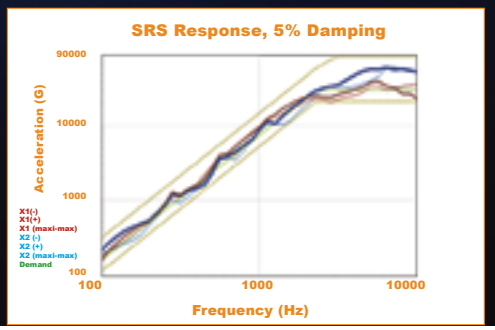
SATCOM for Net-Centric Warfare

MilsatMagazine

APRIL 2018

Cover image of SmallSats is courtesy of Boeing.

HIGH G
DYNAMICS TESTING



Experior Laboratories, a Southern California based independent third party test laboratory, is MIL-STD-790 approved and ISO-17025:2005 accredited. Experior Labs operates multiple state-of-the-art Unholtz-Dickie electrodynamic shaker systems that can handle the most demanding vibration and shock test specifications.

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DISPATCHES

Offutt AFB says farewell to their legacy dish

If you've ever driven along Butler Blvd. near the south side of the Offutt Air Force Base in Nebraska, you have most likely noticed the large golf ball-looking structure towering over a one-story building.

Until recently, this structure housed a legacy AN/FSC-78 Heavy Satellite Terminal that had been in use since 1977, providing critical national defense communications to the 55th Wing and U. S. Strategic Command.

After 40 years of service, the terminal was finally replaced with a much smaller but more powerful terminal. The new system, named the AN/GSC-52B, has the capability to provide 10 times the data transfer rate using the new Wideband Global SATCOM (WGS) satellite constellation.

"*Each of those satellites can move as much data per second as the entire constellation of the previous satellites*," said Joe Halamek,

55th Strategic Communications Squadron maintenance and operations supervisor.

The new satellite terminal is one of two installed at Offutt. The terminals now have the ability to use dual-band technology and can transmit and receive multiple telecommunication formats providing critical reach-back capability for the warfighter.

"*We can provide communications from one user to anyone in the satellite footprint*," Halamek said.

The legacy AN/FSC-78 system was officially switched over to the new system late last year as part of the Modernization of Enterprise Terminal program and was one of only a few still in use by the U.S. Air Force and Army.

Throughout its tenure, the terminal has maintained a 99.9 percent terminal uptime rate. The new terminal will ensure critical global communications links remain online for years to come.

Contractors removed parts of the 640,000 pound terminal, including the 60 foot parablic dish, in mid-February.

Story by Delanie Stafford
55th Wing Public Affairs, U.S.A.F.

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DISPATCHES

U.S. Air Force awards EELV launch contracts to SpaceX and ULA

Artistic rendition of a GPS III satellite.

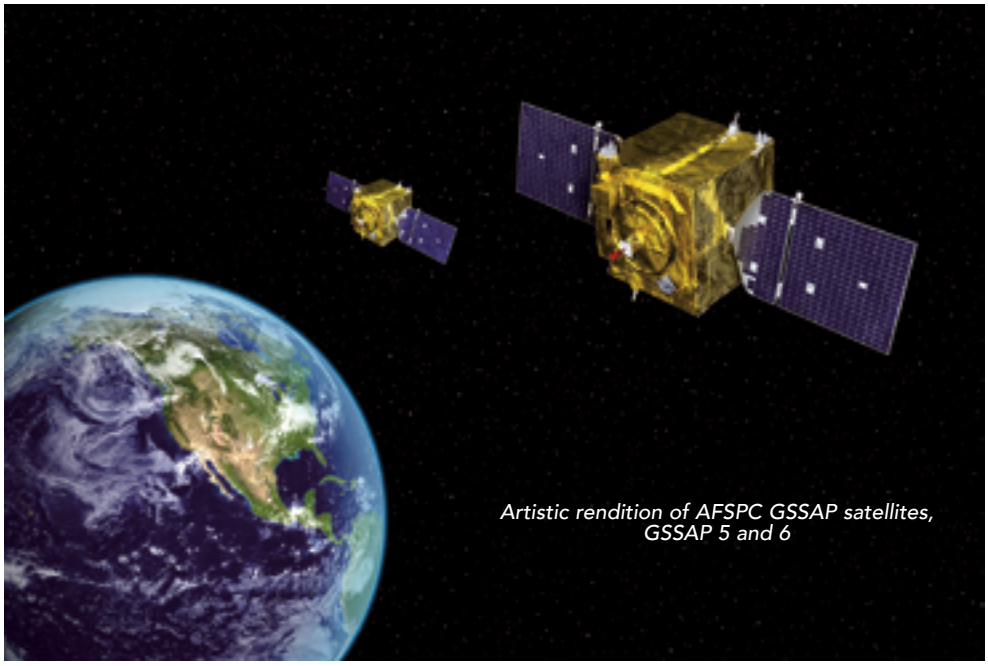
Two big contracts from the U.S. Air Force have been awarded to ULA and SpaceX for the settlement of two Evolved Expendable Launch Vehicle (EELV) launch service contracts.

Space Exploration Technologies Corporation (SpaceX) has been awarded a $290,594,130 firm-fixed-price contract, for launch services to deliver three GPS III missions (1 base and 2 options) to the designated orbit.

United Launch Alliance (ULA) has been awarded a $351,839,510 firm-fixed-price contract, for launch services to deliver Air Force Space Command (AFSPC)-8 and AFSPC-12 satellites to the intended orbit.

Both contracts provide the U.S. Government with a total launch solution for these missions, which includes launch vehicle production, mission integration, launch operations, and spaceflight certification.

These missions are planned to be launched from Cape Canaveral Air Force Station or Kennedy Space Center, Florida.



Artistic rendition of AFSPC GSSAP satellites, GSSAP 5 and 6

This is the fourth competition under the current Phase 1A procurement strategy.

These launch service contract awards strike a balance between meeting operational needs and lowering launch costs through reintroducing competition for National Security Space missions.

Lt. Gen John F. Thompson, U.S. Air Force Program Executive Officer for Space and SMC commander, said that the competitive award of these two EELV launch service contracts directly supports Space and Missile Systems Center's (SMC's) mission of delivering resilient and affordable space capabilities to our Nation while maintaining assured access to space.

The three GPS III missions will deliver sustained, reliable GPS capabilities to America's warfighters, our allies, and civil users.

GPS provides positioning, navigation, and timing service to civil and military users worldwide. The GPS III missions are planned to launch between late 2019 and 2020.

The AFSPC-8 mission comprises two identical Geosynchronous Space Situational Awareness Program (GSSAP) satellites, known as GSSAP 5 and 6. AFSPC-8 is planned for launch in 2020 into a geosynchronous orbit.

The AFSPC-12 mission comprises a forward space vehicle (SV) and an aft SV.

The forward SV is known as the Wide Field of View (WFOV) Testbed and the aft SV is a propulsive Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) that hosts auxiliary payloads.

AFSPC-12 is planned for launch in 2020 into a geosynchronous orbit.

www.spacex.com

www.ulalaunch.com

DISPATCHES

CPI Antenna Systems Division receives Cubic Mission Solutions contract for UAV comms

Communications & Power Industries (CPI) has received multiple contract awards from Cubic Mission Solutions, a business division of Cubic Corporation.

Cubic Mission Solutions provide networked Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities for defense, intelligence, security and commercial missions.

Under these awards, CPI ASD will supply its HD-30T Ground Data Terminal for tracking unmanned aerial vehicles (UAVs) from the ground and enabling encrypted Ku-band communications using Cubic RF modems.

CPI ASD will also provide airborne advanced tactical common data link (TCDL) antenna products, including the AT-20 two-axis Data Link Antenna. This low-weight, high-gain technology ensures reliable connectivity with UAVs operating above warfighters on the ground.

The compact design of CPI ASD's terminals provides maximum gain for their size and weight, which translates into an increased range of operation for the UAV and warfighters.

Like all CPI ASD products for military applications, these advanced antennas are custom-developed on a proven product platform and are fully qualified to stringent military standards. They are manufactured at the CPI ASD's Malibu facility in Camarillo, California.

In the last decade, CPI has provided Cubic with ground-based advanced antenna products for tracking and communicating with UAVs.

This long-term partnership helps provide U.S. and allied warfighters with real-time data streams that enable more informed decisions and actions.

Steve Lonngren, SVP of the CPI Antenna Systems Division, said that the company's core competence is taking an idea and articulating it into a deliverable system, working in close partnership with the customer throughout design and qualification. That approach has demonstrated value to Cubic as it continually adapts its programs in support of military requirements.

www.cpii.com/division.cfm/13

www.cubic.com/cubic-mission-solutions

DISPATCHES

Lockheed Martin Receives DoD Mod Contract

Lockheed Martin Corp. Space Systems Company has been awarded an $8,130,920 modification (P00054) to previously awarded contract FA8823-15-C-0001 for services required to support operations and sustainment for Advanced Extremely High Frequency, Milstar, and Defense Satellite Communications System III.

The modification provides for a technical refresh of the Advanced Extremely High Frequency Tactical-Mission Planning Subsystem platform. This modification brings the total cumulative face value of the contract to $775,496,626. Work will be performed at Sunnyvale, California; Peterson Air Force Base, Colorado; and Schriever Air Force Base, Colorado. Work is expected to be complete by November 30, 2019. Military Satellite Communication Systems Directorate, Space and Missile Systems Center, Peterson Air Force Base, Colorado, is the contracting activity.

The Advanced Extremely High Frequency (AEHF) system provides vastly improved global, survivable, protected communications capabilities for strategic command and tactical warfighters operating on ground, sea and air platforms. The jam-resistant system also serves international partners including Canada, the Netherlands and the United Kingdom.

AEHF is a case study in cost-reduction. Through a continuing focus on affordability via fixed pricing, streamlined engineering teams, improved manufacturing and economies of scale, the company lowered satellite cost by more than 35 percent in AEHF's most recent block buy. In 2014, the Department of Defense honored the U.S. Air Force AEHF Program with the David Packard Excellence in Acquisition Award for saving $1.6 billion from initial government estimates.

