensors in-flight, as dictated by the mission requirements.

The result is a higher level of flexibility to adapt to the changing mission requirements as well as faster transmission of voice, video, including UHD, and data packets that do not need to be compressed.

**GSR**

*How does O3b mPOWER compare with the original O3b constellation? What additional benefits will O3b mPOWER deliver?*

**MB**

With O3b mPOWER, we scale the proven concept of MEO, that we are currently delivering to our customers. Both the O3b mPOWER and the current O3b satellites are stationed at MEO, so the latency is the same.

However, the wider bandwidth and channelization on O3b mPOWER allows up to 2500 MHz of bandwidth to be delivered – that’s about ten times more data for the same sized terminal when compared to the original O3b MEO satellites.

The difference is the amount of bandwidth available and the flexibility. As the Avascent industry briefing showed, the number of UAVs is going to double by 2025. The number of sensors on each UAV is going to double over that same period of time.

The bandwidth requirements to get that actionable data back to decision makers in real-time are going to increase exponentially. O3b mPOWER will be capable of meeting and exceeding those bandwidth requirements.

**GSR**

*What type of connectivity is available on manned military transports and refueling planes today?*

**MB**

There is connectivity available on today’s manned military transports and refueling tankers, predominantly supplied by wideband GEO satellite services. However, with MEO, adding inherently higher throughputs and lower latency, the military can add additional functionality and capability in transport aircraft.

**EG**

In terms of applications, defense and security users are primarily focused on enabling access to mission-critical services and applications enabling information sharing and decision-making. This requires higher bandwidth coming off the aircraft, and not just data to the aircraft.

**GSR**

*You’ve mentioned that these applications need to both send and receive data, but what are they, specifically? What types of use cases and applications could there be for high-bandwidth satellite connectivity on military transports and refueling planes?*

**EG**

All modern widebody military aircraft provide capabilities that go beyond their standard mission sets — such as long-haul transport or refueling missions.

Airlift aircraft require en route communications and planning. Aerial refueling aircraft require communications relay. Air mobility support, including airplanes that provide aeromedical evacuation services, benefit from telemedicine and telehealth implementations for en route surgery. There are numerous reasons why widebody aircraft need high bandwidth connectivity.

Then there are the VIP Special Air Missions (VIPSAM), which involve transporting senior government officials. These individuals have important jobs and would benefit greatly from having the same access to communications and applications en route as they do in their offices. This way, they’re capable of informed decision-making and mission planning even if they’re in transit.

**GSR**

*Why is O3b mPOWER a good solution for widebody aircraft?*

**MB**

Satellite constellations at MEO inherently offer lower latency than GEO satellites. It basically comes down to distance. GEO is further away than MEO by a factor of four, or in other terms, MEO communicates in a quarter of the time that it takes to get data through GEO.

Being comprised of next-generation MEO satellites, the terabit-scale O3b mPOWER system will offer extremely fast, low-latency connections for widebody aircraft, regardless of their communications requirements.

O3b mPOWER also offers incredible bandwidth and high throughputs, which means that transportation and refueling aircraft will essentially have fiber-like connectivity.

Finally, the low latency nature of O3b mPOWER enables more real-time based processes, such as cloud-based services. This can help to relieve downrange operators of maintaining their own forward deployed network and make other cloud services accessible to users.

**EG**

In addition to that unprecedented high throughput and low latency, O3b mPOWER uniquely offers the customer flexibility and adaptability.

Customers can create their own federated secure networks within this O3b mPOWER network; they can route their beams from one terminal to another or to their own gateway and shape their beams to put energy just where they want it; they can respond to contingencies more rapidly than ever before and do all of this with inherent jamming resistance thanks to the design of the narrow beams, the moving nature of MEO satellites, frequency diversity and polarization diversity.

Also, O3b mPOWER offers a significant upload path. This means that it’s well-suited to address the upload and download requirements of military communications and applications.

*For additional information about O3b mPOWER and the benefits that it can deliver to the military, select this direct infolink.*

[ses-gs.com/govsat/#](https://ses-gs.com/govsat/#)

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*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.*



# LAUNCHING THE NEXT CHAPTER OF INNOVATION...

Government mission support through commercial partnerships

By Rebecca Cowen-Hirsch, Senior Vice President, Government Strategy and Policy, Inmarsat Government, Inc.



