SATCOM for Net-Centric Warfare

MilsatMagazine

June 2019

EMERGENCY COMMUNICATIONS

Resilient Emergency Comms

Enterprise SATCOM

Advanced First Responder Vehicle

Space 2.0

The Next Revolution

The Post-JMS World

Dispatches

Cover image is courtesy of Gilat Satellite Networks... see the company's article covering emergency communications on page 16.

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DISPATCHES

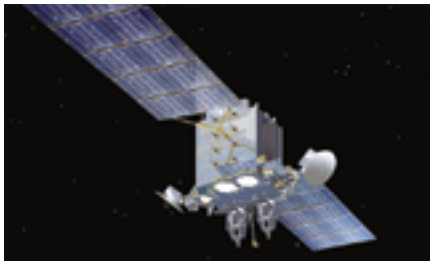
U.S.A.F.'s 4th Space Ops now in control of the AEHF-4 satellite

The U.S.A.F.'s /4th Space Operations Squadron has accepted control of a new satellite in their constellation, Advanced Extremely High Frequency-4, from the Space and Missile Systems Center and 14th Air Force in a satellite control authority ceremony at Schriever Air Force Base, Colorado.

Second Lt. Scott Podlogar, 4th SOPS satellite engineer, said the ceremony designates who has the authority to operate the platform and said the agency accepting control is responsible for maintaining the health and safety of the satellite as well as making sure the mission the satellite is designed for is completed.

Lieutenant Colonel Armon Lansing (photo, right), 4th Space Operations Squadron commander, accepted the key from Colonel David Ashley (photo, left), Space and Missile Center AEHF program manager, signifying the handoff of the Advanced Extremely High Frequency-4 satellite to the 4th SOPS at Schriever Air Force Base

AEHF-4 joins the squadrons of the other military satellite communication satellites that support space and intelligence, nuclear and defense, theater mission defense and special operations.



Artistic rendition of the AEHF-4 satellite.

This is the fourth satellite the squadron commands and controls, with two more launches planned.

According to /Amanda Shepherd-Bond, 4th SOPS satellite spacecraft engineer and event coordinator, the squadron increased their capabilities with the new addition.

She noted that AEHF has increased the coverage over the Milstar satellites as well as approximately 10 times the throughput and better jam or rapid modification of radio waves resistance.

The 14th AF hosted the ceremony via teleconference, with Colonel David Ashley, SMC AEHF program manager, Lieutenant Colonel Paul Freeman, 50th Operations Group deputy commander, Juan E. Cruz, 14th Air Force mission warning program analyst, and Lieutenant Colonel Armon Lansing, 4th SOPS commander in attendance.

During the ceremony, the SMC approved AEHF-4 as being ready for operations, handing control to the 14th AF, who delegated control to the 50th Space Wing, then to the 50th OG and finally to the 4th SOPS.

Shepherd-Bond said the addition of another AEHF platform is significant for 50th SW operations as a whole because it increases coverage across air, land and sea for range communications and greater crosslinking capability. She said that AEHF already supports numerous mission operations including space and intelligence, nuclear and defense, theater mission defense and special operations.

4th SOPS furthers the mission by evolving space and cyberspace warfighting superiority through integrated and innovative operations.

The satellite is the fourth AEHF on-orbit and increases the warfighting superiority of the customers supported by 4th SOPS, Podlogar noted, and commented that the addition of this satellite to the protected communications constellation further promotes Schriever and America as being the masters of space.

Story by
Staff Sgt. Matthew Coleman-Foster
50th Space Wing Public Affairs

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DISPATCHES

Raytheon and United Technologies Corporation to join forces

Raytheon Company (NYSE: RTN) and United Technologies Corp. (NYSE: UTX) have entered into an agreement to combine in an all-stock merger of equals.

The merger of Raytheon, a leading defense company, and United Technologies, a leading aerospace company, comprised of Collins Aerospace and Pratt & Whitney, will offer a complementary portfolio of platform-agnostic aerospace and defense technologies.

The combined company — Raytheon Technologies Corporation — will offer expanded technology and R&D capabilities to deliver innovative and cost-effective solutions aligned with customer priorities and the national defense strategies of the U.S. and its allies and friends.

The combined company will have approximately $74 billion in pro forma 2019 sales. Under the terms of the agreement, which was unanimously approved by the Boards of Directors of both companies, Raytheon shareowners will receive 2.3348 shares in the combined company for each Raytheon share. Upon completion of the merger, United Technologies shareowners will own approximately 57 percent and Raytheon shareowners will own approximately 43 percent of the combined company on a fully diluted basis.

The merger is expected to close in the first half of 2020, following completion by United Technologies of the previously announced separation of its Otis and Carrier businesses. The merger establishes a broad and complementary portfolio of platform-agnostic capabilities across the high-growth segments of aerospace and defense, reducing risk of concentration in any individual platform or program.

With a combined annual company and customer funded R&D spend of approximately $8 billion, seven technology Centers of Excellence, and more than 60,000 engineers, the company will develop new, critical technologies faster and more efficiently than ever before. Areas of joint advancement include, but are not limited to: hypersonics and future missile systems; directed energy weapons; intelligence, surveillance, and reconnaissance (ISR) in contested environments; cyber protection for connected aircraft; next generation connected airspace; and advanced analytics and artificial intelligence for commercial aviation.

Robust free cash flow growth and a strong balance sheet will support continued investment and return of capital to shareowners. The combined company expects to return $18 to $20 billion of capital to shareowners in the first 36 months following completion of the merger. As a result of the combination, the company also expects to capture more than $1 billion in gross annual run-rate cost synergies by year four post-close, with approximately $500 million in annual savings returned to customers.

Raytheon plans to consolidate its four businesses into two businesses to be named Intelligence, Space & Airborne Systems and Integrated Defense & Missile Systems. The new businesses will join Collins Aerospace and Pratt & Whitney to form the four businesses of Raytheon Technologies. Net debt for the combined company at the time of closing is expected to be approximately $26 billion, with United Technologies expected to contribute approximately $24 billion. The combined company targets an 'A' category credit rating at the time of the closing.

The combined company's Board of Directors will be comprised of 15 members, consisting of eight directors from United Technologies and seven from Raytheon, with the lead director from Raytheon. Tom Kennedy will be appointed Executive Chairman and Greg Hayes will be named CEO of Raytheon Technologies. Two years following the close of the transaction, Hayes will assume the role of Chairman and CEO.

Raytheon Technologies will be headquartered in the greater Boston metro area and will retain a corporate presence in existing locations.

MilsatMagazine is published 11 times a year, by Satnews Publishers,
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DISPATCHES:

SpaceX successfully launches Canada's Radarsat Constellation Mission from Vandenberg Air Force Base

The repurposed SpaceX Falcon 9 launch vehicle lifts off with the Canadian Radarsat Constellation payload from Vandenberg AFB in California. Image is courtesy of SpaceX.

Rising majestically from the fog bank surrounding Vandenberg Air Force Base in California, the SpaceX Dragon launch vehicle has successfully pushed Canada's latest Radarsat satellite into orbit.

In addition, the Dragon's stage one plowed back through the fog, accompanied by a sonic boom, and landed securely on SpaceX's Landing Zone 4 (LZ-4) at Vandenberg.

The Falcon 9's first stage for launch of this RADARSAT Constellation Mission previously supported Crew Dragon's first demonstration mission in March of 2019. The RADARSAT Constellation Mission (RCM) is the evolution of the RADARSAT Program and builds on Canada's expertise in Earth Observation (EO) from space.

The constellation consists of three identical C-band Synthetic Aperture Radar (SAR) EO satellites.

Built by MDA, a Maxar company, the three-satellite configuration of the RCM will provide daily revisits of Canada's vast territory and maritime approaches, including the Arctic up to four times a day, as well as daily access to any point of 90 percent of the world's surface.

The RCM will support the Government of Canada in delivering responsive and cost-effective services to meet Canadian needs in areas such as maritime surveillance, ecosystem and climate change monitoring as well as helping disaster relief efforts.

In example...

- *The RCM will help create precise sea ice maps of Canada's oceans and the Great Lakes to facilitate navigation and commercial maritime transportation. Each satellite also carries an Automatic Identification System receiver, allowing improved detection and tracking of vessels of interest.*
- *The highly accurate data collected by RCM will enable farmers to maximize crop yields while reducing energy consumption and the use of potential pollutants.*

The Falcon 9 liftoff continues on course from Vandenberg AFB. Image is courtesy of SpaceX.

The Falcon 9 first stage rocket's landing burn through the fog to settle back on the pad at Vandenberg AFB. Images are courtesy of SpaceX.

- *Like RADARSAT-2, the RCM will support relief efforts by providing images of areas affected by disasters to help organize emergency response efforts and protect the local population.*

SpaceX's Space Launch Complex 4E at Vandenberg Air Force Base has a long history dating back to the early 1960s.

Originally an Atlas launch pad activated in 1962, SLC-4E was in active use until its last Titan IV launching in 2005.

SpaceX's groundbreaking was in July of 2011 and extensive modifications and reconstruction of the launch pad were completed 17 months later.

SLC-4E consists of a concrete launch pad/apron and a flame exhaust duct. Surrounding the pad are RP-1 and liquid oxygen storage tanks and an integration hangar.

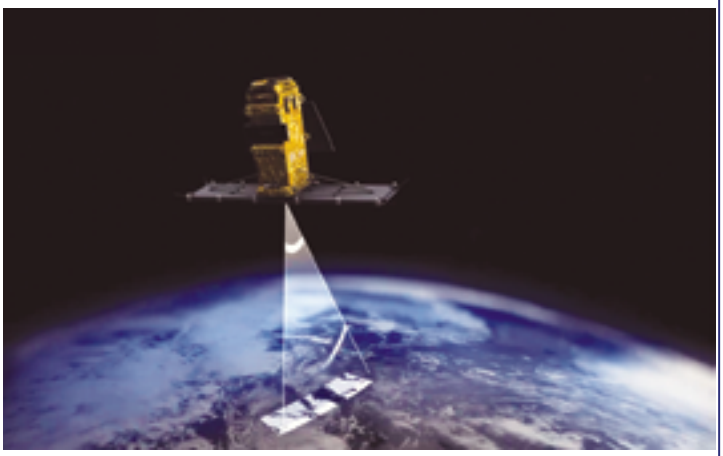
Before launch, Falcon 9's stages, fairing and the mission payload are housed inside the hangar.

A crane/lift system moves Falcon 9 into a transporter erector system and the fairing and its payload are mated to the rocket.

The vehicle is rolled from the hangar to the launch pad shortly before launch to minimize exposure to the elements.

www.spacex.com

asc-csa.gc.ca



Artistic rendition of Canada's Radarsat Constellation Mission satellite. Image is courtesy of Maxar and the Canadian Space Agency.

DISPATCHES: *The seventh of 10 advanced payloads for GPS III delivered by Harris to Lockheed Martin*

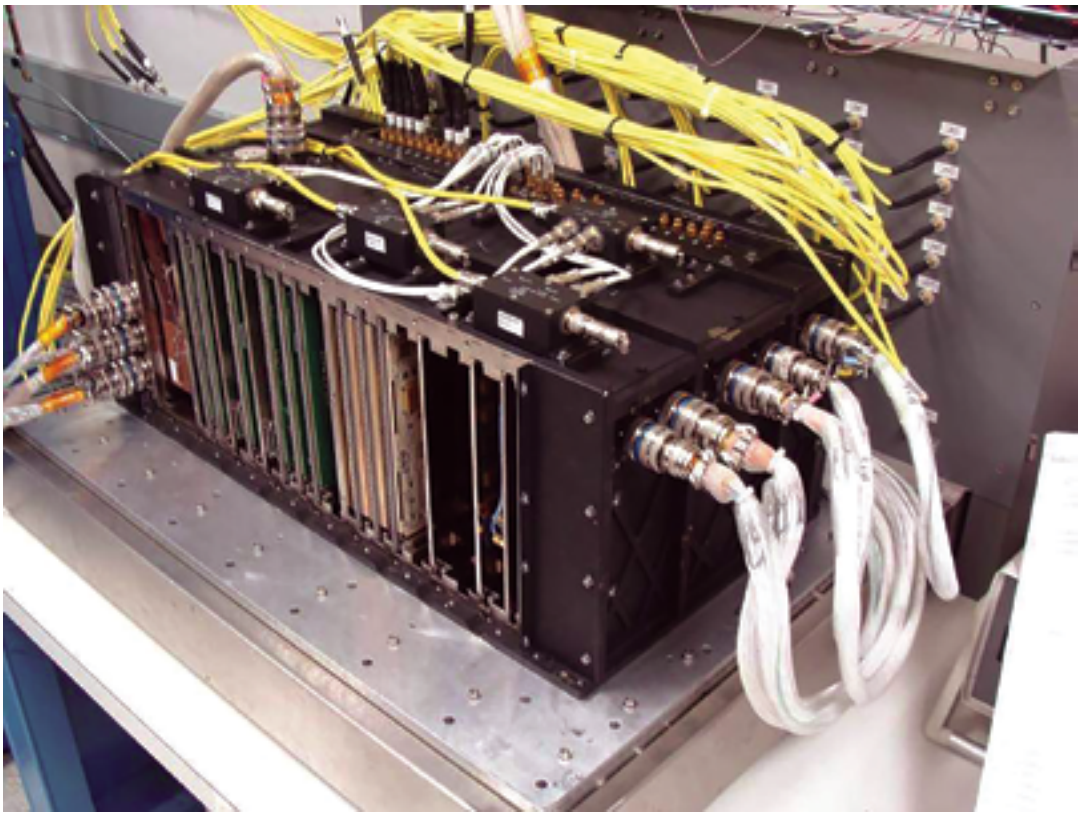
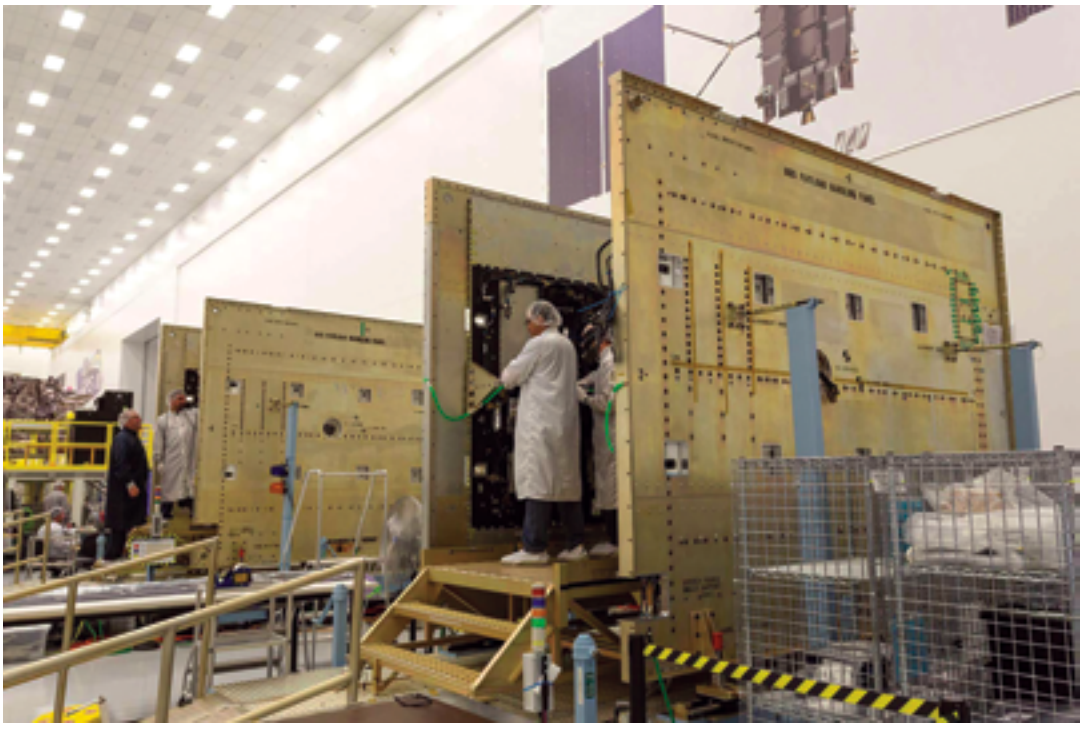


Photo of the Harris advanced MDU navigation payload for GPS III satellites. Photo is courtesy of the company.