A single AEHF satellite provides greater total capacity than the entire legacy five-satellite Milstar constellation. Individual user data rates will be increased five-fold, permitting transmission of tactical military communications, such as real-time video, battlefield maps and targeting data. In addition to its tactical mission, AEHF assures the critical protected communications links for national leaders, such as the President and Joint Chiefs of Staff, in all levels of conflict.

www.lockheedmartin.com

DISPATCHES

Comtech EF Data Garners DoD contractor award for satellite modems

Comtech EF Data has announced that, during their third quarter of fiscal 2018, the company received a $1.6 million order for satellite modems from a major U.S. Department of Defense (DoD) contractor.

The order specified the **DMD2050E MIL-STD-188-165A/STANAG 4486 Edition 3 Compliant Universal Satellite Modem**, which will be used to support the U.S. Army Project Manager (PM) Tactical Network.

The DMD2050E Satellite Modem is designed to comply with the widest possible range of U.S. Government and commercial standards and is compatible with the largest number of satellite modems in the industry.

This modem is fully compliant with MIL-STD-188-165A (all terminal types), fully complies with STANAG 4486 Edition 3, as well as the IESS-308, IESS-309, IESS-310 and IESS-315 commercial standards.

Additional information regarding the DMD2050E offering is available at ***www.comtechefdata.com/products/satellite-modems/dmd2050e.***

DISPATCHES

STRATCOM Commander offers testimony — U.S. Armed Forces ready to deter adversaries

U.S. Air Force General John E. Hyten, commander of U.S. Strategic Command, testifies for the Senate Armed Services Committee in Washington, March 20, 2018. DoD photo is courtesy of E.J. Hersom.

U.S. Strategic Command forces are prepared to deter strategic attack and employ forces, as directed, to guarantee the security of the nation and its allies, the STRATCOM commander told the Senate Armed Services Committee.

Air Force Gen. John E. Hyten, commander of U.S. Strategic Command, testified before the Senate Armed Services Committee in Washington, on March 20, 2018. "*The most important message I want to deliver today is that the forces under my command are fully ready to deter our adversaries and respond decisively, should deterrence ever fail*," the General said. "We are ready for all threats."

STRATCOM personnel are positioned across the world, and are responsible for multiple domains, including air, land, sea and space. The command sets conditions across the globe as the ultimate guarantor of national and allied security, Hyten said.

STRATCOM's responsibilities include strategic deterrence, nuclear operations, space operations, joint electromagnetic spectrum operations, global strike missile defense analysis and targeting and current cyberspace operations.

The general said the country is challenged by adversaries who continue to expand their range of capabilities across all of these domains, and that STRATCOM must continue to develop capabilities to defeat those adversaries.

The recently completed 2018 Nuclear Posture Review reinforces and clearly defines long-standing national objectives regarding nuclear weapons, while focusing on current and future threats, Hyten said. Providing nuclear deterrence is the lead priority for STRATCOM, the general added.

Hyten said the nuclear triad is critical to current and future success. This includes modernization programs, such as the B-21 bomber, the Columbia-class ballistic missile submarine, the ground-based strategic deterrent, the long-range standoff cruise missile, nuclear command and control, and life-extended nuclear warheads. He said these capabilities will undoubtedly meet the nuclear deterrent needs now and well into the future.

"*To maintain military superiority in this multi-polar, all-domain world, we must out-think, out-maneuver, out-partner and out-innovate our adversaries*," General Hyten said. "*Deterrence in the 21st century requires the integration of all our capabilities, across all domains, enabling us to respond to adversary aggression any time, anywhere. Our forces and capabilities underpin and enable all other joint force operations. [STRATCOM] truly is a global warfighting command, and the strength of its command is its people. The soldiers, sailors, airmen, Marines and civilians of this enterprise have the most important mission in our entire department, in our entire nation. Their hard work and dedication ensures our nation's strategic capabilities remain safe, secure, reliable, and ready*."

The general then added, "*The bedrock of our nation's deterrence continues to be our safe, secure, ready, and reliable nuclear triad. We started the NPR with an assessment of the threat... and based our approach on what our adversaries are doing today and the increasing challenges of the future. The surest way to prevent war is to be prepared for it. While the current [nuclear] triad continues to provide the backbone of our national security, we will eventually consume the last remaining margin from our investments made in the Cold War*."

He closed by stating, "*We have to remember that the strategic environment is dynamic. It changes constantly and our approach to deterrence must be equally dynamic to address these evolving threats. Sustained Congressional support will ensure we remain ready, agile, and effective at deterring strategic attacks, ensuring our allies and partners today and into the future*."

Story by U.S. Air Force Tech. Sgt. Chuck Broadway, DoD News, Defense Media Activity

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DISPATCHES

Harris selected by Asian military to modernize and upgrade comms network

An Asian nation made an agreement with Harris Corporation to become the prime systems integrator to modernize their military communications network.

Harris will replace existing disparate systems and integrate both military and commercial products and software into a turnkey solution. This integrated network will include:

- *a multi-service common operating picture*
- *strategic satellite communications*
- *IT modernization*
- *Harris Falcon III® tactical radios*

The Falcon III® radios will provide secure voice and data communications and friendly force tracking at the tactical level.

Harris' hC2 Software Suite battle management system will improve command and control and create a common operating picture shared across services and echelons, providing enhanced situational awareness across the land, sea and air domains.

hC2 Software Suite is a complete command and control solution that connects all echelons throughout the battlefield.

Chris Young, president, Harris Communication Systems remarked that this significant program win showcases Harris' ability to integrate command and control networks, positioning them for additional international programs in the future. Their solid track record, extensive capabilities and expertise in providing customized tactical solutions led to their selection as the prime systems integrator for this important project.

Young added that this selection reflects the company's strategy of expanding beyond individual solutions to provide customers with integrated command and control systems, such as battle management systems for the United Arab Emirates and Australia.

www.harris.com/solution/harris-rf-7800n-bmxxx-hc2-software-suite

DISPATCHES

Defense Health Agency awards on-site services to Cherokee Nation Technologies

Cherokee Nation Technologies LLC, a native tribe doing business as CNT, Catoosa, Oklahoma, is being awarded a $55,067,430 firm-fixed-price order, HT0011-18-F-0022 to provide services to assist the Assistant Secretary of Defense (Health Affairs), the Defense Health Agency's (DHA) Healthcare Operations Directorate Public Health Division Armed Forces Health Surveillance Branch in its mission to conduct comprehensive health surveillance efforts for the Department of Defense (DoD).

CNT will provide on-site scientific, professional, and technical service support, including Army satellite support, epidemiology and analysis support, global emerging infections surveillance support; integrated bio-surveillance support; and, U.S. Air Force mortality registry support.

Work will be performed at the primary location in Silver Spring, Maryland, with some personnel will be located at DHA satellites at Aberdeen, Maryland; and Dayton, Ohio. The estimated completion date is March 2023.

The scope of this award is to maintain established infrastructure and capabilities; respond to inquiries from the DoD medical and health authorities; assist in analyzing, interpreting, and disseminating information regarding the status, trends, and determinants of the health and fitness of Armed Forces and other DoD approved target populations; and enable DoD health surveillance activities to strengthen its global infectious disease reduction efforts through: centralized coordination, improved preventive health programs and epidemiological capabilities, and enhanced involvement with DoD overseas laboratories.

The period of performance is one year plus four option periods of one year each with an additional option to extend services up to six months under Federal Acquisition Regulation (FAR) 52.217-8 – extension of services.

The award was made on a competitive basis to CNT.

cherokee-cnt.com/

DISPATCHES

GOES-S in Geosynchronous Transfer Orbit above Earth

A United Launch Alliance Atlas V rocket lifts off from Space Launch Complex 41 on March 1, 2018, at Cape Canaveral Air Force Station carrying NOAA's Geostationary Operational Environmental Satellite (GOES-S). Liftoff was at 5:02 p.m. EST. Photo credit: NASA/Bill White

The second in a series of four next-generation weather satellites is now in geosynchronous transfer orbit above the Earth. NOAA's Geostationary Operational Environmental Satellite-S (GOES-S) launched on a United Launch Alliance Atlas V rocket at 5:02 p.m. EST on March 1, 2018, from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida.

There were no weather constraints at the time of rocket liftoff.

"*It was a chamber of commerce day*," said NASA Launch Director Tim Dunn. "*We've been working on GOES-S for about 15 months. This is a huge year for the Launch Services Program*."

GOES-S separated from the United Launch Alliance Centaur upper stage at 8:34 p.m. EST, followed shortly afterward by mission manager confirmation that the spacecraft's Stage 1 solar array successfully deployed and the spacecraft was operating on its own power.

When it reaches geostationary orbit 22,300 miles above Earth, in approximately two weeks, it will be renamed GOES-17.

This is the second in the GOES-R Series of weather satellites that includes GOES-16 (formerly GOES-R), along with -S, -T and -U.

When the satellite is declared operational, late this year, it will occupy NOAA's GOES-West position and provide faster, more accurate data for tracking wildfires, tropical cyclones, fog and other storm systems and hazards that threaten the western United States, including Hawaii and Alaska, Mexico, Central America and the Pacific Ocean, all the way to New Zealand.

NOAA manages the GOES-R Series program through an integrated NOAA/NASA office at NASA's Goddard Space Flight Center in Greenbelt, Maryland. NASA also oversees the acquisition of the spacecraft, instruments and launch vehicles. Lockheed Martin Space of Littleton, Colorado, built the spacecraft and is responsible for spacecraft development, integration and testing.

More information regarding NOAA's GOES satellites is available at ***www.nasa.gov/content/goes***.

Story by Linda Herridge, NASA.

DISPATCHES

The "Eyes in the Sky" connection to the boots on the ground

The RQ-4 Global Hawk is a remotely piloted high-altitude intelligence gathering aircraft capable of flying more than 30 hours straight.

The ability to remotely pilot the aircraft is made possible by a unique group of maintainers in the 9th Aircraft Maintenance Squadron, known as the 9th Aircraft Communications Maintenance Unit.

According to Air Force Staff Sgt. John Brummett, 9th ACMU ground communication segment maintenance noncommissioned officer, there are two sides of the shop: the maintenance side and the network side.

"*The network portion ensures all the imagery and data coming into the shelter is passed along,*" he said. "*The maintenance side generates the cockpit and makes sure all the processes can reach the pilot of the Global Hawk*."