**In recent years, the U.S. Government (USG) has taken a number of steps and implemented strategies that promise to redefine how it acquires satellite communications (SATCOM), with the goal of developing an “integrated SATCOM architecture of the future” driven by a partnership with the commercial SATCOM sector.**

## **Change We Must**

The promise of a change is reflected in General John Hyten, Commander, United States Strategic Command’s statement before the Senate Committee on Armed Services: *“Future SATCOM systems remain key to our continued strategic posture in space. We must design and fund replacement systems and remain on schedule for smooth transition of operations to these new systems. We must expand international SATCOM partnerships, strengthen our industrial base response to acquisition challenges, and integrate commercial opportunities to evolve future satellite payloads toward commercial solutions wherever possible.”*

The commercial SATCOM industry has demonstrated time and again that we understand government customers’ requirements and — in responding to those requirements — have invested heavily into enhancing mobility, flexibility, redundancy, throughput, resiliency and protection for satellite systems.

Officials from the Department of Defense (DoD) and the House Appropriations Subcommittee on Defense have said that they are seeking a better long-term plan to buy commercial SATCOM (COMSATCOM) via a more seamless, integrated network structure and that significant changes in SATCOM procurement are required to make this happen.

This is supported by the Fiscal Year (FY) 2019 budget, where Congress appropriated \$49.5 million in Research, Development, Test and Evaluation (RDT&E) funding to create a new “program of record for commercial satellite communications” within the U.S. Air Force (USAF). The program is intended to pursue a “wideband and narrowband communications architecture

and acquisition strategy” that includes both government and commercial space systems.

General Hyten’s statement reveals how DoD leaders are increasingly recognizing that they must have open access to nothing less than a “fully stocked toolshed” — comprised of a combination of legacy, purpose-built platforms and primarily more modern, commercially-developed options — to readily obtain mission-critical mobile and highly-available wideband. Without such a toolshed — an essential, fully integrated architecture with a heterogeneous network — modern capabilities and unquestioned resiliency will remain out-of-reach.

## **Provisioning**

As a trusted, commercial owner-operator delivering robust and secure SATCOM services worldwide, Inmarsat provides flexible and scalable alternatives for the USG and Allies, complementing military SATCOM (MILSATCOM) in both narrowband and wideband.

For 40 years, Inmarsat has been a major driving force behind technological innovation in mobile satellite communications. The company has sustained its leadership through substantial investments in a powerful network of technology and value-added manufacturing and wholesale partners. Users leverage Inmarsat’s our Ka- and L-band services for core functions, while seamlessly integrating with MILSATCOM to address any remaining gaps to ensure optimal redundancy, diversity, protection, scalability and global portability: the ultimate resilience approach. This frees up government members from administering disparate networks, allowing them to focus on mission-critical operations.

Inmarsat continues to invest in L- and Ka-band enhanced capabilities to include satellites, ground segment, terminals and services to support users’ unique needs anywhere around the globe, while delivering greater value to government customers. In example, Inmarsat recently announced the expansion of Global Xpress, delivering greater, seamless capacity in regions with the highest demand. These next-generation satellites and payloads will bring ground-breaking advancements in support of ever-increasing

**To take part in this exciting era of innovation and help the U.S. government forge a path to integrated SATCOM / MILSATCOM architectures of the future is highly encouraging — even inspiring.**



worldwide demand for government mobile connectivity with unprecedented flexibility, scalability and cost efficiency.

### **Evolutionary**

Importantly, the next evolution of Global Xpress will also provide military Ka-band capacity, complementing U.S. and NATO Allied military satellite resources cost effectively anywhere around the globe. The initiatives seamlessly integrate increased diversity, interoperability and resilience to government architectures without additional infrastructure investment from end users.

The company's next generation of Global Xpress — of which three new satellites (GX7, 8 and 9) will launch from 2023 — will deliver dynamically-formed beams that enable agile and precise allocation of ultra high-power capacity over high-demand areas and allow for superior interference resistance.

This innovative, software-defined, global architecture — with geostationary orbit (GEO) satellites augmented by two recently announced dedicated payloads covering arctic coverage — will have flexible payloads that can be relocated when and where required across the geostationary arc and connect to any Inmarsat software-defined ground network node. The satellites will bring higher throughput speeds and flexible and dynamic capacity scaling based on user-specific resource demands.

Inmarsat will deliver the world's first and only global mobile wideband services to the Arctic region via two new satellite payloads hosted on board Space Norway satellites, scheduled to launch in 2022.

These payloads will be placed into Highly Elliptical Orbit (HEO), ensuring continuous coverage above 65° North while directing capacity in real-time to the areas of highest demand. Importantly these payloads will also provide mil-Ka capability through service beams and high-capacity steerable beams, complementing military satellite resources.