Harris Corporation (NYSE:HRS) has provided Lockheed Martin (NYSE:LMT) with its seventh of 10 advanced navigation payloads contracted for the U.S. Air Force's GPS III satellite program.

The GPS III navigation payload features a Mission Data Unit (MDU) with a unique 70-percent digital design that links atomic clocks, radiation-hardened processors and powerful transmitters — enabling signals up to three times more accurate than any GPS satellites currently in operation.



The Lockheed Martin GPS III "satellite factory." Photo is courtesy of the company.

The payload also boosts signal power, which increases jamming resistance by eight times and helps extend the satellite's lifespan.

In 2017, Harris announced that it completed development of an even more-capable, fully digital MDU for the Air Force's GPS III Follow On (GPS IIIF) program.

The new GPS IIIF payload design will further enhance the satellite's capabilities and performance.

In September 2018, the U.S. Air Force selected Lockheed Martin for a fixed-price-type production contract for up to 22 GPS IIIF satellites.

Harris is Lockheed Martin's navigation signal partner for GPS IIIF satellites, and in January received a $243 million award to provide the navigation signals for the first two GPS IIIF satellites, space vehicles 11 and 12.

Harris' expertise in creating and sending GPS signals extends back to the mid-1970s — providing navigation technology for every U.S. GPS satellite ever launched.

While the U.S. Air Force originally developed GPS for warfighters, millions of people around the world and billions of dollars of commerce now depend on the accurate, reliable signal created and sent by Harris navigation technology.

www.harris.com

www.lockheedmartin.com

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DISPATCHES: *SOTM Terminal from Get SAT gains armed forces tactical comms contract*

Get SAT has secured a multi-million-dollar contract from an undisclosed armed force to supply mil-standard, micronized, tactical high-bandwidth broadband communications battlefield ManPacks.

This initial project based on Get SAT's Nano SAT-H Ka-band terminal, will bring complete Satellite-On-The-Move (SOTM) broadband communications – voice, video and data — to the tactical battlefield level.

Get SAT opens a new era of real-time video, audio and information flow by providing direct high bandwidth communications between ground forces and HQ.

The ability to attain seamless 'on the move' communications furthers flexible tactical and strategic decision- making processes on constantly changing battlefields.

Nano Sat-H is an ultra-portable lightweight, low-profile terminal optimized for 'on-the-move' applications and man-carried portability and mobility.

Simply put, Nano SAT-H replaces a truck load of equipment.

Weighing only two kilograms, it provides autonomous operation for transmission and reception of high bandwidth data-rates at more than 2 Mbps.

Kfir Benjamin, CEO of Get SAT stated that connectivity will now be limitless. The ability of ground forces to provide full motion video directly to HQ is the next horizon for MILCOM broadband communications. No longer will decision makers be in the 'fog of the battlefield', rather they will be able to see and hear in real time.

Kfir added that Get SAT is proud to supply this tech savvy military. The company's leap forward in micronized technologies enables the firm's team to lead SWaP and SOTM innovations.

www.getsat.com/products/nanosat_h/

DISPATCHES: *Viasat's CBM-400 software defined modem operates on the WGS network*

Viasat Inc. has revealed that their Commercial Broadband Modem (CBM)-400 has now become the first software-defined modem to successfully complete the Army Forces Strategic Command (ARSTRAT) certification process.

By successfully completing the certification process, the Viasat CBM-400 modem is now the only software-defined modem authorized to operate on the Wideband Global Satellite (WGS) communications network, which will significantly enhance air, land and sea performance capabilities while reducing overall satellite communications (SATCOM) costs for U.S. Department of Defense (DoD) customers.

The Viasat CBM-400 combines the power of high-speed connectivity with the flexibility to switch over to new satellite networks in near real-time in order to meet the needs of nearly any mission and application. The CBM-400 delivers satellite broadband performance whether at-the-halt or on-the-move. With the CBM-400, ground vehicles, sea vessels and aircraft will have the ability to securely send and receive high-definition video, voice and cloud-based networking data from nearly anywhere across the battlespace.

The CBM-400 currently supports three waveforms heavily fielded throughout the DoD including the LinkWay waveform, the Enhanced Bandwidth Efficient Modem (EBEM) waveform and the ArcLight waveform. The software-defined nature of the CBM-400 also allows operators to easily switch between waveforms to meet the unique demands of each mission. The CBM-400 running the LinkWay, EBEM, or ArcLight waveform have all been certified by ARSTRAT for operation on the WGS constellation. The software-defined architecture enables the CBM-400 to readily embrace innovation due to its ability to keep pace with rapidly accelerating private sector SATCOM technology trajectories.

Importantly, the Viasat CBM-400 is purposefully designed to fit into Viasat's Hybrid Adaptive Network (HAN) architecture concept, which would allow users to seamlessly operate across both commercial and government purpose-built SATCOM networks, such as WGS. The HAN concept creates an end-to-end network that provides mitigation against congestion situations, intentional and unintentional interference sources and cyber threats through implementation of layered resiliency in highly-contested environments. Terminal equipment like the CBM-400 supports the HAN architecture concept by readily and affordably adapting to operate over new, innovative SATCOM networks as they become available.

Ken Peterman, President, Government Systems, Viasat, noted that with Viasat's CBM-400, DoD customers now have access to the significant advantages and flexibility of a software-defined architecture, which will allow customers to rapidly meet evolving communications needs and emerging mission requirements by using modems and terminals that readily and affordably adapt to embrace new waveforms and satellite networks.

www.viasat.com

DISPATCHES: *Esri Software Powers Location Intelligence in Microsoft's Defense System Demo*

Esri has announced that Microsoft's Tactical Edge Platform will use Esri's ArcGIS Enterprise to give its Microsoft Azure and Azure Cognitive Services a geographic context through Esri's advanced mapping and spatial analytics technology.

The platform is intended to demonstrate to defense and intelligence professionals how they can use connecting field sensor data and cloud services for domestic emergency response, or for tactical field operations support in theater.

This demonstration is displayed by deploying the platform in a fully operational car called the Tactical Edge Vehicle.

Soldiers or disaster response field personnel, coupled with mobile phones turned autonomous ground sensors, can capture the seen and unseen world around them with elements ranging from wireless infrastructure to photos of the population.

That data is transmitted to ArcGIS, residing in Azure and using Azure Cognitive Services to apply artificial intelligence to the collected data.

The AI-processed results are fused with ArcGIS's spatial analytics, and become actionable across the ArcGIS platform, including pushing results forward into the tactical vehicle's displayed ArcGIS Operations Dashboards.

Operations Dashboards can be quickly created by anyone and custom built for all roles in a mission.

Cloud computing has opened up more versatile and efficient ways of deploying technology to different types of work environments and infrastructures by setting organizations free from the reliance on a central server.

Market research firm Forrester recognized Esri in The Forrester Wave™: Location Intelligence Platforms, Q4 2018 Evaluation, which acknowledges Esri's leadership in location intelligence technology and highlights the company's long-term commitment to innovation in its market-leading geospatial cloud.

Using the open-standards of these Commercial-Off-The-Shelf (COTS) products immediately connects ArcGIS compatible partners through ArcGIS to Azure and can be used by the tactical vehicle. In this demonstration, it includes Knowledge Bridge International (KBI) for the sensor network, and Meemim's vGIS using Microsoft Hololens. Both KBI and Meemim are among the hundreds of Esri partners.

Lily Kim, GM, Azure Global at Microsoft, said Esri's cloud-based platform enables networks of sensors to be analyzed geospatially and, coupled with Microsoft Azure Cognitive Services, allows for that sensor information to be analyzed around the clock supporting various roles from the edge to the intelligence centers.

This delivers the type of data insights to customers in the field that they require to respond effectively in today's fast paced world.

Tim Murphy, Director of Contextual Intelligence at Esri, added that Microsoft has provided a great opportunity for the firm to demonstrate the rapid deployment of the company's geospatial capabilities, providing online and offline capabilities to customers in disaster management and those forward supporting humanitarian and national defense missions alike.

He noted that Microsoft's collaboration with Esri has provided unparalleled value to our customers for more than 15 years. This new demonstration in the Microsoft Tactical Vehicle brings together how Esri's technology can fully geo-enable tactical operations for real-time spatial awareness.

www.esri.com/

DISPATCHES:

Lockheed Martin's COps software for the USAF's Ground Control System is checked in for GPS III satellites

On May 22, Lockheed Martin (NYSE: LMT) delivered the GPS III Contingency Operations (COps) software upgrade to the U.S. Air Force's current GPS ground control system.

This upgrade will enable the U.S. Air Force (USAF) to start commanding the new, next-generation GPS III satellites now coming off the production line and starting to launch.

The first GPS III satellite launched in December 2018; the second GPS III shipped to Cape Canaveral in March for a July launch; and the USAF, on May 17, declared the third new GPS III "Available for Launch" next.

The challenge was modernizing the current ground system — formally known as the GPS Architecture Evolution Plan Operational Control System (AEP OCS) — to fly the legacy constellation, as well as the new, modern GPS III satellites, until the next generation Operational Control System (OCX) Block 1, still in development, is delivered.

To address this, in 2016, the USAF contracted Lockheed Martin to develop the GPS III COps program.

Currently, the AEP OCS controls 31 GPS IIA, IIR, IIR-M and IIF satellites launched between 1993 and 2016. With the AEP OCS' new GPS III COps upgrade, the USAF will be able to command and control both the legacy satellites, as well the more powerful GPS III satellites.

Meanwhile, the first GPS III space vehicle (GPS III SV01), launched in December 2018, is finishing up pre-operational on-orbit check-out.

It continues to be controlled by OCX Block 0 software installed at Lockheed Martin's GPS III Launch and Checkout Center at the company's Denver facility.

GPS III SV01 is expected to be "handed over" to the COps OCS later this year after the legacy constellation is moved over to the updated AEP OCS.

Lockheed Martin has sustained the AEP OCS since 2013. In November 2018, the company completed the AEP 7.5 upgrade -- the largest architectural change in the systems history -- replacing significant code, hardware and software to improve the system's cybersecurity capabilities and positioning the USAF to better operate in contested, degraded and operationally limited environments.

In December 2018, the USAF awarded Lockheed Martin the GPS Control Segment Sustainment II (GCS II) contract to continue to further modernize and sustain the AEP OCS through 2025.

In 2020, the AEP OCS is expected to receive the M-Code Early Use (MCEU) upgrade, which will allow control of M-Code, an advanced, new signal designed to improve anti-jamming and anti-spoofing, as well as to increase secure access to military GPS signals for U.S. and allied armed forces.

Lockheed Martin is under contract to develop and build up to 32 GPS III/IIIF satellites.

GPS III will deliver three times better accuracy and provide up to eight times improved anti-jamming capabilities. GPS III's new L1C civil signal will make it the first GPS satellite to be interoperable with other international global navigation satellite systems.

Additional "IIIF" capabilities, beginning at the 11th satellite, will include a fully digital navigation payload, Regional Military Protection, an accuracy-enhancing laser retroreflector array, and a Search & Rescue payload.

www.lockheedmartin.com

A GPS III satellite in production at Lockheed Martin. Photo is courtesy of the company.

DISPATCHES: *U.S. Marines now fielding MUOS SATCOM system*

U.S. Marine Corps Cpl. Frankie Garcia, a radio chief with Alpha Battery, Battalion Landing Team 3/5, 11th Marine Expeditionary Unit (MEU), calls for a radio check using a PRC-117G radio at Marine Corps Base Camp Pendleton, California. The Marines and Sailors of the 11th MEU are conducting routine operations as part of the Boxer Amphibious Ready Group. Photo is courtesy of the U.S. Marine Corps — Lance Cpl. Jason Monty.

The U.S. Marine Corps (USMC) recently began fielding a next-generation, narrowband, satellite communication system that assists warfighters in connecting to networks on the battlefield.

Fielded in the first quarter of 2019, the Mobile User Objective System provides satellite communication capabilities to mobile or stationary Marines. The system enables the warfighter to leverage cellular technology to increase access to voice and data communication while using the MUOS network.

The MUOS capability encompasses updated firmware to the AN/PRC-117G radio system and one of three antenna kits. The antennas help Marines simultaneously access SATCOM networks and gives them secure and non-secure internet access. MUOS also improves overall reliability in urban environments, challenging vegetation and other arduous conditions.

The first service to widely employ MUOS, the USMC is deploying thousands of antenna kits for the AN/PRC-117G radio system and hundreds of diplexers that enable vehicular systems to access MUOS satellites.

Satellite communication has become increasingly important for the USMC in the 21st century. According to the Department of Defense (DoD), more than 50 percent of DoD satellite communication involves narrowband communication. Yet, this form of communication accounts for less than 2 percent of the DoD's bandwidth, making it an efficient way to transmit information.

Prior to fielding MUOS, MCSC had to demonstrate to the Milestone Decision Authority that the system was safe, met technical performance and was ready to use by the warfighter. Since MUOS's Field User Evaluation in 2017, Marines have raved about the benefits of the system.