The airmen must ensure all of the communication equipment and the Mission Control Element are functioning properly.

"*We maintain the data links connecting the ground segment with the aircraft*," said Air Force Senior Airman Adrian Santos, 9th ACMU ground communication segment technician. "*This entails maintaining the computer systems in the MCEs, maintaining the cabling which connects the MCE with our antennas, and maintaining the data link, which connects the antenna to the satellite and forwards it to the aircraft*."

Santos said they also work inside the MCEs while real-world missions are being flown and that their role is to ensure the operators have control of the aircraft while gathering intelligence. Transmitting the data to the Distributed Control Ground System on base also falls on the 9th ACMU. The intelligence is also relayed to commanders in theater so they can make decisions.

"*We provide near real-time intelligence to the warfighter*," Brummett said. "*All of the imagery being actively taken is collected in the shelter and we are pushing it out to our clients, so the combatant commander can receive it in near real-time*."

"*It is a humbling feeling being out here because our job directly affects the sorties being flown and the missions being completed. We understand that doing our jobs enables us to fly real-world missions and collect information which helps us accomplish tasks we need to*," Santos said. "*You can't launch an airstrike without knowing what you're going into, and that is what we provide with our high-altitude intelligence, surveillance and reconnaissance*."

Story by Air Force Airman 1st Class Tristan Viglianco
9th Reconnaissance Wing, U.S.A.F.

DISPATCHES

Citizen soldiers support Atlas V launch

Reserve Citizen Airmen from the 920th Rescue Wing, Patrick Air Force Base, Florida, support an Atlas V rocket launch March 1, 2018, at Cape Canaveral, Florida, much like the one shown.

Reserve Citizen Airmen of the 920th Rescue Wing supported the Atlas V rocket launch, which delivered a next-generation weather satellite for the National Oceanic and Atmospheric Administration (NOAA) on March 1.

During the launch window, the 301st Rescue Squadron worked with other military and civilian agencies by flying HH-60G Pave Hawk helicopters to help ensure the safety of maritime traffic in the launch path in case of an anomaly.

"*Each launch is unique, as it depends on the rocket type and support requirements*," said Lt. Col. John Tatton, 301st RQS chief of mobility.

Tatton, who led the 301st RQS launch support efforts, joined the 301st RQS in 2003 and began flying in 2005. Since then he has supported 13 different shuttle missions and numerous rocket launches.

"*It is a unique experience to be a part of history*," he said. "*We have been able to support the space program as it transitions from manned shuttle missions through the development of new technology and potentially back to manned missions*."

According to NASA's web site, the recent launch of the new Operational Environment Satellite" *will provide faster, more accurate and more detailed data, in near real-time, to track storm systems, lightning, wildfires, coastal fog and other hazards that affect the western United States*."

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DISPATCHES

Raytheon sees the light at the end of the location, location, location

This has been a long process for the Raytheon Company in their determined effort to provide the next generation of GPS for the U.S. military — here's the report on the progress of their ongoing software development.

The GPS Operational Control System's launch and checkout system will control launch and early orbit operations and the on-orbit checkout of all GPS III satellites.

Raytheon's GPS Next-Generation Operational Control System, known as GPS OCX, is in the final software development phase.

This phase focuses on increasing automation and building controls for both L1C, a civilian GPS signal aimed at increasing international access, and M-code, a military GPS signal with better anti-jam capability.

Once completed, the team will initiate integration and testing to keep the program on track for full system delivery in June of 2021.

"*Our team has two primary goals this year*," said Dave Wajsgras, president of Raytheon Intelligence, Information and Services. "*We will support the U.S. Air Force's GPS III launch this fall and complete the software build for the full operational system by year's end*."

GPS OCX is the enhanced ground control segment of a U.S. Air Force-led effort to modernize America's GPS system.

The program is implementing 100 percent of DODI 8500.2 "*Defense in Depth*" information assurance standards without waivers, giving it the highest level of cybersecurity protections of any DoD space system.

For protection against future cyber threats, the system's open architecture allows it to integrate new capabilities and signals as they become available.

As GPS OCX can manage nearly twice the satellites of the current system, it will increase signal strength in hard-to-reach areas such as dense cities and mountainous terrain.

Also, advanced automation will free crews to focus on mission-critical tasks such as updating satellite positions more often.

Learn more here about the program's progress and additional capabilities at ***www.raytheon.com/news/feature/location-location-location***.


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DISPATCHES

General Dynamics Mission Systems Fortress LTE System now has full operability with SKYWAN 5G

General Dynamics Mission Systems and ND SatCom recently conducted successful interoperability tests of the Fortress LTE system and the SKYWAN 5G.

The tests demonstrated full interoperability between Fortress decentralized network architecture for autonomous LTE deployables and SKYWAN satellite mesh capabilities for a resilient and bandwidth efficient distributed network of sites with full end-to-end network communications and mobility.

The combined platform provides an ideal solution for transportable and fixed LTE networks that are increasingly becoming a technology of choice for military, tactical, public safety and private mobile users.

The Fortress LTE solution offers autonomous, decentralized LTE sites providing temporary or permanent coverage. ND SatCom's satellite mesh network solution combined with SKYWAN 5G supplements the solution, enabling direct, single-hop communication between sites.

Fortress LTE products use IP as a convergence layer. The edge centric capabilities of the Fortress Evolved Packet Core, combined with SKYWAN satellite mesh topologies, significantly improve the user experience with reduced network signaling and single hops between rapidly deployable LTE cells.

ND SatCom's SKYWAN 5G.

As a result, the OPEX is cut in half which reduces transmission delay and jitter.

With QoS mechanisms and real-time services of SKYWAN 5G's MF-TDMA, waveform jitter was validated at less than 10 ms, with an MOS value of four even on overloaded links.

Fortress LTE provides a multi-band capability for global operations making it an ideal fit with the topology flexibility of the SKYWAN solution, including mesh.

The low size, weight and power, ease-of-transport, and simplified management of Fortress LTE enables quick deployment of multiple base stations regardless of existing infrastructure.

This configuration enables users to roam the network and perform seamless handovers, both inter-cell and inter-EPC with minimal reliance on backhaul links.

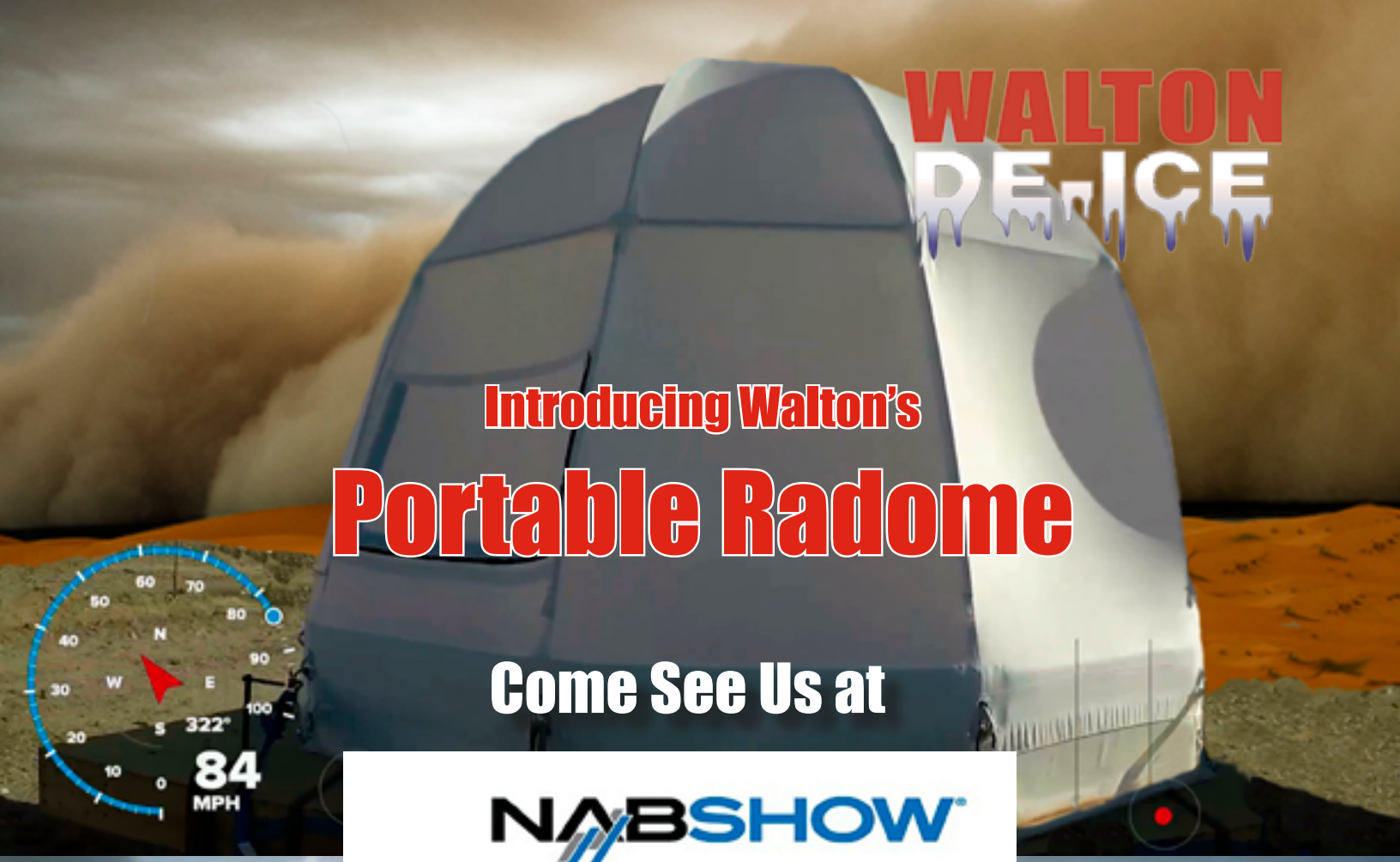
Jacek Jarmul, Cellular Backhaul Sales and Business Development Director at ND SATCOM, reported that, over the past month, the company has been actively pursuing the cellular backhaul segment.