The HEO satellites will fully integrate with the Global Xpress GEO network to deliver a single, seamless service. They will be fully compatible with current and future Global Xpress terminals, so that existing and new Global Xpress customers can benefit from the further extension of the network.

In addition to the evolution in Ka-band, government users continue to have access to innovative capabilities in L-band as complementary resources to MILSATCOM, offering services that are designed for every aspect of Communications-On-The-Move (COTM) missions — from Machine-to-Machine (M2M) to high-throughput data and video distribution for highly mobile platforms — via Inmarsat's Wideband Streaming L-Band (WiSL), L-band Tactical Satellite (L-TAC), Broadband Global Area Network (BGAN) High Data Rate (HDR), SwiftBroadband-Safety (SB-S) and other services.

Users will also benefit from the continuation of the firm's award-winning L-band services via the sixth-generation (Inmarsat-6) fleet, scheduled for launch in 2020. The Inmarsat-6 fleet is a unique dual band payload covering L- and Ka-band services and will support a new generation of capabilities for the 5G era, from advanced global safety services and low-cost mobile services to high-definition streaming. The advanced Ka-band

payload will add further depth to Global Xpress coverage, delivering greater capacity in regions with the highest demand.

### **Strengthened SATCOM**

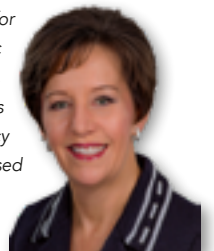
To take part in this exciting era of innovation and help the U.S. government forge a path to integrated SATCOM / MILSATCOM architectures of the future is highly encouraging — even inspiring.

Inmarsat is investing heavily into improving SATCOM mobility, flexibility, redundancy, throughput, resilience and protection. The company is incorporating new and enhanced capabilities into the baseline DoD architecture, ensuring consistent, robust advancements and technology upgrades.

The vision for the future is clear. With a continuing, successful partnership between government and industry, this vision of full cooperation will be achieved and become even more of a reality.

[www.inmarsat.com](http://www.inmarsat.com)

*Ms. Cowen-Hirsch is responsible for establishing Inmarsat's strategic direction and policy with respect to U.S. government. She also leads Inmarsat's government outreach and advocacy program shaping its government focused capabilities and strategy. Ms. Cowen-Hirsch brings more than 25 years of defense, aerospace and executive leadership experience to Inmarsat.*



# USERS ARE BEING SOUGHT...

## for the NRL Plasma Physics Division's Space Chamber

By Emanuel Cavallaro, U.S. Naval Research Laboratory Public Affairs

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### The blackness of space is deceptive. It looks empty. It's not.

At the Earth's ionosphere, about 60 to 1,000 kilometers altitude, the sun's ultraviolet radiation ionizes the gasses of the Earth's atmosphere, knocking off electrons and leaving behind electrically charged positive and negative particles.

That collection of particles is called a plasma, and the Earth is swathed in it. In fact, most of the visible universe is plasma, 99 percent of it, according to NASA.

Our sun is comprised of plasma. Stars are plasma. The tails of comets are plasma.