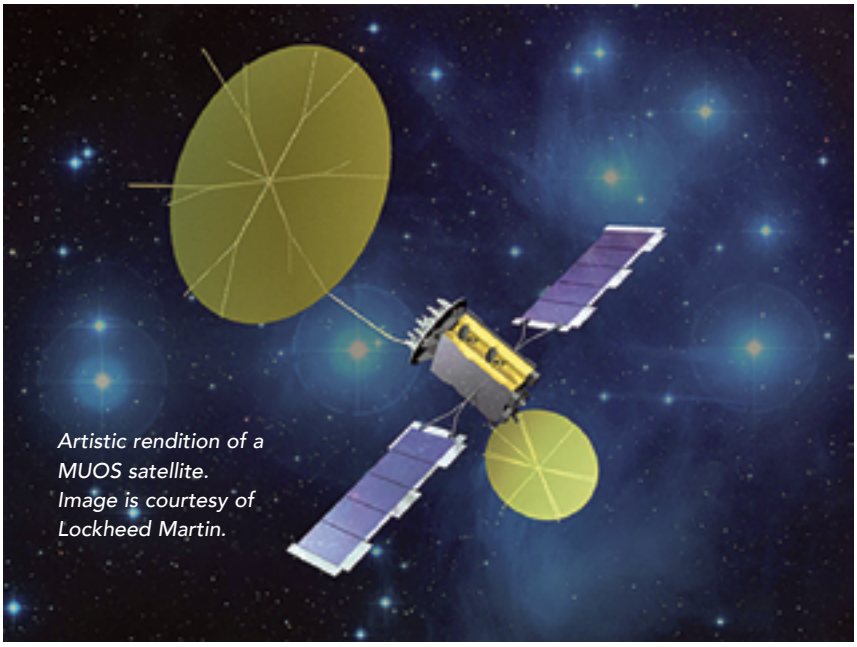
Eddie Young, project officer of Multiband Radio II Family of Systems at Marine Corps Systems Command, said MUOS is another way for warfighters to communicate in a tactical environment.

The system brings SATCOM capabilities in various formats to Marines. The Marine Corps is leading all services in terms of getting MUOS to warfighters. Marines find MUOS useful in completing their missions — a lot of positive feedback has been received, thus far.

According to *Noah Slemp*, systems engineer at MCSC, MUOS is essentially software and an antenna capability augmenting existing hardware. It's similar to adding an application to a cellphone. MUOS is particularly important because the SATCOM infrastructure of the legacy system is nearing its expiration — as a result, the Corps intends to incrementally replace the older capabilities with the MUOS waveform, enabling more Marines to access ultra-high frequency tactical satellite communications.

The efforts of Young's team in getting the system out to the warfighter have not gone unnoticed. In May 2018, at a Narrowband Working Group conference in Colorado Springs, Colorado, the Joint Staff J6 and the DOD Chief Information Officer recognized Young and Slemp for leading the services in employing MUOS.

The J6 and DOD CIO also emphasized the joint effort between the Multi-band Radio II team and the Naval Information Warfare Center in using the Multiple Reconfigurable Training Systems, an interactive training aid that will be used to assist in the rapid fielding of MUOS.



Artistic rendition of a MUOS satellite. Image is courtesy of Lockheed Martin.

DISPATCHES: *MANTA+ terminal is adopted by U.S. SOF community*

Paradigm, Lepton Global Solutions and Kymeta are proud to announce that the MANTA+ solution has been adopted by the United States Special Operations Forces community and is now commercially available for other users.

This fully integrated satcom and LTE solution ensures constant connectivity by seamlessly switching between satellite, cellular and WiFi networks.

Operational both as a comms-on-the-pause terminal and a comms-on-the-move terminal, the MANTA+ is self-pointing and provides automatic network switching via the integrated LTE router.

The unit has no moving parts and is discreet, the user just adds power. Any device connected to the MANTA+ (whether wirelessly or via a physical port) will be routed via WiFi, cellular or satellite depending on real time availability, service weighting and/or least cost.

paracomm.co.uk
leptonglobal.com
www.kymetacorp.com

DISPATCHES: *Astrotech encapsulates AEHF-5*

The U.S. Air Force's fifth Advanced Extremely High Frequency (AEHF-5) communication satellite was encapsulated on June 5 at the Astrotech Space Operations processing facility in Florida.

The encapsulation of AEHF-5 in the United Launch Alliance Atlas V launch vehicle payload fairing is a significant milestone in AEHF-5's launch process as it marks the completion of all major testing activity prior to launch. AEHF-5 is now ready to make the journey to Space Launch Complex-41, where it will be mated with its Atlas V launch vehicle. The launch window is currently scheduled to open at 06:00 a.m. EDT on June 27.

Artistic rendition of the U.S.A.F.'s AEHF-5 satellite.

AEHF is a joint service satellite communications system that will provide survivable, global, secure, protected, and jam-resistant communications for high-priority military ground, sea, and air assets.

The AEHF system is the follow-on to the Milstar system, augmenting, improving, and expanding the Department of Defense's MILSATCOM architecture.

AEHF-5 was procured from Lockheed Martin Space Systems Company by the MILSATCOM Systems Directorate, part of the Air Force's Space and Missile Systems Center.

The MILSATCOM Systems Directorate plans, acquires, and sustains space-based global communications in support of the President, Secretary of Defense, and combat forces. The MILSATCOM enterprise consists of satellites, terminals and control stations, and provides communications for more than 16,000 air, land, and sea platforms.

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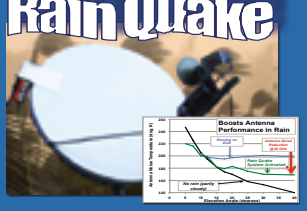

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FOR RESILIENT EMERGENCY RESPONSE COMMS…

Satellite is the new "Go To" Solution

By Doreet Oren, Product Marketing and Corporate Communications, ***Gilat Satellite Networks***
www.gilat.com/

Government and defense organizations responsible for homeland security, public safety and emergency response cannot compromise when it comes to connecting assets in the field to their command centers. Whether dealing with a natural disaster or a terrorist attack, reliable communications and access to live information are essential prerequisites for effective emergency response.

The inconvenient truth, however, is that establishing secure broadband connectivity can be a major challenge in homeland security and other emergency scenarios. Natural and other disasters may take place in remote areas beyond the reach of terrestrial networks, or in other cases may cause the existing communications infrastructure to collapse.

When lives are on the line and every second counts, first responders and security forces require advanced technologies that can be rapidly deployed anywhere to support voice, video and data applications. Effective real-time communications and continuous situational awareness are crucial for making high-pressure decisions in the most challenging circumstances.

Climate Change Ramping Up Frequency and Severity of Natural Disasters

Climate change is not going away and its impact on natural disasters is causing governments and mobile network operators (MNOs) to rethink their emergency preparedness and emergency response strategies.

Secure broadband connectivity can be a major challenge in homeland security and other emergency scenarios.

Weather patterns are becoming more volatile and are expected to become even more extreme in the future. In 2018, there were 58,000 wildfires in the U.S. alone, while the Atlantic hurricane season produced 15 tropical storms, including eight hurricanes. The impact of such storms on communication networks can be catastrophic. In 95.2 percent of the cell sites in Puerto Rico — or 1,703 out of 1,789 — were knocked out of service (according to the FCC). At the same time, severed fiber connections and flooding brought down the terrestrial backhaul networks.

To meet the public's ever-growing reliance on mobile communications, there is a growing interest in broadband communication that is not dependent on the risk-prone terrestrial infrastructure. This is why we are seeing more government organizations, MNOs and emergency organizations adopting alternative solutions, such as satellite communications, for emergency response and disaster recovery.

As more satellites are being launched we are witnessing an abundance of capacity which

The Gilat-Sprint emergency response team in Puerto Rico deploying the company's VSATs. Photo is courtesy of Gilat Satellite Networks.

in turn is lowering prices, making satellite communication ever more affordable and thus a feasible solution for emergency response.

Satellite Communications to the Rescue

Independent from terrestrial and wireless infrastructure, satellite communications provide a secure and reliable solution that can be deployed quickly for disaster response or national emergencies. Its value proposition is derived from the following key attributes:

Bypass terrestrial

Satellite communications are commonly the only viable connectivity option in areas where terrestrial infrastructure does not exist. Cellular backhaul over satellite solutions enable MNOs to extend network coverage to remote areas beyond the reach of terrestrial infrastructure, enabling emergency services to operate seamlessly in virtually any location.

In other cases, satellite backhaul can serve as a backup solution should the terrestrial network go offline due to a disaster. In emergency situations in metro areas, the terrestrial infrastructure is often destroyed by a sudden disaster.

This means that precisely when communication is most important for saving lives it is, all too often, not available due to network breakdown.

Reliability

Satellite is a robust alternative to terrestrial fixed or wireless technologies. Satellites have almost complete immunity from catastrophic events such as hurricanes, floods, and earthquakes. In these emergency scenarios, satellite enables immediate vital communications for relief efforts, which otherwise could take days or weeks (and sometimes longer) to set up.

The EE emergency services deployed with Gilat On-The-Pause VSAT solution.

Moreover, as SATCOM does not rely on the same last mile pipes as the terrestrial network, connectivity can often be maintained during a disaster, or be restored rapidly afterwards so public safety personnel can continue working after the primary terrestrial network fails. Using a VSAT connected to the hub via a satellite link, emergency crews can have full access to voice and data communications.

Resiliency

Satellite is the only wireless communications infrastructure that is not susceptible to damage from disasters, because the main repeaters sending and receiving signals (on the satellite) are located outside the Earth's atmosphere.

Due to its reach and reliability, satellite-enabled solutions can quickly connect security forces and first responders in any location. Such solutions are proven to be a highly efficient and reliable method for supporting public safety and disaster relief.

Easy and fast to deploy

Satellite communications enable easy network deployment and integration with the core network in both fixed sites and ad-hoc locations. For example, on-the-move and on-the-pause communication can be quickly set-up and deployed on vehicles to provide public safety and security forces in any location with secure and reliable voice and data communications.

SATCOM systems are portable and quickly deployable, while allowing plug-and-play connectivity. In addition, satellite-enabled solutions are compatible with the whole range of communication tools used by first responders, whether based on narrow band (*e.g.*, Tetra) or broadband (*e.g.*, cellular LTE network) infrastructure.

Direct broadband connectivity for voice and data

As satellite bandwidth capacity costs continue to come down, satellite has become an affordable alternative for direct broadband connectivity. On-the-pause and on-the-move communications can support high-speed data, voice and internet access for first responders and security personnel. This includes broadcasting alerts and messages to selected population in times of emergency over a public network.

Supporting Multiple Emergency Response Use Cases

Satellite-enabled solutions support a wide variety of emergency preparedness and response use cases. Not only is satellite an ideal solution in rural and remote areas where deploying a terrestrial network is cost-prohibitive or unfeasible, it is also an effective backup solution for critical BTS' in urban and other areas.

Permanent Coverage Extension

Satellite backhaul can be used as a primary connection to reach remote locations not covered by terrestrial network. In this way, remote locations enjoy high-speed services and continuous coverage independent of the terrestrial network.

In the event of an emergency, satellite-enabled coverage extension ensures connectivity at remote sites.

Permanent Network Backup

Critical BTS sites in the network use a satellite connection to backup the terrestrial backhaul to ensure business continuity. The satellite connection serves as a redundant secondary network deployed in stand-by mode and is activated in the case of a primary network failure. For example, if the terrestrial network goes offline due to flooding or earthquake, satellite connectivity allows mission-critical applications to get back online in seconds.

Public Safety and Security

Satellite-On-The-Move (SOTM) solutions provide first responders with reliable voice and data communications from vehicles, as well as handling backhaul for 2G/3G/4G networks. Secure, broadband connectivity improves situational awareness and response time for police and frontier guards, as well as supporting off-road emergency command and control tasks. Using on-the-move antennas, emergency personnel can communicate on their way to the scene with other vehicles and with HQ to receive live updates and coordinate rescue efforts.

Temporary Backhaul Recovery

Often, the effectiveness of emergency response efforts depends on the ability to quickly mobilize and deploy the right solution. When the terrestrial backhaul, link fails due to any type of disaster, a portable Flyaway kit provides responders with a quick-to-deploy satellite solution. This lightweight suitcase includes the full VSAT terminal and tripod for easy and fast mounting of the antenna for temporarily restoring communication.

Temporary Site Recovery

When the permanent BTS fails, fast on-the-pause communication recovery can be provided using a vehicle-mounted solution. These solutions typically comprise a Cellular on Wheels (COW)/ Cellular on Light Truck (CoLT) BTS and a VSAT terminal for handling the satellite backhaul.

Temporary Increased Capacity

A vehicle-based terminal with satellite backhauling can be rolled-in temporarily to provide additional coverage and increased capacity over the terrestrial link for both planned and unplanned scenarios. Examples include emergency support for a field hospital, large gathering of refugees or displaced persons, as well as major sporting events or outdoor concerts.

Temporary Airborne Site

Tethered balloons and drones can be deployed to temporarily fill coverage gaps at short notice and re-establish the communication network. The balloon or drone carries a 3G/4G small cell on board, while the VSAT on the ground connects to the main network via a satellite backhaul link. Such a solution is useful in providing connectivity in areas hit by natural disasters and to increase coverage as needed.

Real-World Emergency Response and Backup Deployments

Let's take a look at some examples of how government organizations responsible for emergency response teams are adopting satellite-based solutions to enable fast and effective emergency response communications in both urban and rural areas.

Network Resilience and Backup in the UK

EE, part of the BT Group and an operator of one of Europe's largest 4G networks, is working with Gilat Satellite Networks to build out the world's largest 4G Emergency Services Network (ESN). EE was commissioned by the UK's Home Office to deliver emergency service coverage for the whole of the UK over its soon-to-be nationwide 4G network. EE's objective is to extend LTE network coverage to over 95 percent of the UK landmass by 2020. The ESN will run over EE's commercial network and automatically grant priority use to Emergency Services.

EE is using Gilat's field-proven cellular backhaul solution to extend ESN coverage to remote areas without terrestrial infrastructure, enabling emergency services to operate seamlessly in any location throughout the UK.

Gilat is in the process of deploying about 1,000 LTE satellite backhaul sites, including weather-proof VSATs. These sites will enable service in areas without terrestrial infrastructure or in other cases serving as a backup solution. Satellite capacity for the dedicated ESN is provided by Avanti's Ka-band HYLAS satellite fleet, which covers 100 percent of the UK and will connect all EE LTE sites across the country.

The ESN enables network resilience in the event of a cell site failure, as well as providing immediate high-speed voice and data connectivity to emergency response teams in the field. Gilat's VSAT delivers true LTE speeds to 4G handsets and fully supports encrypted data. The ESN deployment comprises both fixed and portable on-the-pause cell sites, which use a vehicle-mounted solution containing both the cell node and the Gilat VSAT that handles the backhaul.