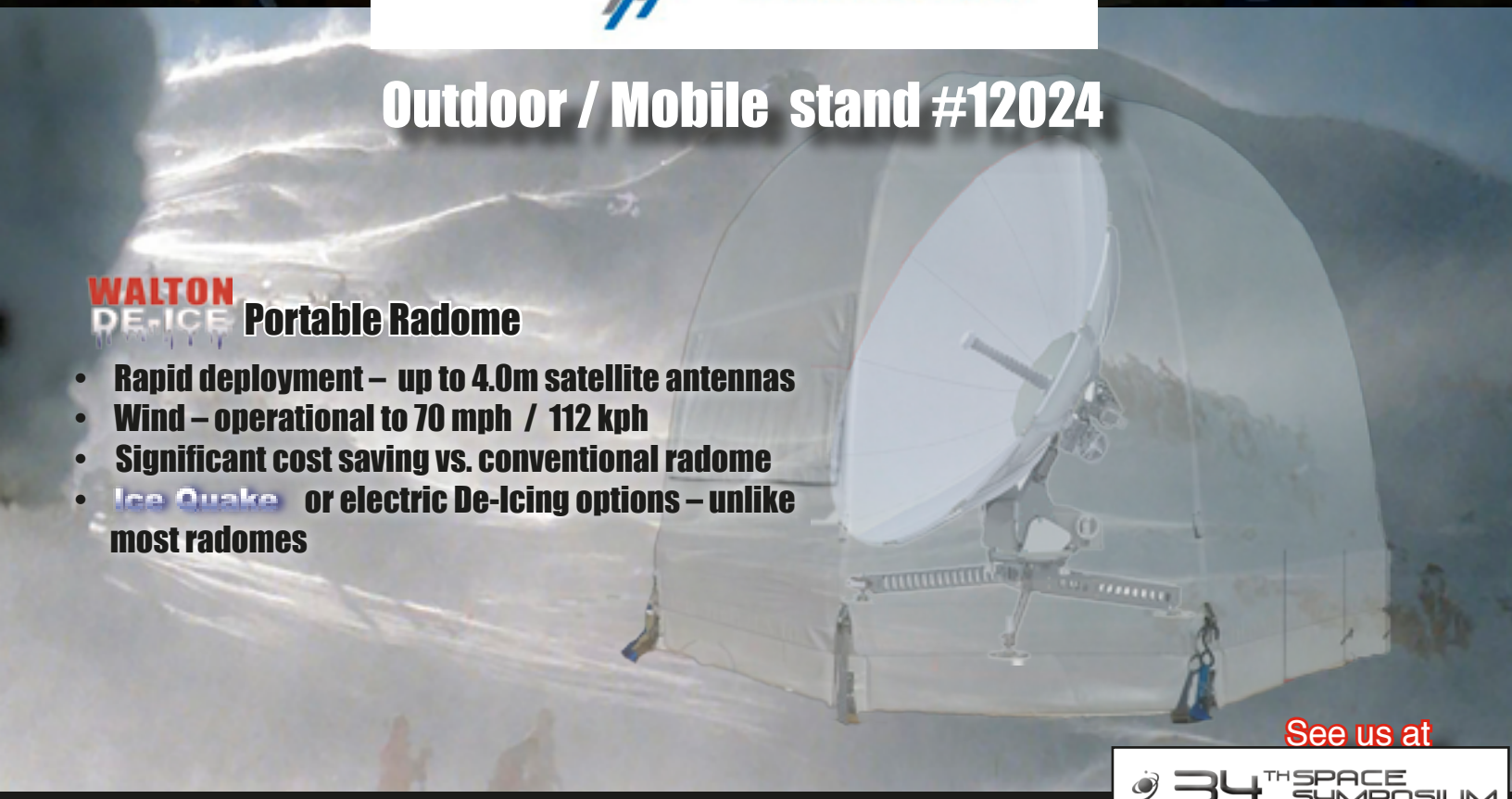
There is a momentum for the firm's Cellular Backhaul suite (including mesh) in 4G networks which, in comparison to 2G and 3G, can be decentralized and autonomous. He added that this especially applies to portable and deployable systems for disaster recovery, public safety and similar.

Following the requests of the company's customers for comprehensive LTE solutions, including satellite backhaul, ND SATCOM selected General Dynamics Fortress LTE Solutions to expand the company's product portfolio and meet customers' requirements.

gdmissionsystems.com/

www.ndsatcom.com/





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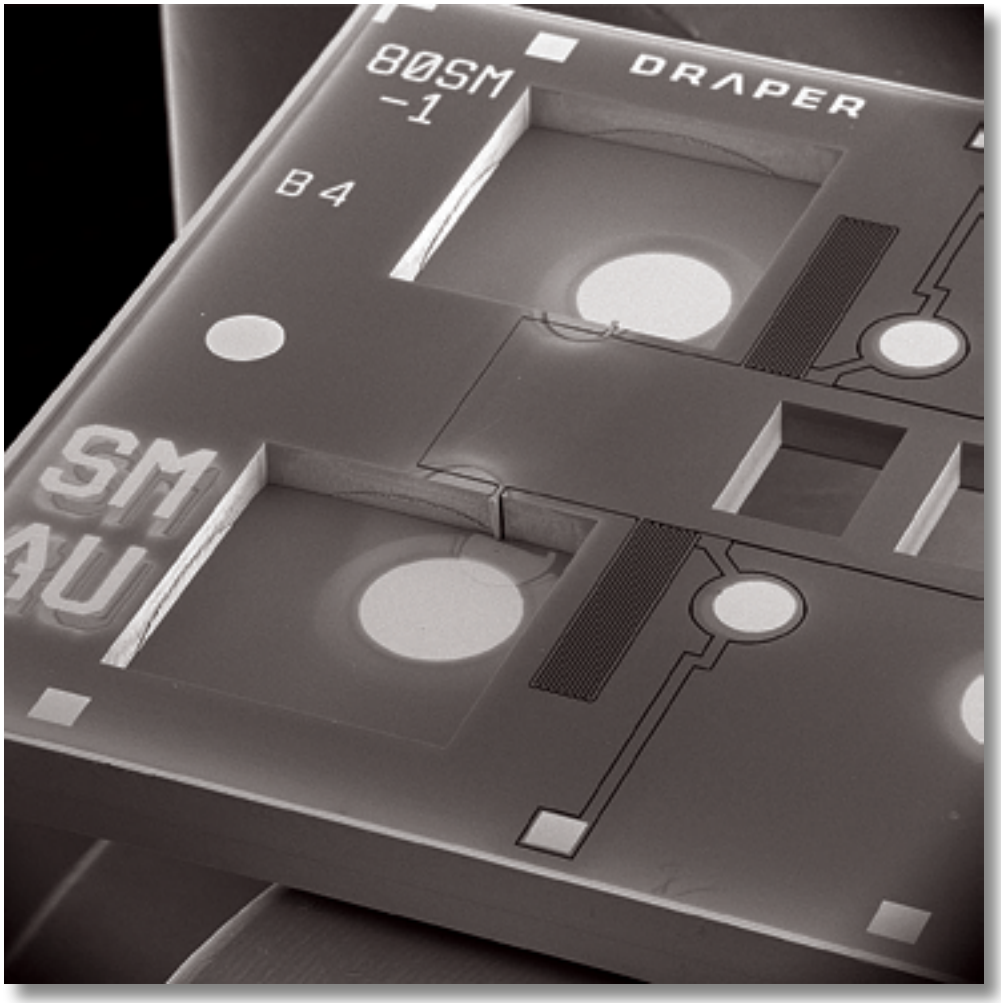
DISPATCHES

Tiny wake-up receivers could extend sensor life, providing benefits to the military and IoT



Warfighters rely on sensors in war zones that provide critical information. Sensors watch over roads U.S. armed forces trave — they detect when adversaries bury improvised explosive devices.

A new sensor developed by Draper is designed to work for years with almost no power, providing benefits to the military and the Internet of Things (IoT).

But to constantly monitor battlefield conditions, sensors are always "on" to detect vibration, light, sound or other signals for situational awareness and to inform tactical planning and action.

With their current dependence on small batteries with short lives, sensors can put soldiers in jeopardy by forcing them to expose themselves to ambush attacks while changing sensor batteries.

Draper addressed this challenge by developing a sensor that awakens only in the presence of target acoustic signals—and requires far less power to operate.

In a radical redesign, Draper engineers found they could reduce the sensor's standby power needs to near-zero if they built the sensor as a microelectromechanical system (MEMS).

"*Sensors constantly consume power, with much of that power spent processing what often turns out to be irrelevant data or noise*," said Jonathan Bernstein, a microelectromechanical engineer at Draper. "*We solved that by designing a zero-power acoustic wake-up switch actuated by environmental sounds that will enable sensor systems to last for years, limited only by battery discharge rates*."

Bernstein invents, designs and fabricates novel MEMS devices. A pre-print of a paper on Draper's new sensor has is available for download at the Journal of Microelectromechanical Systems.

Their discovery could be useful for extending battery life by conserving energy and reducing drain, a beneficial feature for both internet of things devices and unattended ground sensors, the paper said.

"*One area where sensor systems need to advance is power consumption and battery life*," said Marc Weinberg, design engineer in Draper's Mechanical Engineering and System Packaging division. "*As sensors move into more applications, from the military, to our homes, to the internet of things, there's a search on for ways to optimize battery consumption. We believe an acoustic wake-up switch shows promise for the future of sensors*."

The current research into MEMS, which was funded by the DARPA for its N-Zero Program, is part of Draper's materials engineering and microfabrication portfolio.

Draper develops sensors for energy, transportation, defense and cybersecurity, and excels at developing extremely small sensor systems with surprising sensitivity and resolution that are cost-effective and thus easier to distribute widely.

Draper facilities in Cambridge, Massachusetts, include a microfabrication center, MEMS facility, polymer fabrication, precision machine shop and a Center for Additive Manufacturing.

The journal article, titled "***Resonant Acoustic MEMS Wake-Up Switch***," was written by Bernstein and Draper engineers *Mirela G. Bancu*, *Eugene H. Cook*, *Amy E. Duwel*, *Richard D. Elliott*, *Douglas A. Gauthier*, *Stephanie L. Golmon*, *John J. LeBlanc*, *Michael Tomaino-Iannucci*, *Jonathan S. Ung* and *Weinberg*.