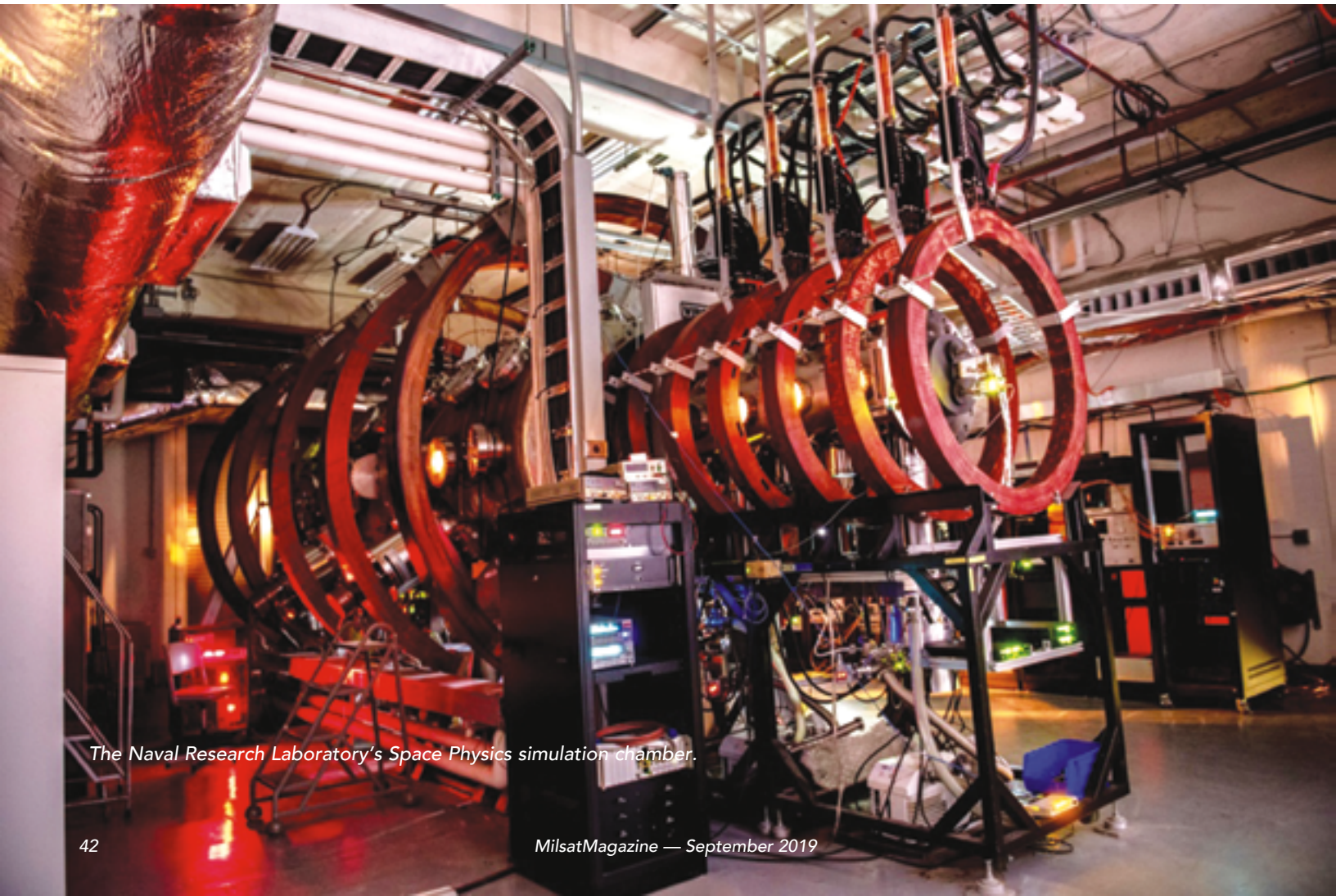
"It's a dynamic medium," explained Bill Amatucci, physicist and head of the U.S. Naval Research Laboratory's (NRL) Charged Particle Physics Branch. "[The concentration of plasma] decreases as you get away from planets, but most of the rest of the universe is in the plasma state. We just happen to live in a cold spot, relatively."

While naturally-occurring plasmas are rare on the Earth's surface, man-made plasmas can be found in such everyday things as neon signs and fluorescent lights. They can also be found at NRL's Plasma Physics Division, where Amatucci and his team of research physicists have been using a massive chamber to create and study them.

A large-scale vacuum vessel for the creation of space-like conditions, the Space Physics Simulation Chamber is one of only a handful of its kind in the United States and one of the biggest in the world.

Now the researchers who operate it are looking for external partners who might want to use it to conduct space plasma experiments or test spacecraft hardware.

**By mounting hardware, such as probes or miniature satellites, on a 3D-positioning system, the researchers can move the hardware within the full volume of the chamber through different areas of the plasma in precision fashion.**



The Naval Research Laboratory's Space Physics simulation chamber.

"There are a lot of people [within the Department of Defense] who build experiments to fly in space, and this is a place where you could test them in a realistic environment prior to flight," Amatucci said.

In the Charged Particle Physics Branch lab, Amatucci's team designs instruments to take their own measurements, and sometimes they design hardware that will fly in space, as well.

In May of this year, their Space Plasma Diagnostic suite (SPADE) experiment launched on a SpaceX Falcon 9 resupply mission for the International Space Station.