National Emergency Response in Portugal

Due to Portugal's very dry summers, devastating wildfires are a common seasonal occurrence, endangering lives and causing severe damage to communication providers' critical infrastructure.

The Portuguese government, together with its communications partner Altice/Portugal Telecom, established the National Emergency and Safety Network (known as SIRESP) to provide rapid service recovery in the event of a wildfire or other

EE emergency service in use.

major disaster. The partners realized that the legacy TETRA-based emergency communications network in Portugal could not perform reliably with the terrestrial infrastructure in disaster scenarios.

To overcome the limitations of terrestrial networks, they decided to deploy satellite backhaul as a backup service for the Tetra network. If the terrestrial backhaul fails, satellite is used to connect the core network to outlying BTS' until the terrestrial backhaul network can be restored.

Over 600 Gilat VSATs were deployed across Portugal to enable fixed and on-the-pause satellite backhauling to serve the national emergency Tetra network. The Gilat VSAT is deployed on a vehicle, while the temporary cell can be deployed on the vehicle or a fixed site. Using Gilat's solution, the critical communications infrastructure that covers most of the country is now backed up via satellite.

Restoring Communications in Hurricane-Stricken Puerto Rico

Sprint is federally funded to assist in communication in times of emergency. Working with Gilat, Sprint has upgraded its nationwide Emergency Response Team (ERT) fleet to LTE to be prepared to rapidly provide communication throughout the U.S. in case of disasters such as floods, hurricanes or fires. Satellite backhaul gives Sprint ERT the flexibility to bring communications into hard hit areas using SatCOLTs (Satellite Cell on Light Trucks) and Fly Away Kits to provide cellular, LTE and IP data services during times of emergency and disaster.

Sprint played a vital role in restoring mobile communications to Puerto Rico following Hurricane Maria in 2017. More than 50 Gilat VSATs were installed by Sprint's ERT on the main island of Puerto Rico, as well as Vieques, Culebra and the U.S. Virgin Islands. Gilat's satellite backhaul solution allowed Sprint to restore key cell sites within hours in areas where there were no communications. In addition to restoring cell sites and broadband connectivity, satellite backhaul was also used to assist emergency management officials.

Next Generation Disaster Response Platform in Japan

LASCOM

Local Authorities Satellite Communication — is responsible for operating a Disaster Response system for Japan's 47 prefectures. LASCOM required a resilient, high throughput and affordable VSAT network that could ensure communication services to local governments, individuals, and first responders in the event of a disaster. These services include voice, video feeds from disaster sites, video multicasts to local sites, emergency alerts, mobility and data services.

To meet its five-year goals for national coverage, LASCOM chose to deploy Gilat's direct broadband connectivity over satellite solution. This deployment comprises Gilat's redundant multi-service hubs deployed in two different locations and thousands of VSATs will be deployed across Japan.

Conclusion

As the magnitude of natural disasters, terrorist attacks and other security incidents continues to increase, satellite-based solutions are being adopted by government agencies, homeland security and communications service providers to support emergency services and network resiliency. Offering unique and proven value for emergency responders, satellite communications are quickly becoming an indispensable component for disaster recovery, emergency preparedness and response planning.

Governments and network operators realize that satellite not only helps to strengthen the resiliency of existing communication networks, it also contributes directly to saving lives.

When disaster strikes, satellite often remains the only viable connectivity solution in areas where existing terrestrial infrastructure is no longer available.

Furthermore, the dropping prices of satellite capacity are making satellite communication the feasible solution to solve today's emergency communication needs.

Gilat is at the forefront of delivering emergency service communication solutions for numerous deployments worldwide.

www.gilat.com/

Doreet Oren (doreeto@gilat.com) is the Director of Product Marketing and Corporate Communications for Gilat Satellite Networks. Doreet Oren has been in this role since 2012 and has been responsible for defining product positioning, messaging, go-to-market strategies, market research, and analyst relations.

Oren has more than 20 years of industry experience, and has held management positions in R&D, product management and product marketing, for international high-tech companies. In this capacity she contributed to next generation product definition and was responsible for delivering the company's vision to the media and analyst community.

Oren has published thought leadership articles in renowned international journals, and has spoken at numerous industry conferences worldwide. She received a BSc in Computer Science from George Washington University.

Sprint emergency response team in Puerto Rico deploying Gilat VSATs

THE URGENCY, NECESSITY AND CHALLENGES OF ENTERPRISE SATCOM

By Mike Moran, Vice President, Space Strategies, ***Peraton***
www.peraton.com/

U.S. military and intelligence operations must effectively navigate through contested environments with life and liberty critically reliant on communications — adversaries understand our ability to do so is acutely dependent on space systems. That's why adding resilience and diversified solutions to satellite communications (SATCOM) is so essential.

Historically, as the U.S. Department of Defense (DoD) was the lead investor for SATCOM, DoD was in control of SATCOM capabilities.

Now, as commercial market innovations frequently outpace military technology, there's ample opportunity to diversify DoD's SATCOM solutions by bringing commercial technology more broadly into the mix, particularly with the transition of commercial SATCOM services procurement from the Defense Information Systems Agency (DISA) to the U.S. Air Force Space Command (AFSPC).

The stage is now set for true enterprise satellite communications capabilities that allow a military or intelligence operator to seamlessly flex between any available resources to successfully achieve vital mission outcomes when communications are contested.

"*The SATCOM mission is critical to the success of our joint warfighters on the battlefield and requirements for this capability continue to increase*," said General *Jay Raymond*, AFSPC commander and nominee to command U.S. Space Command. "*The new acquisition authority better integrates our military and private SATCOM sectors, ensuring our warfighters have the communications capabilities they need to fight and win. Our vision is for users to be able to connect quickly among different satellite constellations or service providers.*"

Within the SATCOM paradigm, retaining the option to tailor solutions that allow customers to control and manage specific capabilities remains a required construct.

Challenges remain in bridging past and present communications infrastructures, concepts of operations, and procurement practices to maximize enterprise agility, given historical differences in how DISA and AFSPC have approached SATCOM capabilities. An effective enterprise SATCOM approach, however, can serve to bridge these challenges.

Key to this enterprise approach will be the nexus of trusted mission partners to AFSPC's commercial satellite communications office and military SATCOM (MILSATCOM) systems directorate.

Agile relationships with emerging commercial technology providers, and SATCOM integrators such as Peraton who can broker a broad array of fielded SATCOM capabilities while offering rapid demonstration and testing of emerging technologies, are necessary.

Additionally, leveraging future mega-Low Earth Orbit (LEO) communications satellite constellations and supporting test, evaluation, and military utility assessments can streamline the process of expediting nascent capabilities and technologies to sufficient maturity for DoD use.

The resultant advantage for military customers is more rapid, reliable injection of impactful new SATCOM technologies and communications diversity into operational environments.

Within the SATCOM paradigm, retaining the option to tailor solutions that allow customers to control and manage specific capabilities remains a required construct.

On the flip side, for those needing standard capabilities, providing reliable managed services at all levels of classification must also be an integral element.

One non-negotiable condition applicable to every customer is security — it must always be baked into the mix. Peraton's cybersecurity expertise runs deep and wide — from defending infrastructures against cyber-attacks to offering integrated cross-domain solutions, products, and services.

The interconnected SATCOM enterprise demands optimal security vigilance with proven risk management practices to continuously monitor, detect, and respond to adversary attacks that target the very infrastructure upon which SATCOM capabilities rely.

In addition to bridging military and commercial capabilities, there's a compelling reason to consider the civil component in the wider communications discussion. With more than three decades of mission partnership with NASA, Peraton has supported national space and range programs from launch to on-orbit operations.

The company's advanced technologies manage distant spacecraft and facilitate vital data exchange while driving efficiencies in the development, operation, and maintenance of some of the most complex mission systems on Earth. Effectively linking these complementary defense, intel, commercial, and civil SATCOM components offers more expansive, cost-effective, low-risk synergies for military and government customers while adding resilience to the enterprise. Integrating emerging technologies from the commercial and civil realm with clear-eyed understanding of the complex operational demands of the defense and intel community is precisely Peraton's forte.

At the heart of the company's highly reliable enterprise SATCOM architecture is a network of partnerships that spans U.S. defense, intel, civil, interagency, and commercial alliances, as well as extends to international and coalition partners, to seamlessly deliver the secure, resilient global capability demanded. Engaging with a proven global mission partner can help augment and complement formal government-to-government relations on both the civil and the military side.

Moreover, rapidly integrating new technologies, particularly those arising from commercial ventures, can be a real game-changer.

Peraton's enduring government customer partnerships aligned with its commercial relationships serve to ensure emerging technologies of interest are quickly made available for consideration in advancing national security missions.

Government customers can rest assured not only of their reliable receipt of contracted communications services, but also gain the opportunity to test drive what's new — weigh the pros and cons — and implement incrementally or wholesale into their enterprise SATCOM architecture and associated acquisition programs.

As General Raymond summed up the matter, "*The end-state vision is for a SATCOM user to be able to roam rapidly among different satellite providers and/or constellations, ultimately enabling more flexible, resilient SATCOM.*"

Peraton, built on a strong legacy of advanced communications capabilities and trusted partnerships, is bringing new technologies and resilient, integrated enterprise solutions to defend and expand the nation's space advantage. The imperative is to empower U.S. and allied warfighters and explorers to advance their vital national security missions.

Michael J. (Mike) Moran is Vice President, Space Strategies. In this role, he establishes and directs the growth strategy for Peraton's Air Force space portfolio. Mike serves as account executive for Air Force space programs while supporting Peraton's broader space and cyber strategy within the Department of Defense and Intelligence Community.

Additionally, Mike leads executive level engagement with senior government clients to facilitate understanding of customers' strategic needs and guides solutions that increase customer value and achieve revenue growth.

Previously, Mike served for more than 26 years in the United States Air Force (USAF) with command assignments at the squadron, group and wing levels. His USAF career spans space, launch, cyber, airborne, and foreign military sales programs to include executive and enterprise leadership within Air Force Space Command, the National Reconnaissance Office, the Pentagon, and the North Atlantic Treaty Organization. In these capacities, his responsibilities included program management, engineering, and operations in the U.S. and in Afghanistan while deployed during Operation Enduring Freedom.

Mike is a senior executive fellow with the John F. Kennedy School of Government at Harvard University. He holds a master of science degree in national resource strategy from the National Defense University; master of science degree in military operational art and science from Air University; master of science degree in systems management from the University of Southern California; and a bachelor of science degree in mechanical engineering from the University of Virginia. He is a certified Program Management Professional and Certified Information Systems Security Professional.

THE ADVANCED FIRST RESPONDER VEHICLE:

A prototype for the autonomous car

By Ben Posthuma, Connectivity Solutions Manager, ***Kymeta***
www.kymetacorp.com/

Automobile and technology companies are competing fiercely to be the first to launch fully autonomous vehicles (AVs). These vehicles will have sophisticated, high-speed systems and computers that generate, process, and transfer vast amounts of data.

In addition to internally generated data from vehicle cameras, radar, LIDAR, and sensors, there will be huge amounts of external data from cloud services, such as realtime high-resolution maps that integrate static and dynamic conditions, driving assistance, and systems updates.

Additionally, vehicle occupants will want access to infotainment services, social media, and mobile office capabilities.

The Automotive Edge Computing Consortium (AECC) estimates that the data volume per vehicle by 2025 will approach 10 exabytes per month, up to 10,000 times more than the present volume [1].

The transfer of enormous amounts of data to and from the vehicle will require it to be connected via reliable distributed networks to the cloud (V2C), other vehicles (V2V), and the surrounding infrastructure (V2I). Also, safety requires that network connections be constant, since even brief interruptions could be catastrophic.

The challenging requirements of high data volume and constant connection will have to be met for the success of tomorrow's autonomous cars, but these problems are already being faced and solved by the designers of bespoke first responder (FR) vehicles.

"... vehicles will have sophisticated, high-speed systems and computers that generate, process, and transfer vast amounts of data."

Their solutions can serve as a model for the data and communications architectures of AVs.

The Advanced First Responder Vehicle

First responders are relied upon 24 hours a day to provide assistance, security, and medical aid at the scenes of accidents, disasters, and other emergencies.

The ability to communicate instantly and reliably with personnel at the scene, with headquarters, and with the cloud is essential.

Their vehicle is the local hub for incident data collection and analysis as well as voice and video communications.

Examples of high-end custom FR vehicles include...

The Nomad Global Communication Solutions vehicles

The Microsoft Tactical Command Vehicle

The Microsoft Advanced Patrol Platform.

These vehicles:

- *Act as IoT (Internet of Things) hubs by collecting and analyzing data from cameras and sensors (Figure 1)*
- *Process and store edge data (including maps, building diagrams, and incident information) with an on-board cloud instance (Figure 2)*
- *Serve as local communication hubs via radio and mesh networks (Figure 3)*
- *Provide always-on connectivity to the cloud by seamlessly integrating cellular and satellite links (Figure 4)*

Comparison of First Responder and Autonomous Vehicles

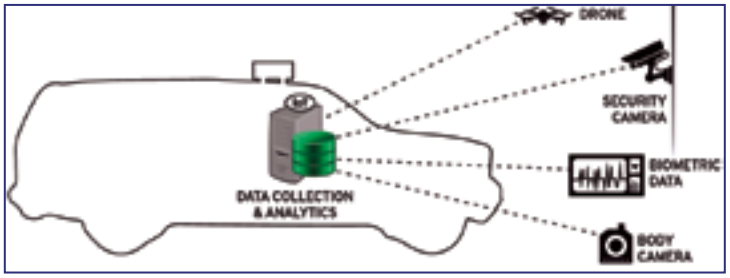
If we compare the data collection, processing, and communications functions of today's custom FR vehicles with the expected requirements for fully autonomous (SAE level 5 automation [2]) vehicles, the parallels are evident (***please see Table 1 on the following article page***).

Although the data volumes are not of the same order, both types of vehicles rely on edge and cloud processing, and on a reliable flow of information with field personnel and between local and remote locations. For both, a constant wireless backhaul connection is essential.

Ensuring Always-On Connectivity

The problem of maintaining constant connectivity is a significant one for first responders. The capacity of current terrestrial networks is often overloaded during disasters or crowded events such as concerts and games, causing interruptions in service. Despite the investments by mobile service operators to increase the capacity of their networks, the rapid increase in mobile data traffic means that overload situations will continue to occur. Furthermore, natural disasters such as hurricanes and earthquakes can damage cellular infrastructure, causing service to be down for days at a time.