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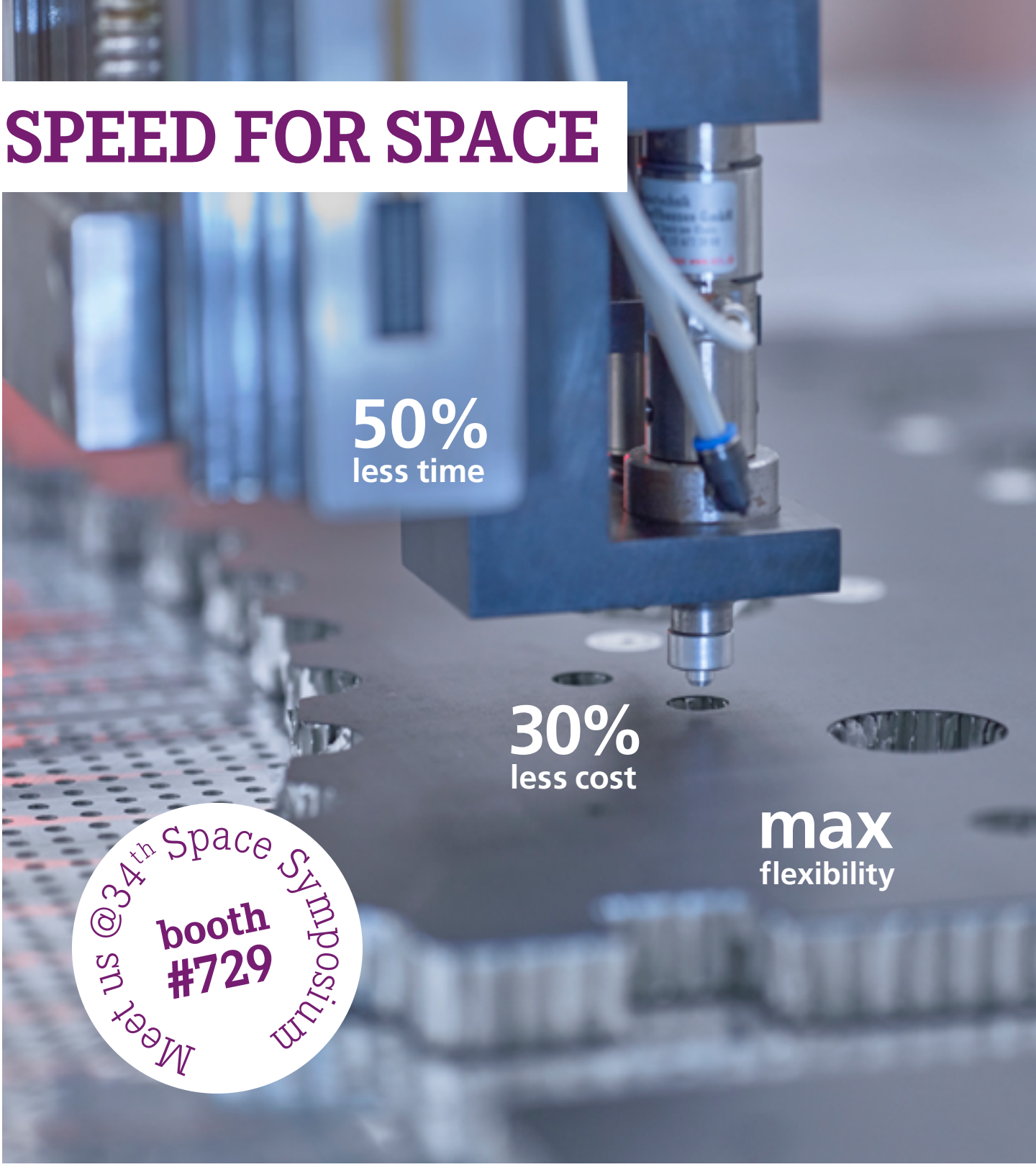

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SMALL SATELLITES GROW UP

A Boeing Perspective

By Christian Dommell, Small Satellite Innovation Lead, Boeing Phantom Works

To an outside observer, it must seem as if smallsats have finally made it big — hundreds of millions of dollars are being invested in the smallsat ecosystem, bolstered by an energetic, ever-growing international community.

This enthusiasm is not lost on the United States government, where smaller systems are becoming a key element of a more resilient space enterprise. For the purposes of this discussion, smallsat refers to a class of vehicles inclusive of cubesats through approximately 400 kg.

If you have been part of this community for a while, you might feel like the record store hipster who can't help but brag, "*I was into smallsats before they were big.*" Certainly, there seems to be a serendipitous confluence of enablers providing credibility where previous hype had faltered. These enablers include low cost launch, miniaturized hardware and advanced data processing techniques, all supported by innovative business plans, new financing models and a few outspoken billionaires.

In spite of an abundance of positive momentum, there is much work left to be completed. In many ways, the next two years will decide the fate of the smallsat community — now that everyone is watching, we have little margin for error.

If smallsats are to become the new normal for critical missions in support of the nation's warfighters, work must be done cooperatively to mature the industry. This goal can be achieved by strategically fusing the best new ideas with the essential practices that have made traditional providers successful for over 50 years.

Boeing and the company's teammates are working to accomplish just that. Boeing recognized the value of smallsats years ago and invested in the development of the versatile, modular 502 product line, which spans rideshare and multi-manifest class vehicles. The company's venerable satellite communications business continues to disrupt the industry with smaller solutions, from the all-electric 702SP to the flexible multi-terabit **mPower** constellation for SES.

Here to Stay

Smallsats are here to stay, therefore here are five key areas where Boeing is working to help make that future a reality:

Terminology — To some, a smallsat is cheap, expendable and "good-enough". While that's a fair description of a technology demonstrator, this phrasing is not an accurate representation of a high-performance, high-availability national asset. Imprecise terminology can lead to unrealistic expectations — there are smallsat customers who expect Lamborghini performance for the price of a moped. There are varying classes of smallsats, each tailored to the unique mission needs of their customers. Community bodies, such as the ***USGIF SmallSat Working Group*** (*usgif.org/community/Committees/SmallSat*), are excellent forums to socialize new language and taxonomies to help us all communicate about our products and capabilities better.

Furthermore, reliance on rubrics such as Technology Readiness Level can bias how risk is assessed and how acquisition decisions are made. Technology is moving quickly, motivating providers to continually insert new technology and improve on existing designs. Drawing on lessons learned from successes and failures, Boeing uses robust modeling and simulation, flexible manufacturing processes and digital configuration management to show that higher technological dynamism is not an inherently higher risk.

Dependability — Early value propositions posited that if one could build enough smallsats at a low enough cost, one could tolerate the loss of a few on-orbit assets *i.e.*, constellation level reliability. Though this vision has played out for a handful of commercial constellations, many more missions are being seen with one to three satellites, where each vehicle must operate nominally to achieve the desired outcome. Unfortunately, many of the processes, tools and techniques developed to provide mission assurance for 15+ years at Geostationary Earth Orbit (GEO) are too time consuming and cost intensive for smallsats.

On the other hand, cooperation is required to ensure smallsat component suppliers gain the experience and process rigor to consistently deliver parts that meet company specifications with a predictable rate of failure. As smallsat missions proliferate into Medium Earth Orbit (MEO), GEO and beyond, improved reliability will be necessary to ensure safe operations and assured disposal.

Community efforts such as NASA's ***SmallSat Parts On-Orbit Now Database*** and the mission success interviews conducted by the ***Mission Assurance Improvement Workshop*** (MAIW) are great first steps. Based on our own experience, Boeing and the firm's industry partners have developed an approach to smallsat mission assurance that takes the essential tenets of traditional space and applies them to a rapid development framework. As Boeing customers begin to rely on smallsats to perform more critical and time-sensitive missions, we must work together diligently to create systems our customers can rely on.

Cyber — The sad truth is that the more successful something becomes, the more it becomes a target. Commercial and government operators are facing ever-increasing threats to their systems — large constellations only exacerbate the problem by presenting a larger attack surface, spanning space and ground. As smallsats generate more economic value and perform more critical missions, the industry simply cannot just react to the increased pace and complexity of the cyber threats that will follow. Boeing is working to protect all of satellite products, starting with the Command & Control and mission data systems on the ground to on-board cybersecurity applications running on hardware built by an assured supply chain.

Data— The solution to the impending data tsunami about to be unleashed by blackened skies usually includes buzzwords such as 'cloud', 'machine learning' and 'artificial intelligence'. While these technologies help to revolutionize the industry, they are hardly magic fairy dust for solving all big data problems.

Engineers and data scientists still toil for months to transform the data (and the customer's needs) into a problem that can be solved by machine learning if one is lucky enough to have good training data. Many ventures depend on this transformation of data to close their business case but spend more time tinkering with hardware than talking to customers.

Boeing starts with the customer and brings the correct technologies to bear for each unique mission. That could include optimizing tip-and-cue architectures using predictive analytics or enabling scalable mission computing using the ***Boeing Multi-Processing Framework on Commercial Cloud Services*** (C2S).

Openness — If the smallsat community hopes to be successful, we must fight the tendency to sequester ourselves. Diverse perspectives and orthogonal thinking are going to be required to solve the challenges ahead. Boeing is engaged with the startup community through our newly-formed **HorizonX** (*www.boeing.com/company/key-orgs/horizon-x/*) venture arm. Additionally, the company is working across air, cyber and sea domains to leverage low-size, weight and power sensors, on-board processing and swarm autonomy from innovative Boeing subsidiaries like **Aurora Flight Sciences** and **Liquid Robotics**.

There is much to be done — the fun is also just starting. At Boeing, all are excited about using smallsats to help the company fulfill the crucial mission to connect, protect, explore and inspire the world.

Author Christian Dommell is the Small Satellite Innovation Lead at Boeing Phantom Works

LEADERSHIP AND INDUSTRY DEVELOPMENT PAVE A NEW PATH FOR UNIFIED SATCOM

By Rebecca M. Cowen-Hirsch, Senior Contributor and Senior Vice President of Government Strategy and Policy, Inmarsat Government

Whether responding to natural disasters or supporting command and control (C2) of unmanned aerial vehicle (UAV) links and data streams for intelligence, surveillance and reconnaissance (ISR), commercial satellite communications (COMSATCOM) provides the preponderance of Department of Defense (DoD) communication capabilities for SATCOM users across the full spectrum of operations.