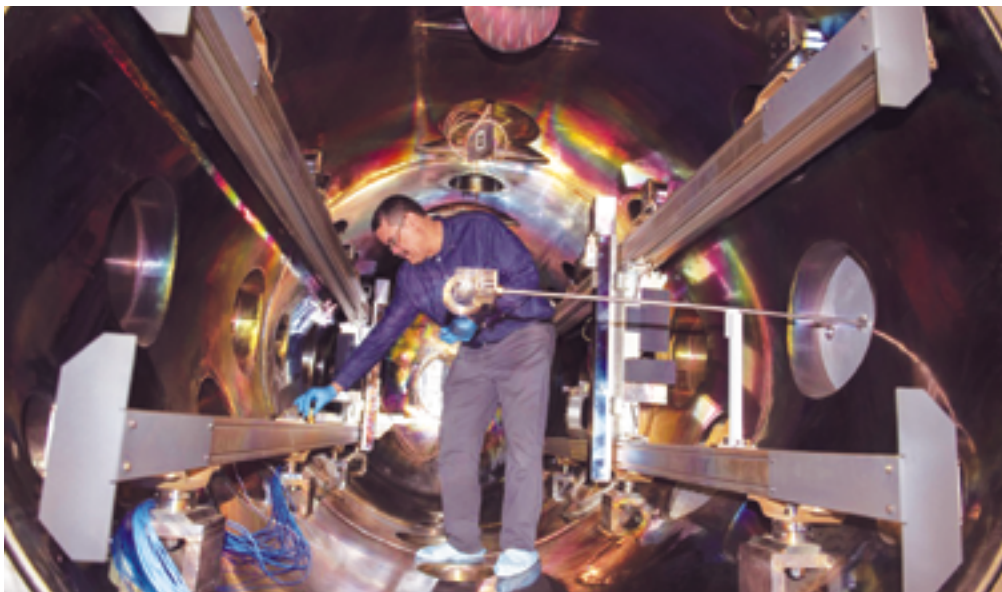
The experiment consists of a pair of "plasma impedance probes" designed to monitor the background plasma conditions for space weather measurements and also monitor for hazardous levels of spacecraft charging on the space station, which goes through day-to-night cycles of charging and discharging as it travels through different plasmas.

Now that SPADE is on the space station, everything is going according to plan, Amatucci said. Each day, his team downloads new data from the experiment.

"It's been fantastic," Amatucci said. "We're getting tons of data. More than we can swallow right now. So we're in the initial stages of doing our deep dives into the data."



Research physicist and head of the U.S. Naval Research Laboratory's Charged Particle Physics Branch Bill Amatucci stands in front of the source chamber section of the Space NRL Physics Simulation Chamber.



Research physicist David Blackwell performing a calibration of a plasma sensor inside the NRL Space Physics Simulation Chamber.

As one of the biggest operators of satellites, the U.S. Navy has a keen interest in understanding the fundamental properties of space plasmas and the applied plasma physics problems that the lab is using the chamber to study.

### Mimicking Space

NRL began construction on the chamber in 1990 and it was operational two years later. The chamber is made up of two sections: the large, main chamber, which is 5 meters long and about 2 meters in diameter, and a smaller chamber that is 2 meters long and 0.5 meter in diameter.

The smaller section is called the source chamber — researchers use it to create and manipulate the plasmas before sending them into the main chamber.

During operation, researchers evacuate the chamber of air, fill it with noble gas (often argon, though they use a range of different gasses in their experiments) and then ionize the gas by stripping electrons from the gas atoms.

"Our chamber is unique in that we can make steady-state plasmas with properties that either match or scale to many different regions of near-Earth space plasmas," Amatucci said. "We have a steady feed of gas, which is steadily being ionized, creating this uniform condition in the chamber that we can scale to different regions of space."

To hold together the plasma inside the chamber, the researchers create a background magnetic field using electromagnet coils that encircle the vacuum chamber.

During their experiments, they can fine-tune this magnetic field to mimic the different conditions in

the ionosphere or different regions of the Earth's magnetosphere.

"Depending on where they occur in space, plasmas have a range of properties," Amatucci said. "There are places where the magnetic field is fairly uniform, so we can make a uniform magnetic field. There are places where it may be stronger in one area than another, and we can do that in the lab as well."

They're also using the chamber for diagnostic development and preflight testing of hardware that must withstand the rigors of spaceflight.

Like the space station, a spacecraft passing through plasma will accumulate electrical charges, occasionally resulting in high voltages and electrical discharges that can damage electronics and even disable satellites.

"These charged particles can interact with each other over long distances," Amatucci said. "So there's a rich variety of disturbances and waves that can ripple through them. We want to understand the basic behavior of the medium so that we can have reliable and persistent operation of our satellites."

By mounting hardware, such as probes or miniature satellites, on a 3D-positioning system, the researchers can move the hardware within the full volume of the chamber through different areas of the plasma in precision fashion.

"It's great for diagnosing the entire plasma or moving your probe from one set of conditions to another set of conditions," Amatucci said. "That's a big selling point for external users."

[www.navy.mil/local/nrl/](http://www.navy.mil/local/nrl/)