Even when terrestrial networks are functioning normally, coverage can be spotty in hilly or heavily forested terrain, between tall buildings in a city, or during heavy rainfall. In rural regions outside of cellular coverage areas, there is no service. This situation will not improve significantly in the near future. Projections indicate that by 2020 only 63 percent of the world's population and 37 percent of the landmass will be covered by LTE [3].



The FR vehicle is an IoT hub.

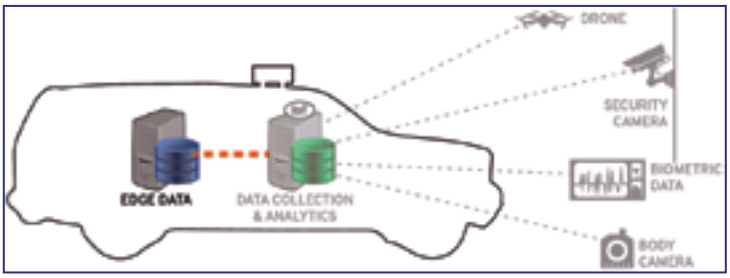


Figure 2. The high-end FR vehicle stores and processes edge data (cloud instance in vehicle.)

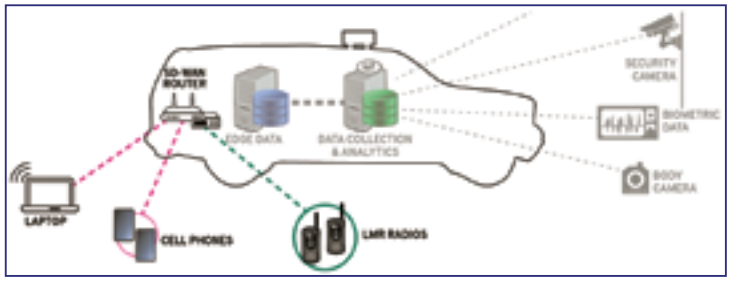


Figure 3. The FR vehicle is a local comms hub.

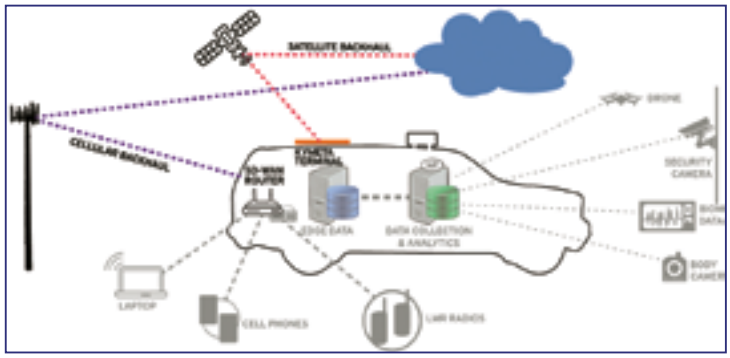


Figure 4. the advanced FR vehicle seamlessly integrates satellite and terrestrial networks.

Because of these issues with cellular services, first responders must sometimes deploy emergency satellite communications vehicles or trailers to the scene of the incident to ensure reliable broadband data connections (***Figure 5***). These vehicles typically have parabolic dish antennas, so they must be parked before the dish can be pointed at a GEO (geosynchronous) satellite to establish a link.

Until recently, satellite connectivity with moving vehicles has been impractical because of the gimbal mount (often motorized) needed to keep a traditional dish antenna pointed at a satellite. This limitation means that typically the vehicle must be stationary before satellite acquisition can be performed and the link maintained. The size and weight of the dish and gimbal mount also make dish antennas impractical for use on smaller vehicles. In addition, mechanically steered antennas are ill-suited for mobile or even fixed use with the upcoming LEO and MEO satellite constellations, as these new satellites will be in constant motion, requiring the beam to continuously track moving satellites and switch from one satellite to the next.

The introduction by Kymeta of the first commercial flat panel, electronically scanned (or steered) antenna (ESA) in 2017 made high-throughput mobile satellite communications from moving platforms a practical reality.

The low-profile Kymeta u7 antenna uses metamaterials surface antenna technology (MSAT) to form and steer the microwave beam electronically, allowing fast acquisition and tracking of GEO, LEO, and MEO satellites even from fast-moving vehicles. It is light and compact enough to be mounted simply in a horizontal orientation on the roof of a vehicle. The small size, low weight, and agile electronic scanning ability of this terminal makes it possible for a single vehicle to have terrestrial or satellite connectivity while moving or stationary.

In the wake of Hurricane Michael in October, 2018, a major mobile network operator sent two custom all-terrain vehicles (ATVs) equipped with a hybrid cellular-satellite communications system to Mexico Beach, Florida.

Emergency communications response vehicle (American Red Cross).

The system on the ATVs provided continuous connectivity from cellular networks when available and satellite networks when the cell networks were congested or unavailable because of infrastructure damage.

The ***Kymeta u7 terminal***, consisting of a roof-mounted antenna plus an interior satellite modem and I/O box, has also been installed in a police SUV, which is equipped with Microsoft Azure Edge servers (a cloud instance in the vehicle) for collecting and processing camera and sensor data. There is also a cellular modem and a software-defined router that automatically switches between cellular and satellite networks to ensure connectivity when terrestrial networks are overloaded or unavailable [4].

A hybrid network system that uses a small ESA for satellite communications is also ideally suited for future autonomous vehicles, to ensure that connectivity is maintained in all driving situations.

Conclusion

The autonomous vehicles now in development will collect, process, and transfer massive amounts of data to ensure safe and efficient operation and to provide infotainment and office services to the occupants. Most of this data will be transferred between the vehicle and the cloud by wireless networks, which will have to be fast and reliable in all driving conditions. Although terrestrial networks will be essential for this data exchange, they are subject to service interruptions from the terrain, man-made structures, weather, and data traffic congestion. Also, their coverage in rural regions is limited, and they are not expected to provide global coverage in the foreseeable future. Because of the limitations of terrestrial networks, AVs will need to rely on satellite networks for an alternative backhaul path to the cloud. The optimal solution is probably a hybrid cellular-satellite network that uses software-defined routing to seamlessly switch between cellular and satellite networks according to optimization parameters and real-time conditions. The advent of lightweight, low-profile, electronically scanned antennas now makes this practical.

First responder vehicles also require constant connectivity, and several bespoke vehicles are using a hybrid network to achieve this by integrating the Kymeta u7 terminal with an LTE system. These advanced FR vehicles also have data collection from local cameras and sensors and on-board processing by a cloud instance.

The implementation of these communications and computing capabilities in FR vehicles provides a model for the designers of tomorrow's autonomous vehicles.

www.kymeta.com

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Author Ben Posthuma is an accomplished strategist, architect, and thought leader in next-generation communications systems intended to connect the disconnected across the world. For nearly the last two decades, Ben has been building, imagining, integrating, deploying, and leading the establishment of complex communications networks in any environment imaginable across the world so those who rely on communications can stay connected. Ben began his career as a Communications Electronics Engineer in the United States Marine Corps. There, he gained an appreciation for the demand that communications systems, particularly those relied upon in critical situations, must be robust, dependable, and leverage the best that industry can offer.

Ben then joined a major defense contractor and worked as the flight test director and chief engineer of a research and development group which specialized in rapidly deployable airborne-based networks; networks that were intended to provide mission critical communications in denied or austere environments. Notably, Ben was the flight test director and overall integration director for an award winning urgent operational need program which connected disparate networks across the battlefield from high altitude, long endurance aircraft.

Traveling to active military theaters, Ben also led the initial deployment of this technology which had an immediate life-saving impact. Additionally, Ben was the chief engineer of a program which brought a persistent and robust communications gateway into the stratosphere

Ben joined the National Institute of Standards and Technology to continue researching methods of bringing critical communications to first responders. Working to support the Department of Homeland Security's Science and Technology Directorate, Ben led efforts to research the optimal way of rapidly delivering LTE-based public safety networks in any environment. This research leveraged forward looking concepts within industry to include edge-based computing, software defined networking, deep learning, and self-optimizing networks and is designed to keep first responders connected regardless of location or condition.

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A CASE FOR SPACE 2.0

How commercial networks can enhance U.S. Government capabilities.

By Joseph Campagna, Chief Operating Officer, BridgeSat, Inc.

The U.S. has historically benefited from the use of commercial systems, government-owned systems and a combination of both for the research, development and delivery of new innovative technologies, products and services that not only drive economic growth but also meet national security goals.

The image of the Telstar 1 satellite [inset] is courtesy of Bell Labs The photo of the Thor/Delta 316 launch with the Telstar 1 satellite from Cape Canaveral Air Force Station's Space Launch Complex 17B, July 10, 1962, is courtesy of NASA.

Since World War II, the U.S. has demonstrated time and again how this vital network has accelerated the speed of implementation while significantly reducing costs, minimizing redundancies and extending existing capabilities.

Consider the experimental satellite ***Telstar***, the world's first active communications satellite and the world's first commercial payload in space developed largely by **AT&T** and launched by **NASA** in 1962.

A privately sponsored space mission, it gave the U.S. a foothold against rival Russia in the space race while revolutionizing mass communication throughout the United States and eventually the world.

In unique instances, it has been a government-only system that has served the best interest of national need. The U.S. Air Force's ***Wideband Global SATCOM*** (**WGS**) satellite, for example, is a constellation of highly capable military satellites designed to empower the U.S. Military and its allies with high-capacity broadband communications while augmenting the one-way ***Global Broadcast Service*** (**GBS**).

One of the best examples of a government-owned system made available commercially after a period of time is **GPS** *(**Global Positioning System**)...*

Leveraging cost-effective, advanced technologies of the communications satellite industry, the WGS system has provided U.S. military forces and international partners a quantum leap in communications capacity, connectivity and flexibility, with the unprecedented ability for ground forces using an X-band terminal or radio to communicate with other forces using a Ka-band terminal or radio.

One of the best examples of a government-owned system made available commercially after a period of time is **GPS** (***Global Positioning System***), the conceptual foundation of which began with the Russian satellite *Sputnik* in the late 1950s.

According to leading telematics company **Geotab**, the ***Magellen NAV 1000*** was the first handheld GPS device made available to consumers in 1989. Today, that same technology is commercially ubiquitous, relied on by businesses and individuals around the world not only

The Magellan NAV 100.

for navigation but also to track people, packages and processes of all kinds.

Space Situational Awareness — or, **SSA**, and also referred to as ***Space Battle Management***) has also expanded to include tracking services performed by both the U.S. Government and private companies such as **ExoAnalytic** and **Engility Corporation** (now SAIC).

The latter company was recently awarded a U.S. Air Force $655 million contract for satellite-tracking services.

Replacing incumbent **Lockheed Martin**, the contract encompasses ground systems' engineering, development, integration and sustainment and involves the current ***Ground System Enterprise*** and the transition and buildout to Enterprise Ground Services at **Kirtland Air Force Base** in New Mexico.

While the U.S. Government has inarguably developed some of the most sophisticated communications and satellite systems in the world that support military, commercial and civilian applications, declining costs of technology and easier access to space have resulted in increased opportunities for commercial enterprises.

Recognizing the benefits offered in the space sector, foreign government participation in space programs has also increased, with Russia and China, in particular, posing real threats to the United States.

With that, the ***Defense Intelligence Agency*** (**DIA**) has outlined new emerging risks for U.S. military networks, as legacy systems comprised mostly of massive and costly satellites architected for low-intensity conflicts require enhanced capacity to face potential challenges of cyber warfare.

With the nation dependent on satellites across the spectrum, from emergency response to the stock market, it is a concern that has commanded considerable attention from both the government and private sectors.


In a March 2018 statement, General *John Raymond*, head of U.S. ***Air Force Space Command*** (**AFSPC**) at **Peterson Air Force Base** in Colorado Springs, Colorado, told the U.S. House Armed Services Subcommittee on Strategic Forces that "*Commercial partnership and collaboration is vitally important to the AFSPC's ability to succeed in our mission and more importantly, move forward in a manner that outpaces our strategic competitors. In response to the increasingly contested space environment, Congress has asked the Air Force to examine commercial solutions to rapidly fill critical operational gaps and mitigate emerging threats.*"

To fill gaps in both network and ground system defenses, the U.S. Government is exploring several commercial ground and space capabilities to address the need for increased bandwidth to support **GEO** (***Geosynchronous Equatorial Orbit***) and **LEO** (***Low Earth Orbit***) satellites, as well as complementary technologies, including *optical wireless communications* (OWC).

A technology NASA has been using for decades to support critical exploration activities such as their *Laser Communications Relay Demonstration* and the *Orion Exploration Mission 2 Optical Communications* project, OWC addresses the need for cost-effective, highly secure, reliable, rapid satellite communications for mission-critical and bandwidth-intensive applications while augmenting existing RF capabilities.

In the same way cooperation with industry paved the way for airplanes to take over U.S. reconnaissance from the cavalry in World War I, commercial assets are apt to herald in the next generation of satellite capabilities.

In June 2018, after reviewing ***Department of Defense*** (**DoD**) policies, documentation and planning documents, as well as interviewing a wide range of DoD and civil government officials and commercial stakeholders, the ***Government Accountability Office*** (**GAO**) reaffirmed its first findings in a 2011 report that supported the use of commercial satellites to host government payloads to help the DoD achieve on-orbit capability faster and more affordably — the work that actually started at the U.S. Air Force ***Space and Missile Command*** (**SMC**) in 2012.

The GAO report included Pentagon estimates of several hundred million dollars in cost savings from using commercially hosted payloads. The Pentagon also expects to realize additional savings and deliver faster capabilities on orbit from planned missions by sharing development, launch and ground system costs with the commercial host company.

Imagine the implications of commercial partnerships for U.S. bases in remote regions in the Middle East where broadband communication is vital.


Inmarsat Senior Vice President of Government Strategy and Policy, *Rebecca Cowen-Hirsch* (*former Program Executive Officer for SATCOM, Teleport and Services at DISA and the first Vice Component Acquisition Executive for DISA*) suggests that, in light of the shortage of satellite capacity in government networks, the military should look to a hybrid business model that leverages the best commercial assets available.


Artistic rendition of a GPS satellite on-orbit.

That strategy was echoed most recently during the May 2019 Senate Select Committee on Intelligence hearing considering the nomination of *Chris Scolese* (*Director of NASA's Goddard Space Flight Center*) as Director of the ***National Reconnaissance Office*** (**NRO**).