After years of using COMSATCOM as a gap filler to augment military capability, the government now recognizes the strategic importance of commercial SATCOM sources that are vital to our nation's military and national security and are the foundation for superior diversity and redundancy, adding further resilience to its operations.

What has driven this change? A satellite environment that has grown increasingly conflicted and contested. Space is a warfighting domain, and there are imperatives for action to ensure persistent, critical space warfighting capabilities, capabilities which COMSATCOM readily delivers.

More than ever, our nation's leaders are acknowledging this, paving the way for these and other welcomed developments:

The National Defense Authorization Act (NDAA) for Fiscal Year 2018

The potential impact of the **NDAA** — signed into law in December by the President — cannot be overstated: the NDAA signifies the U.S. government's recognition of the criticality of space resilience and the importance of consistent, consolidated and strategic leadership in space. It serves as a legislative response to the urgent need for military users to have ready access to resilient, robust and secure SATCOM across the full spectrum of engagement through the support of COMSATCOM.

The NDAA provides a framework for, and marks the first step toward, crucial reorganization and consolidation of space capabilities with a clear opportunity for COMSATCOM to become an integral part of the SATCOM architecture.

Specifically, three NDAA components underscore these themes:

SATCOM consolidation. Among the NDAA's key provisions for national security space programs are changes in space organization and management. The NDAA requires the Deputy Secretary of Defense to develop an independent plan to establish a separate military department responsible for the national security space activities of the DoD by December 31, 2018.

This is a clear recognition that SATCOM has emerged as an area that requires extremely senior-level organizational strength and focus. A single DoD office will oversee all national space activities, claiming ownership of procurement, policies and practices. It will address key issues such as the need to elevate SATCOM capabilities while building a more protected, resilient space environment.

Expanded SATCOM capabilities. Under the NDAA, COMSATCOM will "*enter the mainstream*" in new and compelling ways. All of this will start with what has become "*two-hatted*" roles under the **Commander of Air Force Space Command** (**AFSPC**) and the **Joint Force Space Component Commander** of at least six years, with the "*sole*" authority for organizing, training, equipping and maintaining mission-ready space and cyberspace forces and capabilities for the **North American Aerospace Defense Command, U.S. Strategic Command** (**USSTRATCOM**) and other combatant commands around the world. As part of the responsibilities is the acquisitions for defense in space, while procuring all COMSATCOM for the DoD beginning one year after the enactment of the NDAA.

The convergence of SATCOM acquisition and operations. The NDAA promises a notable expansion of authority by aligning acquisition and operational responsibilities under a single senior leadership with the Air Force. This demonstrates further movement toward consolidation of authority, while specifying that COMSATCOM must play a key role in the government space acquisition model. For the first time, COMSATCOM will "*sit*" alongside military SATCOM (MILSATCOM), a transition which will position the DoD to take full advantage of a fully integrated and holistic approach to SATCOM as it moves toward a unified SATCOM architecture.

In his roles, General Raymond, Commander, Air Force Space Command (**Air Forces Strategic-Space**) and the Joint Force Space Component Commander, U.S. Strategic Command will be responsible for the organizing, training and equipping of Air Force space forces as well as for executing operational C2 of joint space forces.

This amounts to far more than a shuffling of assignments. It is an acknowledgement — backed by action — that General Raymond will oversee both space acquisition and operations. Again, it is a movement toward optimal integration and consolidation, a critical connection if we seek to respond to the complexities and challenges of the modern mission. With the satellite industry fully prepared to profoundly enhance SATCOM capabilities for the military, we consider the expansion of General Raymond's duties to be quite a milestone.

The Analysis of Alternatives (AoA)

Explored since December 2016, the AoA offers an opportunity to define — arguably for the first time — a new approach that harnesses the scale, scope and innovation of industry to achieve essential outcomes. The AOA calls for a follow-on wideband communications system to the **Wideband Global SATCOM** (**WGS**) system. The AoA is currently underway, with unprecedented industry and Allied participation bringing the promise of expanded space, air and ground layer communication capabilities. It will significantly determine the future of government SATCOM.

The Formal Establishment of a Commercial Presence within the Joint Space Operations Center (JSpOC)

This plan follows the creation of the **Commercial Integration Cell** (**CIC**) pilot program within the JSpOC in June of 2015, in which Inmarsat and six other companies partner with the U.S. government via Cooperative Research and Development Agreements.

Literally working on the JSpOC floor every day, the partnership enables industry and the government via **Cooperative Research and Development Agreements** (**CRADAs**) to share technology and information on a collaborative basis, expanding integration and space situational awareness while increasing the C2 capacity of the Joint Force Space Component under USSTRATCOM. It has focused on the improvement of processes and commercial/government integration in conducting conjunction assessments and addressing electromagnetic interference and resolution. General Raymond has described the CIC as "*the next step in our ongoing efforts to partner with like-minded space-faring entities to promote the peaceful and responsible use of space*" through the enhanced integration of industry cyber capabilities into day-to-day space operations.

The Space Warfighting Construct

This initiative, announced by General Raymond, will combine enhanced situational awareness and responsive C2 to support a space enterprise that can fight through conflict. The Space Warfighting Construct creates the framework for making the Space Enterprise Vision a reality. It is expected to transform the space enterprise into a more robust and resilient architecture to maintain space superiority in the 21st century. In addition, it acknowledges that national security objectives are achieved through partnerships among the U.S. government, its Allies and the commercial space sector. Developing and integrating these partnerships will prove key to the Space Warfighting Construct's success.

Gen. Raymond has also championed a **Battle Management Command and Control**, or **BMC2**, system that will enable commanders to simultaneously maneuver space assets and direct defensive operations against multiple threats while maintaining space capabilities for military users. "*(We seek) to build unity of effort between the DoD and the intelligence community to effectively command and control in a contested domain, which ultimately provides us the capability to be able to fight and win a war if it extends into space*," said General Raymond in unveiling the Space Warfighting Construct and BMC2.

Through these actions, a new path forward for the government and COMSATCOM — the one-time "gap filler" — becomes clear: an enterprise-level, integrated architecture and strategy. This is the true path to ensure reliable, available and resilient seamless, state-of-the-art SATCOM that is fully interoperable with government-owned and operated systems — **welcome to the era of Unified SATCOM.**

Rebecca M. Cowen-Hirsch is Senior Vice President for Government Strategy and Policy of Inmarsat's Government Business Unit and she is also a Senior Contributor to MilsatMagazine.

SMALLSATS... SINGLE ANSWERS OR TOOLS FOR GREATER SOLUTIONS?

A Ball Aerospace Focus

By Debra Facktor, Vice President and General Manager of Strategic Operations and of the Commercial Aerospace strategic business unit for Ball Aerospace

The small satellite market continues to grow — in interest, investment, capability and potential impact.

There is an opportunity for new uses including Earth imaging, space science, weather and climate, biology research, growing security threats and communications. Commercial and government customers are increasingly considering how smaller platforms, coupled with more affordable access to space, shrinking budgets and improvements in technology miniaturization, can contribute to new solutions and markets.

Small satellites (smallsats) are maturing into systems capable of producing potentially valuable data. As this smaller technology becomes widely available, customers and providers must face a challenge relevant to all new products and capabilities — figuring out how it will fit into existing structures.

This process begins with identifying how small sats affect the broader satellite market, specifically the existing capabilities and services that will be changed by the growth in small sat technologies.

In addition, smallsats are emerging as a complement to larger, more exquisite architectures across the defense, science and commercial markets. They are proving useful in areas like technology demonstration missions and rapid access to space, and should be viewed as a supplement, rather than a replacement for programs of record.

Defense

Augmenting large, government-owned systems with small sat-enabled solutions and commercial business models is a benefit small sats can offer in the defense sector.

Government customers are increasingly interested in data from a diverse set of sources including everything from small satellites to airborne instruments and even stratospheric balloons.

Artistic rendition of the STPSat-3, the second STP-SIV spacecraft.
Image is courtesy of Ball

A Ball engineer inspects the U.S. Air Force's STP-SIV smallsat, which is built on Ball's BCP-100 spacecraft, developed for fast and affordable access to space.

Companies that can integrate data from emerging technologies like small sats with data from existing architectures, can find a niche and enhance solutions for government customers.

For example, together with Spire Global, Ball Aerospace is using commercial data from smallsats to improve maritime domain awareness in the Arctic, which provides the National Geospatial-Intelligence Agency (NGA) with information on real-time shipping traffic and other activities in this strategic ocean basin.

By combining data from programs of record like Landsat and Sentinel with new data from Spire cubesats, Ball is creating a data product that does not exist today, and making that data accessible and useful to its customer. This work for NGA demonstrates a successful case of connecting-the-dots across customers and industry partners to improve the NGA's existing data product.

The resiliency and rapid response afforded by smaller spacecraft is also a priority for defense customers. The U.S. Air Force Space Test Program's Standard Interface Vehicle (STP-SIV) project has developed a common spacecraft bus with a standard payload interface that improves the nation's ability to quickly and affordably launch satellites into space.