Several members stressed the need to "fully embrace and leverage commercial space capabilities and expand the scope of NRO contracts," with Scolese stating that the "*burgeoning commercial sector that gives us a full range of capabilities will really enhance our ability to stay at the forefront of national defense and protecting our country.*"

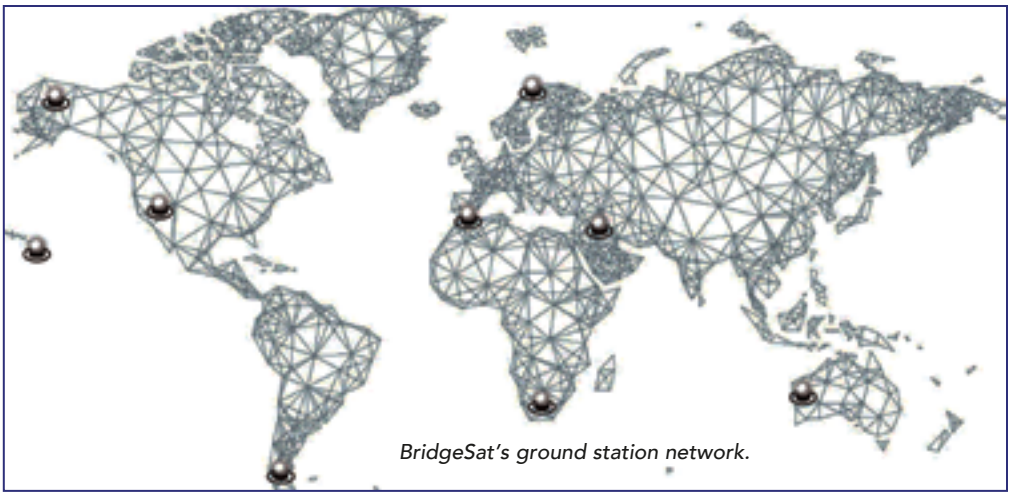
One looming challenge is still in debate: streamlining the U.S. Government acquisition process to expand war-fighting capability.

The use of commercial services and products will undoubtedly contribute significantly to a solution.

Another area for further discussion is the need to treat innovation as part of what can be done commercially and brought into the U.S. Government.

Looking beyond the near future to long-term solutions, adoption of OWC, hosted payloads, commercial innovation, etc., will depend on need, cost and a swift procurement process. The need is undoubtedly there, but technical, regulatory and affordability hurdles continue to widen the gap.

Critical decisions must be made now. Respondents in a 2018 report compiled by the **Mitchell Institute for Aerospace Studies** and the **Center for Space Policy and Strategy** advocate collaboration with the commercial space sector to reinforce space capabilities.



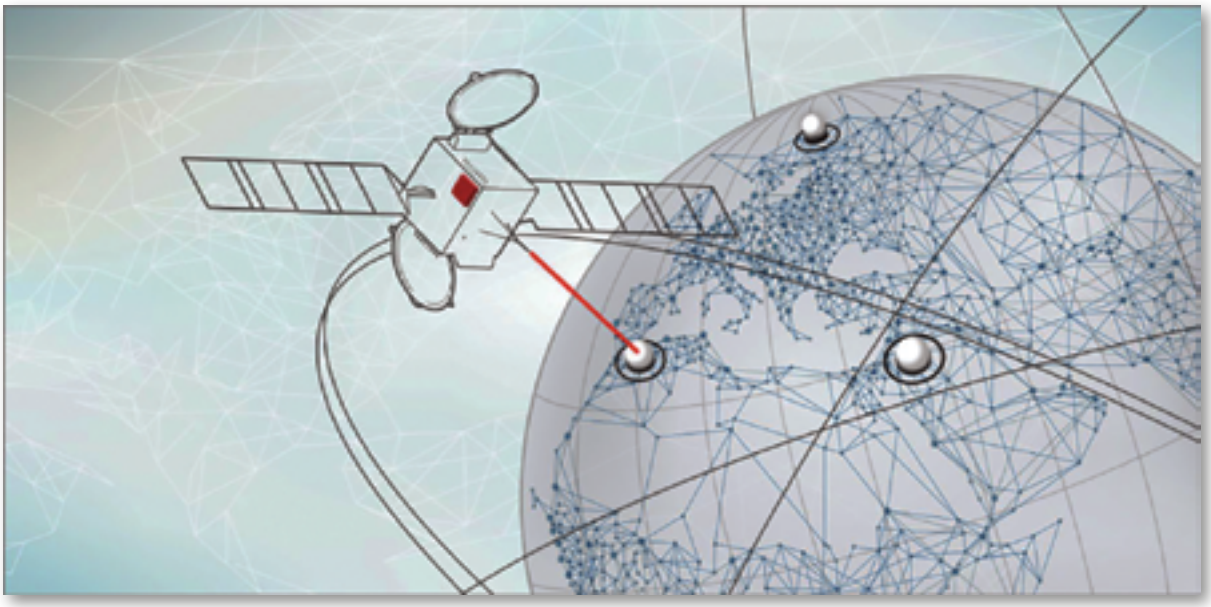
BridgeSat's ground station network.

In addition to arguing that commercial partners could architect a network at a cost three to five times less than one developed solely by the government, and with schedule advantages, the report concurs that commercial developments will create "*some of the most exciting and potentially game-changing opportunities ever seen for advancing space capabilities*" — another voice of many reinforcing the need for the U.S. Government to embrace new technologies and diversify assets across public and private sectors to ensure the U.S. achieves its security goals while at the same time shaping the future of **Space 2.0**.

www.bridgesatinc.com

BridgeSat's Chief Operating Officer Joseph Campagna has almost 30 years of experience in commercial and Department of Defense (DoD) satellite operations and ground system engineering and construction. Prior to BridgeSat, he served as CEO and Chief Engineer at Global Ground Systems, focusing on ground system design, systems analysis and business development for a multitude of commercial and DoD customers. Prior to that, Joseph was Director of Ground Systems Engineering at Orbital Sciences (now NGIS), overseeing ground system program management, design, installation and long-term support for GEO (Geosynchronous Equatorial Orbit) and LEO (Low Earth Orbit) missions. Joseph graduated from the University of Maryland with a degree in Aerospace Engineering Management and earned a Leadership Certificate from University of Virginia Darden School of Business.

BridgeSat, Inc. is an optical wireless communication (OWC) company providing competitive turnkey solutions for transmitting big data at faster speeds—and at a lower cost—than traditional radio frequency (RF) systems. Through an expanding global network of proprietary space terminals and optical ground stations (OGS) designed to either augment existing RF systems or provide a primary downlink channel, BridgeSat is at the forefront of innovation. As the first to commercialize OWC and associated ground services that support Low Earth Orbit (LEO) and Geosynchronous Equatorial Orbit (GEO) satellite optical communications, BridgeSat is enabling the future of space-to-ground, ground-to-ground and air-to-ground OWC while solving the battle for RF bandwidth.



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IGNITING THE NEXT REVOLUTION...

... in satellite constellations...

By Shey Sabripour, Founder and Chief Executive Officer, Cesium Astro

The global space industry is undergoing rapid change. No less than 300 new companies are investing in new spacecraft and launch systems for more cost-effective access to space with greater frequency.

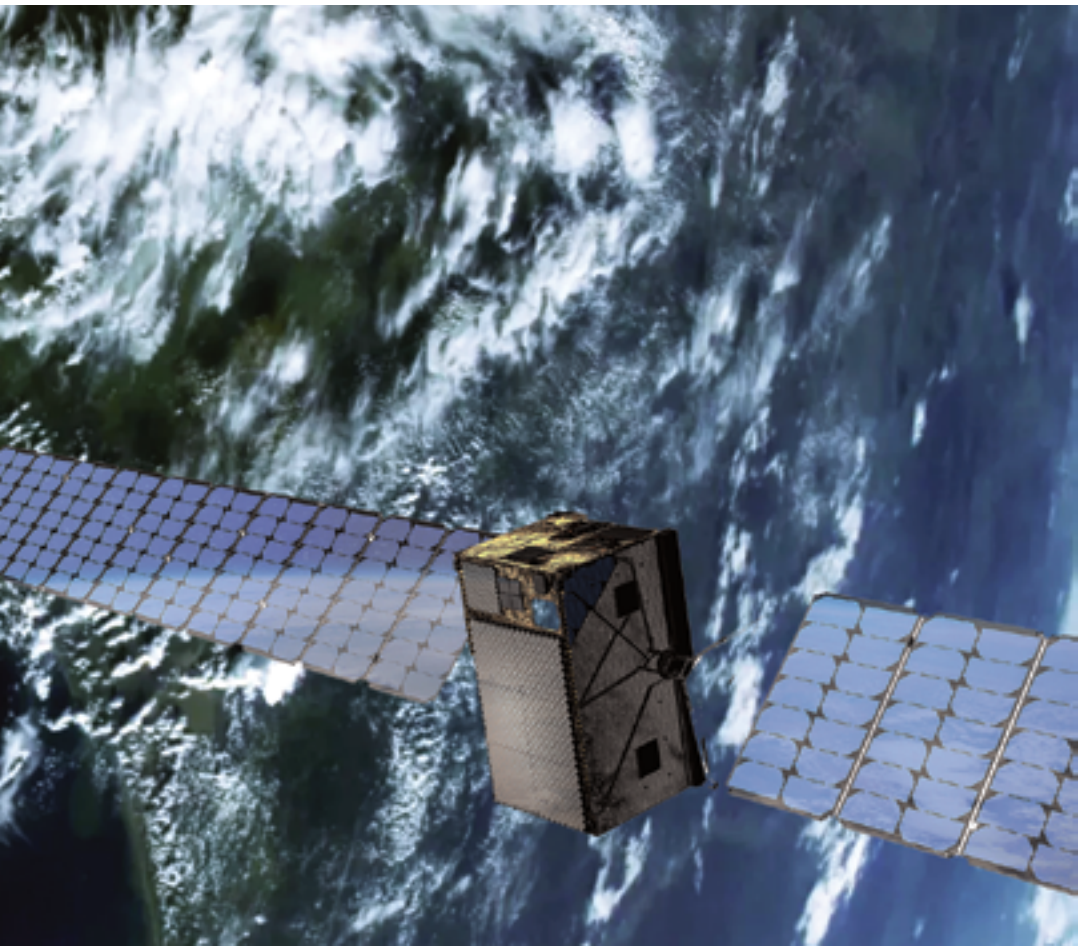
Over the past half-dozen years, several traditional large, geostationary, telecommunication satellites have been replaced by high-throughput (LEO and GEO) versions that are drastically disrupting the market. Today, the demand for large GEO commercial satellites has declined from a steady 25 to 30 satellites a year to five to seven per year. Embracing this shift, a new generation of operators and satellite system manufacturers are re-tooling their infrastructure to better align to this changing market. General ***John Hyten***, United States Air Force (USAF), head of STRATCOM, and now nominated to be Vice Chairman of the Joint Chiefs of Staff, highlighted these strategies in the new '*space enterprise vision*' recently adopted by the USAF and National Reconnaissance Office (*NRO*)...

"*In that vision you won't find any of those big, exquisite, long-term satellites*," stated General Hyten. "*With regard to military satellites, STRATCOM will advocate for a change away from "exquisite" costly systems that take years to develop in favor of "more resilient, more distributed capabilities.*"

An important parallel shift is in the deployment of proposed commercial and military constellations, aircraft connectivity solutions, and advanced weapon and C3ISR systems. These systems now require rapid insertion of Commercial-Off-The-Shelf (*COTS*) part solutions that have been adapted from disruptive developments in adjacent markets, rather than relying on "traditional" mil-qualified parts.

Within a decade, one or more large Low Earth Orbit (*LEO*) constellations of smaller satellites will be fully deployed, each likely numbering in the thousands. These will enable unprecedented services, including highly distributed, interconnected and resilient systems to improve our personal and business security, decentralized remote imaging for enhanced environmental and agricultural monitoring, and a full connection of the plethora of mobile devices that are woven into the fabric of our lives and enterprises.

During the past decade, three markets have pushed small form-factor COTS technologies to new levels: mobile consumer electronics, "intelligent" automotive systems and next-generation space capabilities.



Accelerating Change Drivers

During the past decade, three markets have pushed small form-factor COTS technologies to new levels: *mobile consumer electronics*, *"intelligent" automotive systems* and *next-generation-space capabilities*.

High-end smartphone and tablet markets require electronics that run sophisticated operating systems and radio platforms drawing on minimal battery usage. Many of the companies who have invested in those technologies are

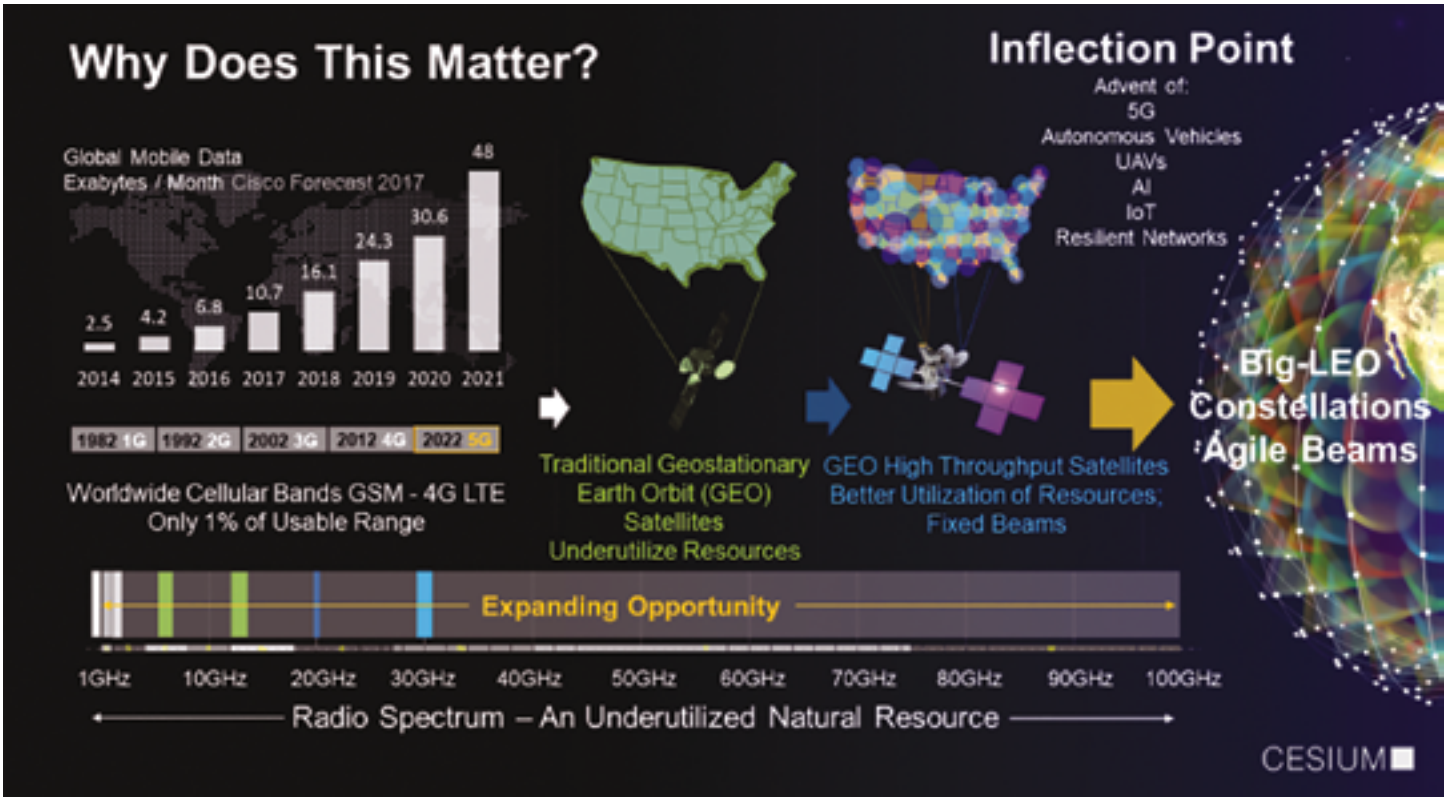


Figure 1. Markets are shifting from large platforms to smaller, distributed platforms and higher throughput systems. Image is courtesy of CesiumAstro.

now pushing into driverless and driver-assisted automotive platforms, adding safety and reliability requirements.

CesiumAstro is an Austin, Texas, startup that was developed on the back of a market strategy to leverage the intersection of all three of those markets. Many system integrators choose not to invest resources into fully custom, fixed beam payloads, creating a market for "out-of-the-box" solutions such as CesiumAstro's ***Nightingale*** series products.

At the same time, the new push for advanced automotive electronics provides a source of highly-capable and highly-reliable components that are well-suited to this next generation LEO space market. Now, reliability advancements have progressed to aerospace requirements, and LEO and low-MEO satellites are a particularly attractive application, as the strict reliability requirements are balanced by relatively low radiation levels.

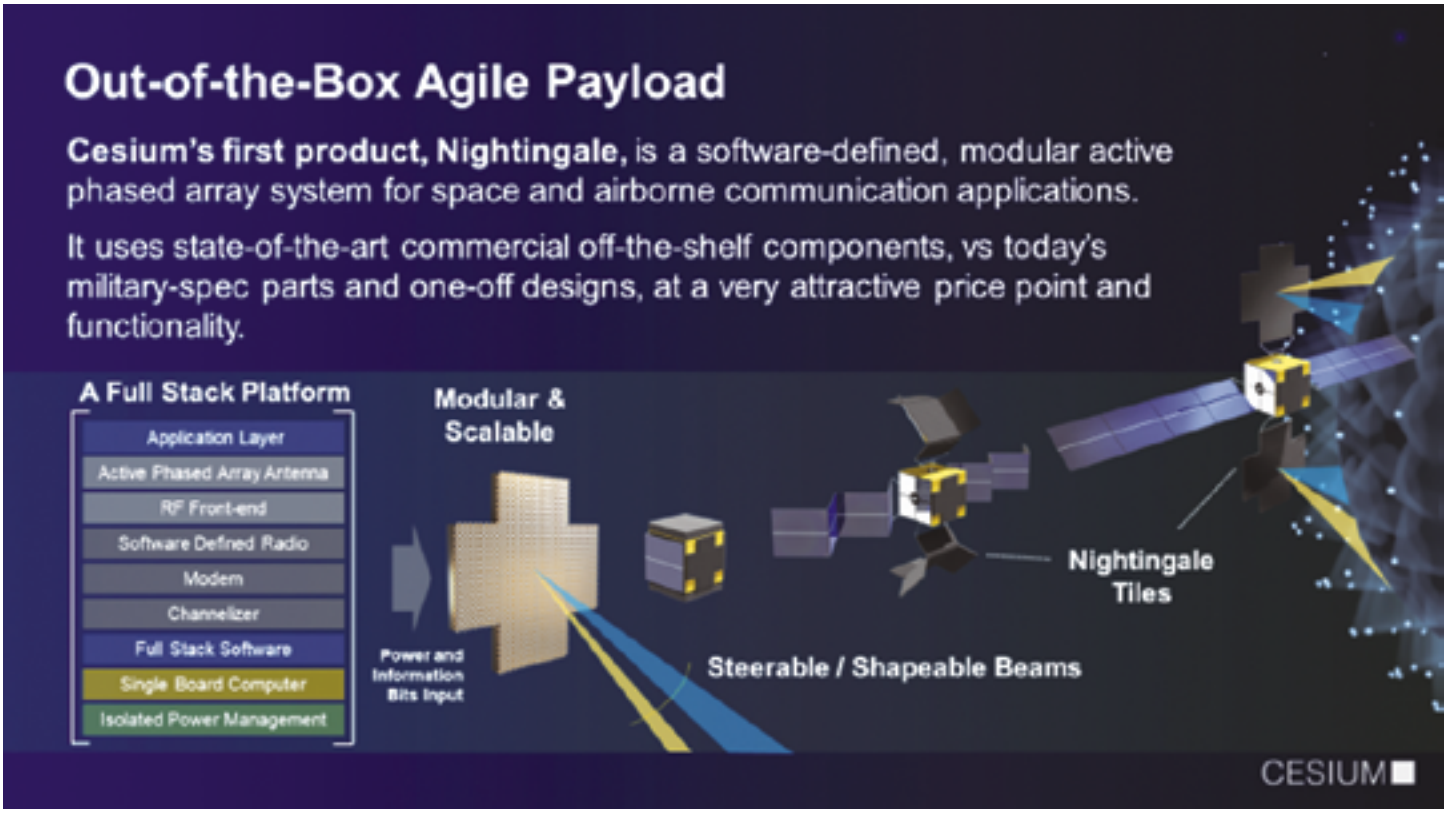


Figure 2. Cesium introduces its first, out-of-the-box agile payload system. Image is courtesy of the company.

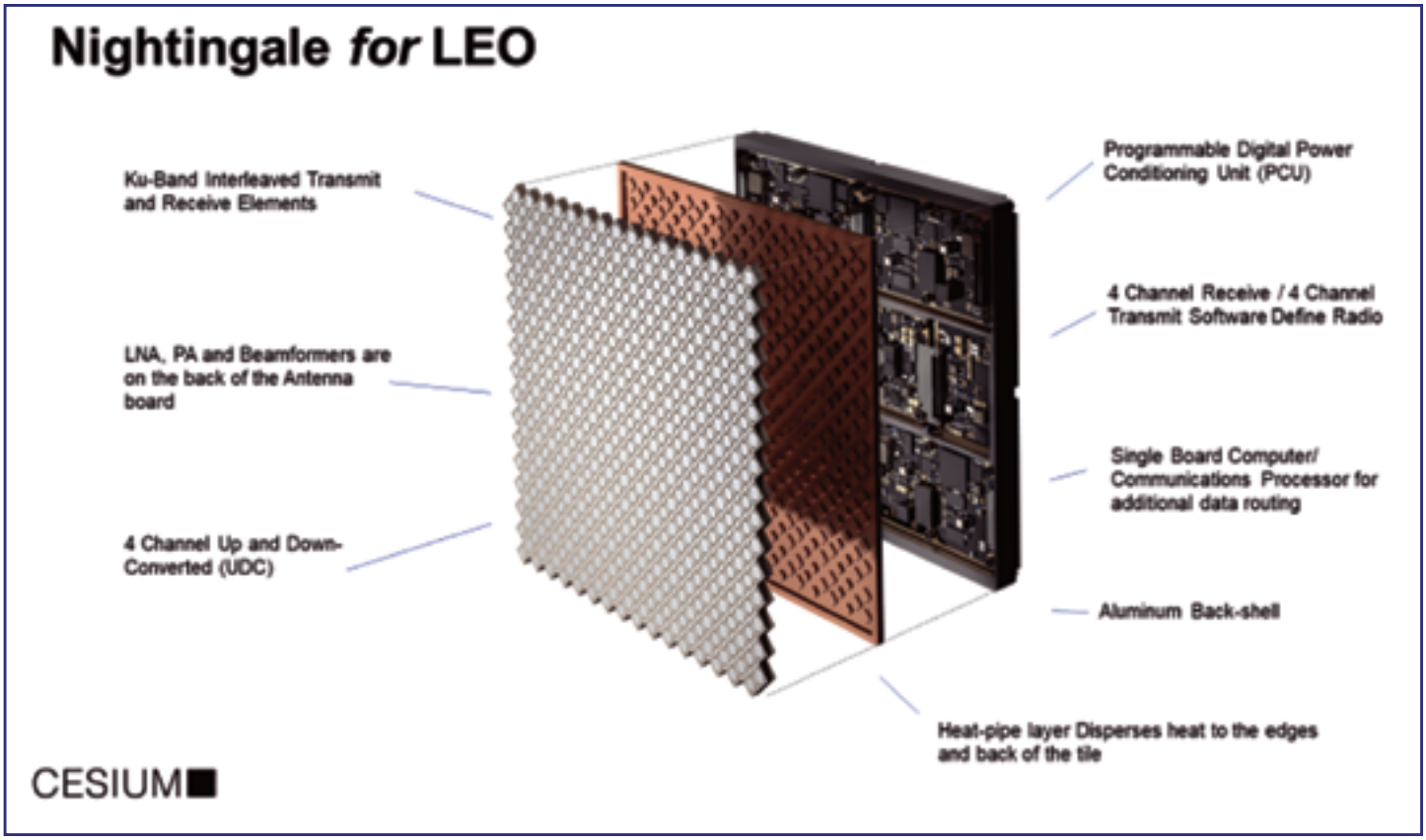


Figure 3. Nightingale system illustration, exploded view. Image is courtesy of CesiumAstro.

Therefore, CesiumAstro is in a unique position to leverage its existing COTS-based, miniaturized telecommunication and advanced avionic products for LEO constellations and other new aerospace applications.

The Cesium Model

CesiumAstro is keenly focused on commercializing out-of-the-box COTS-based phased arrays and modular, high-throughput, software-defined communication systems for LEO, launch vehicles, UAVs, and commercial and Department of Defense (*DoD*) aerospace applications.

CesiumAstro's paradigm shift is to build arrays on a system of scalable and modular "*LEGO®-like*" software defined architecture, turning digital bits into steerable, shapeable radio frequency beams

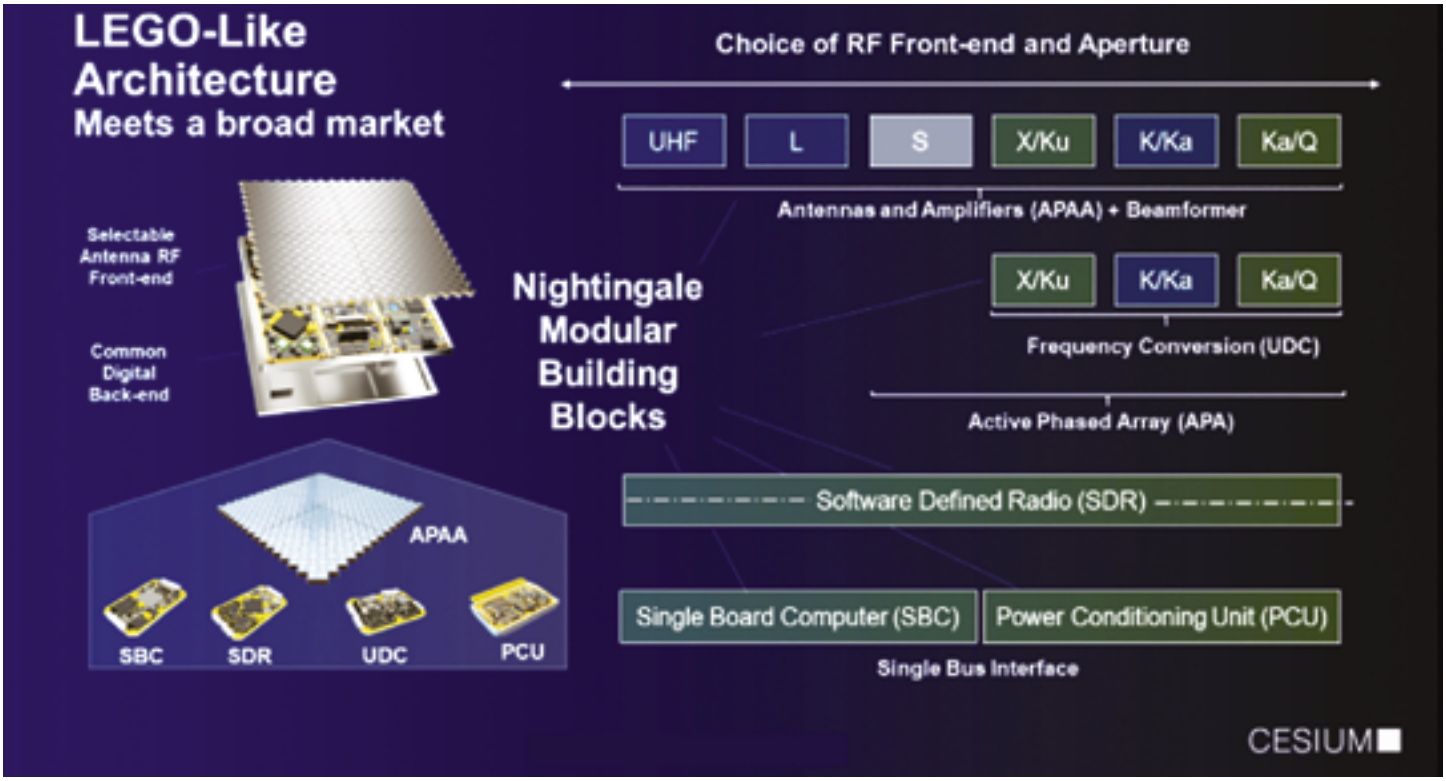


Figure 4. Cesium's LEGO™-like architecture serves a broad and expanding market in DoD and commercial market segments. Image is courtesy of the company.