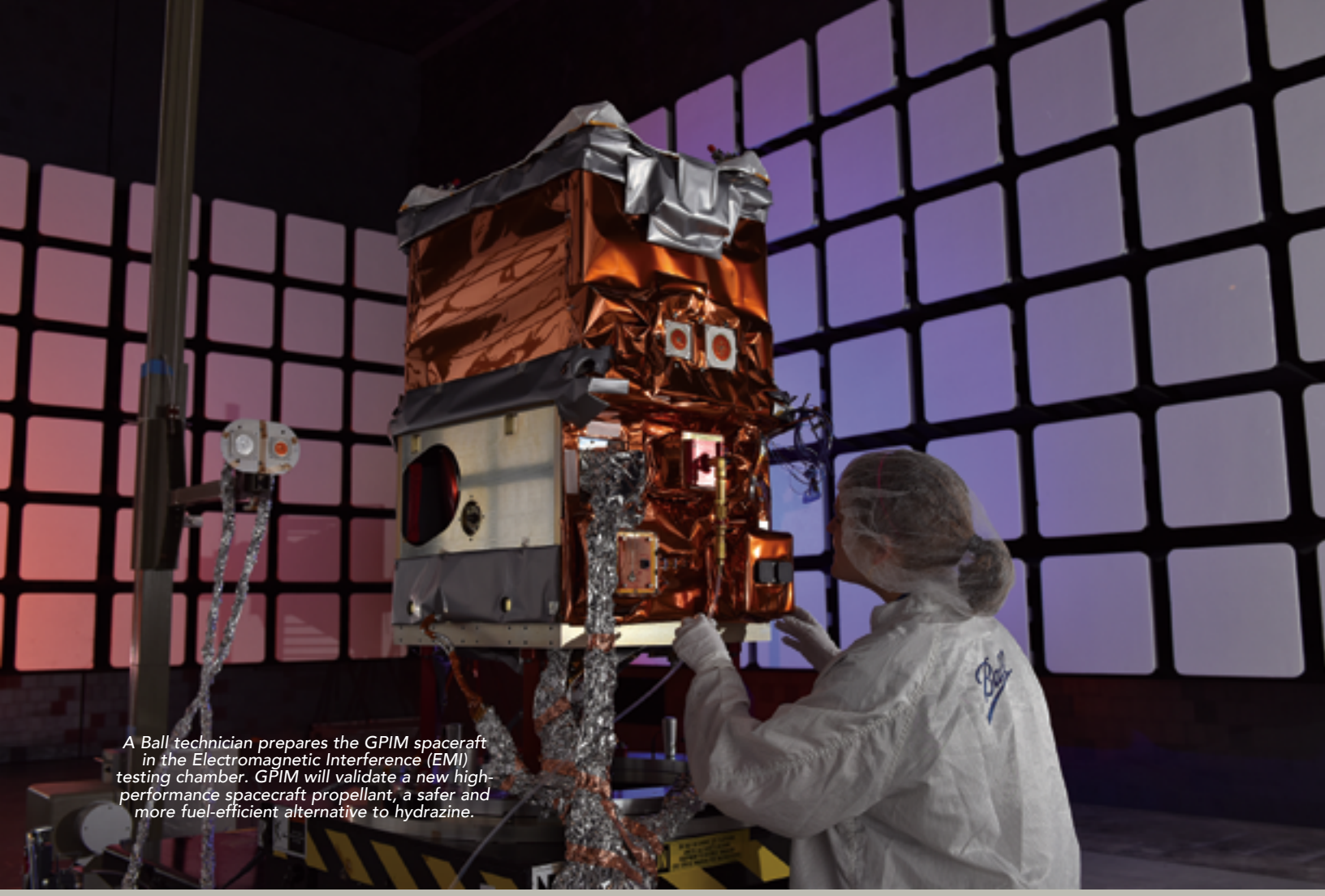
The STP-SIV series of satellites is based on the Ball Configurable Platform (BCP) 100, which is ideal for a variety of science, technology development, risk reduction and operational missions.

Ball built two STP-SIV spacecraft buses with common payload interfaces, the second of which was built in only 47 days. The STP-SIV spacecraft, both STPSat-2 with three payloads, and STPSat-3 with six payloads, continue to fly and demonstrate flexibility and significant cost effectiveness after seven and four years, respectively, of on orbit operations.

Science

Smallsats are also making inroads for scientific applications. The platforms are lower cost, can be fielded more quickly and used to demonstrate technologies. Reduced development and launch costs means more money is available to conduct scientific observations. Government customers like NASA are exploring smallsats both from technology demonstration and mission architecture standpoints.

One example of technology demonstration is NASA's In-Space Validation of Earth Science Technologies (InVEST) program. Ball Aerospace is designing and building the Compact Infrared Radiometer in Space (CIRiS) instrument for integration on a cubesat platform.



A Ball technician prepares the GPIM spacecraft in the Electromagnetic Interference (EMI) testing chamber. GPIM will validate a new high-performance spacecraft propellant, a safer and more fuel-efficient alternative to hydrazine.

CIRiS will validate the ability of miniaturized science instruments, in this case a compact thermal infrared instrument that could be used for land imaging and water management needs, to effectively deliver highly-calibrated and scientifically-significant data while reducing overall costs.

Another technology demonstration, NASA's Green Propellant Infusion Mission (GPIM), will launch later this year to test a high-performance replacement to hydrazine fuel. On GPIM, NASA is collaborating with a Ball Aerospace team that includes Aerojet Rocketdyne, the U.S. Air force Research Laboratory and the Air Force Space and Missile Systems Center.

The mission will fly on Ball's BCP-100 class spacecraft, providing a flexible and agile smallsat solution with standard payload interfaces and streamlined procedures, allowing rapid and cost-effective access to space. GPIM validates a new technology in an affordable way, creating a pathfinder for green propellant to be incorporated into future missions with reduced risk.

NASA is also capitalizing on smallsat architectures with the agency's Explorers Program, which offers low-cost access to space for world-class scientific investigations.

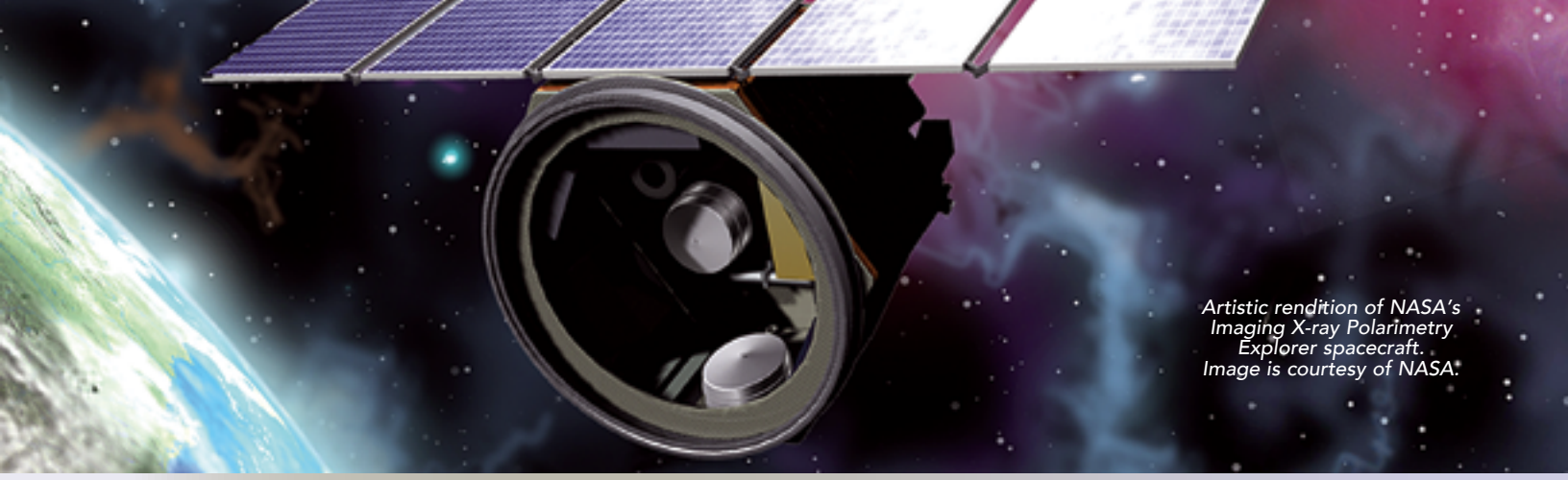
NASA's X-ray Polarimetry Explorer (IXPE), designed on the same BCP-100 configurable bus as the GPIM mission, demonstrates the diversity of small sat science mission architectures. From LEO, IXPE, an astrophysics mission, will examine the makeup of some of the most high-energy astronomical objects in the universe such as neutron stars and black holes.

Commercial

New market applications for smallsat platforms and constellations continue to arrive, expanding opportunities and increasing competition.

This environment is triggering a change in mindset for government customers who traditionally own and operate systems, and who are now open to considering how commercial data can be used to supplement existing capabilities. Government customers are becoming more open to procuring systems and or data in a more commercial way, such as using commercial acquisition practices or buying data results not hardware.

Understanding customer needs and providing data and answers are still the most important priorities for industry partners. For companies looking to do business in the commercial smallsat arena, the challenge lies both in developing reliable and resilient technology, and in integrating small satellite systems into the solution space.



Artistic rendition of NASA's Imaging X-ray Polarimetry Explorer spacecraft. Image is courtesy of NASA.

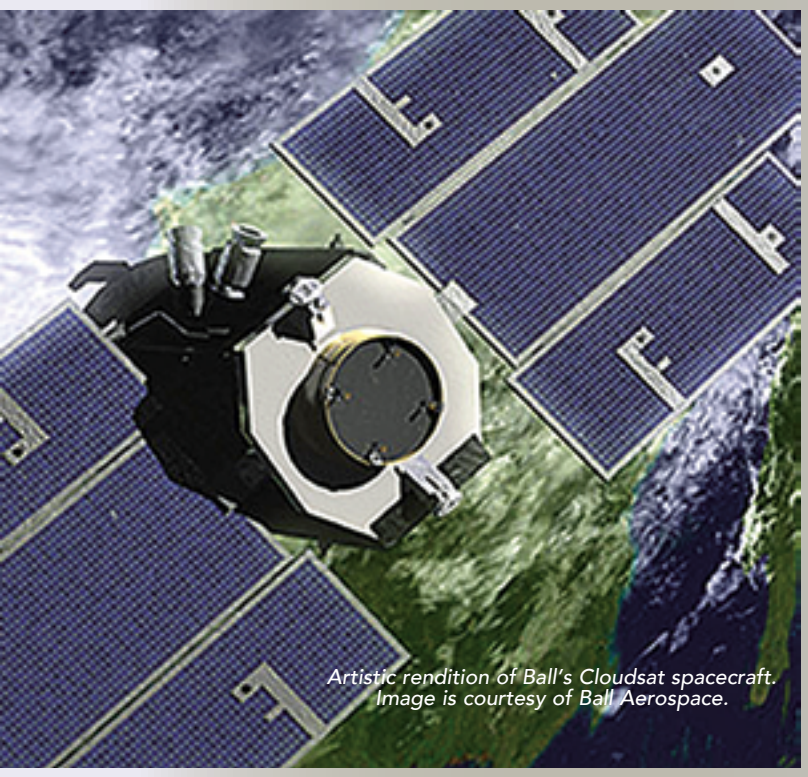
Here again, Ball's work with Spire demonstrates the utility of fusing smallsat data with data from existing government platforms and creating an integrated solution using a commercial model.