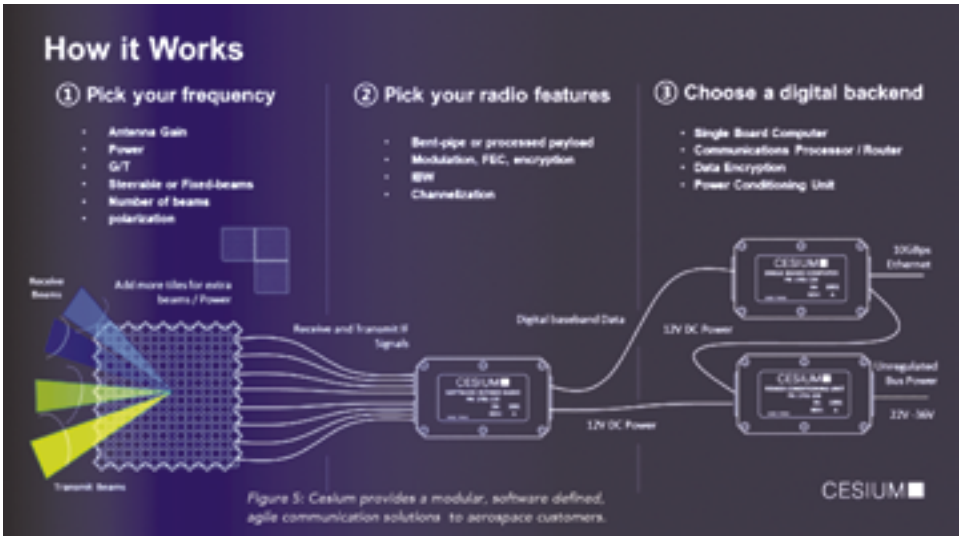


Figure 5. Cesium provides a modular, software defined, agile communication solution to aerospace customers. Image is courtesy of the company.

— providing complete communications systems in an easily customizable plug and play kit.

To create a high-speed communications link, all that is required is a single power cable and a digital connection. (***See Figure 2).***

Nightingale for Commercial LEOs

Cesium's first product, Nightingale, is a complete plug-and-play, active-phased-array communication system in a thin tile — a key enabler for satellite integrators, data providers, and the military. The module combines a cutting-edge **software-defined radio** (**SDR**) with an ultra-wideband, multi-beam phased array antenna, offering a wide choice of communication parameters and dynamic reconfiguration of the system.

Traditional spacecraft antennas, such as shaped reflectors, direct radiating horns and patches, provide fixed spot beam patterns — an approach that commonly leads to a comparably high overall power efficiency and lower payload cost.

A fundamental challenge with this fixed pattern approach however is that, for highly dynamic, maneuvering spacecraft systems, the requirements tend to favor isoflux, omni or mechanically steered reflector antennas leading to inefficient distributions of bandwidth and power using uniform, fixed, wide beams. These fixed beam/fixed waveguide systems are often custom designed solutions for each type of spacecraft and each mission.

Nightingale is an active phased array communication system that produces multiple steerable beams per aperture and allows for reconfigurable, on-board signal processing. This payload architecture maximizes the bandwidth and power that is delivered to users.
Additional advantages of CesiumAstro's fully steerable phased arrays include:

- *Capability to shape Earth coverage areas through phase and amplitude control for each beam at each radiating element. This allows for dynamic optimization of gain pattern for each beam.*
- *Ability to re-allocate available RF output power among beams. This allows for increase of power in high-demand footprints or in applications that have higher priority.*
- *Distribution of solid-state power amplifiers (SSPA) and low now noise amplifiers (LNAs) over hundreds of elements. This leads to higher reliability, as the failure of individual amplifiers has minimal effect on overall array performance.*

The distinguishing features of Cesium's Nightingale active phased array system include:

- *Multiple transmit and receive beams from the same aperture. This reduces the overall aperture size for a given number of beams. Carrier frequency of each beam can be set independently.*
- *Interleaved transmit and receive antenna elements. This allows reduction in either number of components (when using TDD) or aperture size (when using FDD).*
- *A "reliable-COTS" part-selection approach, combining automotive-grade parts with design-for-reliability. This results in a flight-reliable system with state-of-the-art components at below-space-grade cost.*
- *Fully modular architecture. The antenna elements and RF electronics are designed in 'tiles,' while the processors and power control units are line-replaceable modules. This approach leads to a scalable system and lower generation-to-generation development cost.*

Nightingale also offers an order-of-magnitude lower market cost. Because CesiumAstro has designed Nightingale as a modular system, they can provide customers an end-to-end solution in months, not years. As they are platform-agnostic, Cesium products are also easily adapted to multiple aerospace applications.

Another element of Cesium's paradigm shift is their provision of a complete plug-and-play system directly to system designers, replacing a major R&D effort with a single product that works directly out of the box — eliminating the need for customers to employ dedicated staff to develop their own communications systems.

How Does Nightingale Work?

Customers tell CesiumAstro what kind of mission they have in mind, what frequency of operation they prefer and what features they need in their telecommunication systems — and Cesium addresses their needs from those starting points.

The company designs the end-to-end systems,starting from the link budget, to hardware and software directly down to the last digital and power connection needed for a customer's system. Over the past 18 months, Cesium has been working with **NASA Ames**, the **Defense Advanced Research Projects Agency** (*DARPA*), the **Missile Defense Agency** (*MDA*) and **U.S. Navy** on customized communications systems.

In March, the company closed a $12.4 million investment, led by **Airbus Ventures**, and with **Kleiner Perkins**, **Franklin Venture Partners**, **Lavrock Ventures**, **Honeywell Ventures**, and **Analog Devices Ventures**. These investments provide the means to scale the team and expand the development of a wide range of frequency offerings and system configurations to meet the growing demand for affordable, high-throughput aerospace plug-and-play communications systems.

Governments and global space agencies have issued a call to commercial companies to partner on major systems. They recognize that commercial companies and especially entrepreneurs such as CesiumAstro's team are delivering innovative technologies and new business models — and that the COT's approach lowers cost and risk, yet increases the speed to complete a mission.

www.cesiumastro.com

OP-ED:
LIFE IN A POST-JMS WORLD:

U.S. Space Superiority powered by 'Agile' acquisitions

By Colonel Jennifer Krolikowski, Senior Material Leader, Space C2, U.S.A.F.'s Space and Missile Systems Center/SY

In the world of space acquisitions, agility is a best practice. This is because software development and sustainment no longer follow the norms of the previous century. Repeatedly, the DoD has struggled with fielding software intensive programs in a timely fashion and within a reasonable cost.

One Space and Missile Systems Center program, the Joint Space Operational Center Mission System (JMS), was no exception. Plagued with cost and schedule breaches that led to a critical change in the program in 2016, followed by an Office of the Director, Operational Test & Evaluation (OT&E) report in 2018 that declared the system, "…not operationally effective or suitable for its space awareness mission…" it became apparent that something had to change with how the software was being procured.

"With the pivot to space as a warfighting domain, we recognized the JMS structure wasn't adequate, and buckled-down and thought about ways we could make the program better in its acquisition process strategy moving forward," said Col. *Stephen Purdy*, Director of Space Superiority Systems Directorate.

JMS was created to provide space services to enhance the accuracy, sustainability, and responsiveness of space surveillance capabilities as well as a high accuracy space catalog (knowledge of space objects), increased observation verification and capabilities, and improved event processing. However…

Some members of the SMC/SY "Kobayashi Maru" Space C2 team help delivered capabilities to the warfighter through rapid acquisition methods to help "protect and defend" U.S. space missions. Photo is courtesy of SMC.

In August 2018, two major shifts occurred with the JMS program. First, it was combined with Enterprise Space Battle Management Command and Control (ESBMC2) to focus on providing capabilities for Space Command and Control (C2). Space C2 provides a common, integrated baseline that incorporates capabilities across the domain that enable space warfighters to accomplish their "protect and defend" and theater support missions with an effective end-to-end kill chain.

Subsequently, Space C2 shifted from "waterfall" software builds to agile practices. The waterfall model is a relatively linear sequential design approach for certain areas of engineering design. In software development, it tends to be among the less iterative and flexible approaches, as progress flows in largely one direction ("downwards" like a waterfall).

On the other hand, in agile software development, requirements and solutions evolve through collaboration. It promotes adaptive planning, evolutionary development, early delivery and continuous improvement, and it encourages rapid and flexible response to change. Space C2 is doing just that.

"The pivot has been incredible," said Purdy. "Since the decision was made to go Agile Software, we have completed three rounds of our agile requirements process, completed our second 90-day Program Increment, which delivered capability, and already started our third Program Increment that will deliver more capability in another 90 days. This is how software should be done."

The DoD 5000 life-cycle process provides a detailed DoD process for setting requirements for complex systems and ensuring delivered systems are compliant with those requirements. DoD 5000 is designed to give Office of the Secretary of Defense, the Service Acquisition Executives, and Congress some level of visibility and oversight into the development, acquisition and sustainment of large weapons systems. Traditionally, software acquisition – with JMS being a prime example – has been shoehorned into this framework with minimal to no success. This framework is largely based on a 1970's "waterfall" process. As a result, the software for acquisition was found to be late to need, cost substantially more than originally estimated, could not be easily maintained, and had low acceptance rates by the users. This often led to software scrap, rework, and repair.

By contrast, current software methods found throughout industry use a much more iterative process, often referred to as "DevOps" or "Agile Software." Development and operations are continuous efforts that feed off of each other, as shown on the right.

"*As the Defense Innovation Board has pointed out in their Do's and Don'ts for Software, moving to a software development approach will enable the DoD to move from a 'specify-develop-acquire-sustain' mentality to a more 'modern-useful-create-scale-optimize' mentality also known as DevOps/DevSecOps. Enabling rapid iteration will create a system in which the U.S. can update software at least as fast as our adversaries can change tactics, allowing us to get inside their OODA loop,*" said Purdy.

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COTM LAND AND AIRBORNE TECHNOLOGIES

By Aaron Titus, Norsat International

Every military commander will agree that communication is the key to any successful mission or in-field operation. One of the most vital components for military command and control is the ability to communicate seamlessly, offer support and share information for mobile personnel and groups deployed in remote locations anywhere, at any time.

Effective COTM systems ensure that intelligence information reaches personnel on time and surveillance data is properly relayed, even while users are on the move. Leaders can make better tactical command decisions when they receive reconnaissance observations on time, in turn increasing military strategic advantages.

A large number of organizations are now working on improving mobile communications capability beyond the line of sight to enhance their Communications-On-The-Move (COTM) capability. This primarily involves portable satellite technology, specifically relating to military and defense land vehicles, maritime or airborne platforms. The core principle behind COTM is that any moving vehicle on land, air or sea equipped with a satcom system is able to establish and maintain communication with a satellite.

COTM Land and Airborne technologies require specialized equipment that have tight weight and size specifications with extreme form factors, as well as extra design capabilities and standards including electromagnetic interference, vibration and shock. This is because military operations are growing to be asymmetric and non-linear, requiring *live* responses to changes that occur during a mission, or on the battlefield. As the demand for improved on-ground communication increases, state-of-the-art modern military mobility equipment users look toward SATCOM manufacturers to implement innovations in comms technology to deliver data to and from hostile environments without interruption.

Stringent Specifications

In this regard, Norsat has been a pioneer in developing satcom solutions as our LNBs and BUCs are ideal for COTM and airborne applications. Besides great performance, our signature products like the ATOM Series of block upconverters and solid state power amplifiers (BUCs & SSPAs) are tested to meet the most stringent standards like MIL-STD-461 (EMI/EMC), MIL-STD-704A (airborne), MIL-STD-1275D (ground), MIL-STD-810G environmental (shock, vibration, salt fog, blowing rain sand) and RTCA DO-160 (standards for commercial aircrafts).

The engineering team is working on multiple development projects for COTM and airborne applications for the ATOM Ka-band BUC & SSPA and ATOM Ku-band GaN BUC. Another

...modern military mobility equipment users look toward SATCOM manufacturers to implement innovations in comms technology to deliver data to and from hostile environments without interruption.

aspect that we see driving potential growth is the opening of the company's manufacturing facilities in the United States, delivering Norsat's signature North-American quality, which has been well-received by our customers in the military and defense contractor communities.

SWaP Considerations

Size, Weight, and Power (SWaP) are the three crucial physical attributes that must be considered for COTM systems. Minimizing weight and size while maximizing power are competing aims, and optimizing this balance is at the heart of BUC/SSPA design. The advantages of low SWaP in COTM come from lighter, smaller BUCs that are easier to position, operate, access and service. In airborne COTM applications, the constraints of restricted space and fuel consumption margins call for small system size and low weight.

Contrastingly, in maritime COTM weight is less important than space, as the constraints of radome mounting impose compact form factor requirements, in addition to thermal and vibration considerations. In the case of land-based COTM, space is even more limited in vehicles and tanks, and heavy weight reduces speed and performance.

Output power vs Power consumption (Power efficiency) is a factor for every single COTM application, since there is a fixed level of usable power in a moving vehicle, irrespective of being airborne, land-based or maritime. All other factors being equal, the lightest and smallest components outputting the highest power with the lowest possible consumption, is what customers ultimately wish to use.

Future Trends

COTM applications for military purposes require more power to operate independently while on the move. But, adding more power to a unit also results in more heat, which creates the need for more components in order to cool it down. Catching the wave with this trend, Norsat has developed GaN BUCs with excellent thermal management and more output power. For example, Norsat's 80W Ku GaN ATOM BUC is 62% lighter and 70% smaller than competing products in the industry, weighing just 2.3 Kg.

When it comes to terminals, Norsat's premier maritime COTM offering is the MarineLink Naval Series. They are designed to meet the new-age demanding requirements of modern navies as outlined in the following Military Standards:

- *Mechanical Shipboard Vibration: MIL-STD-167-1A*
- *High-Impact Shipborne Shock: MIL-STD-901D*
- *Military EMI / EMC: MIL-STD-461G*

Because of these rigorous and standardized certifications, Norsat is able to provide our military customers with demonstrated, high-capacity communications systems, designed to perform under even the most extreme maritime environments. Additionally, terminals in Norsat's MarineLink Naval series have been certified for use on the Military Wideband (WGS), CE0678, Intelsat and Anatel networks.

These maritime terminals have unique features that benefit COTM applications like fast tracking speeds (90 deg/s) for accurate and dependable signal lock and 3-axis operating platform for WGS reliable operations even in rough sea states (up to Sea State 6). Additionally, they also feature a built-in motor brake, shock absorber, and wire-rope isolator for longevity and reliability, and unlimited azimuth for precise tracking and ease of cable management.

In the near future, satcom manufacturers will need to pay attention to COTM parameters such as ground user uplink power, transponder gain, ground user antenna aperture size and satellite downlink power. Organizations have begun research into mobile antenna pointing and stabilization to provide robust solutions by offsetting the reduction in gain and using numerous wider beam antennas.

COTM Land and Airborne Technologies will witness further development over the next two years as customers expect better SWaP, increased need for manufacturing demands such as FOD, FAI requirements, more standard requirements, higher temperature and lower temperature specs than the usual, altitude specs and tighter integration with the antenna.

Over the past 40 years, Norsat products have been used to support vital mobile communications for not just ISR (intelligence, surveillance and reconnaissance), but also battlefield communications, supply logistics, search and rescue, UAVs (Unmanned Aerial Vehicles) and disaster site video. Norsat remains committed to providing customers with the best solutions for all of their COTM applications where situational awareness and life-saving information is required on a moment's notice.

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