Commercial markets are also emerging for persistent imaging capabilities utilizing results from stratospheric balloons which provide a platform that is complementary to small satellite constellations.

Ball and World View are collaborating on a proof of concept for high-altitude imaging using World View's Stratollites and Ball's sensors and analytics. This paves the way for new markets such as public safety, homeland security, and civic resource mapping and monitoring, by bringing together hardware and analysis at a fraction of the cost of existing technology.

People

Smallsats are also having a positive impact on the aerospace and defense industry's workforce.



Artistic rendition of Ball's Cloudsat spacecraft. Image is courtesy of Ball Aerospace.

The relatively low cost of smallsats, especially cubesats, enables university students in science, engineering and related fields to do hands-on work with space hardware — from design to launch and on orbit operations. The data resulting from these smallsats is increasingly more accessible to students who can learn from their results and test new operations.

Students are entering the workforce today with more hands-on experience on both hardware and data, and with the capability to immediately apply their skillset into the workforce in different ways than previous generations.

Single answers or tools for greater solutions? — Yes

Smallsats are opening doors to new data, partnerships and practices, and can be complementary to existing architectures and traditional programs. Among the potential markets for smallsats, only one demand is constant in all of them: answers.

Government and commercial customers care more about the quality, readiness, applicability and reliability of their data than what platforms those data come from. In today's diverse marketplace, integrators must be prepared to merge smallsat data and capabilities with that of other architectures — large and small — to produce the answers customers need.

www.ballaerospace.com

Debra Facktor is the Vice President and General Manager of Strategic Operations and of the Commercial Aerospace strategic business unit for Ball Aerospace. As the leader of Strategic Operations, Facktor is responsible for increasing Ball Aerospace's profile in the market and facilitating collaboration across the company. She is the company's senior executive in the Washington, DC area and leads Washington Operations, Marketing & Communications and Strategic Development.

As the leader of Ball Aerospace's Commercial Aerospace strategic business, Facktor is responsible for developing and executing new business strategies across the company, and pursuing and performing commercial work in the areas of traditional space, integrated solutions and transformational communications for airborne and space platforms and data analytics.

OPEN SYSTEMS HTS IS BEST FOR GOVERNMENT NEEDS

A SatCom Frontier Perspective

Over the past couple of years, multiple commercial satellite operators have begun launching high-throughput satellite (HTS) constellations.

These next-generation satellites provide far more throughput than existing wideband satellites, with increases in throughput 2 to 6 times the bandwidth equivalent of conventional commercial or **Wideband Global SATCOM** (WGS) satellites.

Moving to HTS in space in many ways is like the move of terrestrial networks from dial-up to broadband access. The United States government stands to greatly benefit from these new HTS constellations, but decision makers need to understand the pros and cons of the individual HTS designs.

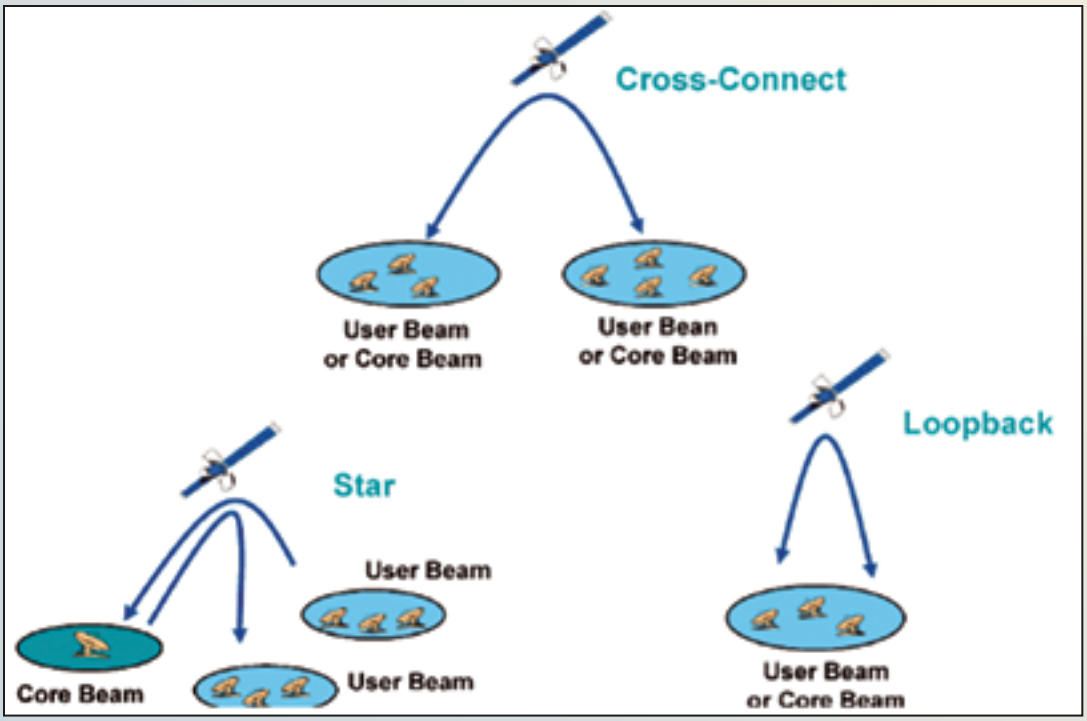
Many HTS operators developed their HTS platforms as closed systems, with purpose-built solutions servicing homogeneous sets of users via a specific architecture. These closed networks include **ViaSat Exede**, **Inmarsat Global Express**, **Hughes Jupiter**, and **Eutelsat KA-SAT**.

Closed vs. open architecture is a very important distinction. Closed systems dictate to the end users which terminals and teleport locations must be used. They also require new investments in proprietary modem technologies and service architectures.

As the provider's infrastructure must be used, confidentiality-of-data and quality control issues come into play. For these and other reasons, most government SATCOM networks cannot migrate to a closed architecture.

Fortunately, open HTS architectures are now being deployed today such as Intelsat **Epic^{NG}**, **Telesat VANTAGE**, and **Inmarsat High Capacity Overlay** (HCO). These architectures are much more appropriate for government missions because they allow the use of existing government-owned terminals and teleports.

Artistic rendition of an Intelsat EPIC^{NG} satellite.



Intelsat Epic^{NG} Satellite Topologies

Intelsat **Epic^{NG}** supports a wide range of communication topologies and allows the military to leverage the Ku-band antenna/modem infrastructure already in place across the **Department of Defense** (DoD) including manpack, flyway, Communications-On-The-Move (COTM), airborne, and unmanned aircraft systems (UAS). This ability to use current ground equipment leads to substantial cost savings for the government customer, and can be leveraged in many ISR applications to support new light-footprint CONOPS that do not require onsite Ground Control Stations.

Recent testing done by the U.S. Marine Corps (USMC) with Intelsat **Epic^{NG}** demonstrated the efficacy of open HTS. The **Network Centric Waveform** was designed to dynamically optimize bandwidth and satellite utilization, providing efficient SATCOM capabilities for **WIN-T Increment 2** while both at-the-halt and on-the-move.

In October 2016, the USMC and the Navy's **Space and Naval Warfare Systems Command** (SPAWAR) conducted testing to evaluate HTS technologies to support these Networking-on-the-Move (NOTM) requirements at Camp Lejeune, North Carolina. USMC typically deploys with two types of key SATCOM assets: the **Point of Presence Vehicle Kit** (POP) and the **Tactical Entry Point** (TEP) **Modem Kit** (TMK) for a 2.4 meter Small Tactical Terminal.

Using the **General Dynamics** 20-20M SATCOM-on-the-Move (SOTM) 20-inch antenna and the **L-3** Linkabit MPM-1000 Net-Centric Waveform (NCW) modem in the POP and TMK units, the test was set up in two phases: normal operations on a typical wide-beam satellite (**Intelsat Galaxy-3C**) and enhanced operations on an open architecture high throughput satellite (**Intelsat-29e**).

While operating over Galaxy-3C, information rates from the terminal (TMK) to the vehicle (POP) were limited to 1536 kbps and 256 kbps from one POP to the TMK. Due to the small size of the SOTM antenna aperture, the POP node had to operate at a modulation and code rate of BPSK1/2spread 12 times in order to establish communications. This means the 256 kbps return link occupied 7.5 MHz of bandwidth alone. In the 9.7 MHz allocated to testing, this limitation severely impacted the amount of bandwidth available for higher burst rates from the TMK to the POP.

When operating over Intelsat-29e HTS, USMC users were able to achieve a total simultaneous throughput capacity of approximately 9 Mbps using the same 9.7 MHz of allocated bandwidth. This represents approximately five times more throughput versus the less than 2 Mbps in the same amount of bandwidth on traditional wide-beam satellites via these VSATs.

Currently, there are five Intelsat EpicNG satellites on orbit covering approximately 80 percent of the Earth's landmasses and littoral waters with high throughput beams. With its launch in 2018, the sixth **Epic^{NG}** satellite will cover Australia, the Pacific Ocean, and McMurdo Station in Antarctica. These areas represent the majority of the ground mobile, fixed site, air traffic, and naval operating lanes.

HTS systems offer quantum leaps forward from the satellite communications of today, but users need to look carefully at the overall designs of the various constellations.

Unlike closed systems, Intelsat **Epic^{NG}** was designed to take full advantage of this next-generation in space-based communications while maximizing the continued use of existing investments. **Epic^{NG}** uses the enhanced Next Generation WGS Boeing digital payload, which enables Intelsat to offer communications from any beam to any beam, even across frequency bands.

This digital switch enables Intelsat to offer communications from any beam to any beam, even across frequency bands. For example, on IS-37e, Intelsat could uplink a signal from a Ku-band spot beam in Bahrain and route that signal through the digital switch to a C-band downlink in the Falkland Islands or anywhere else in the footprint of the satellite.

For these reasons, open architectures such as that offered by Intelsat Epic^{NG} are the right HTS choice for the DoD. It provides the most compelling value proposition for government customers, and will play a large role in keeping the United States ahead of potential adversaries in space.

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The preceding article is courtesy of Intelsat General's SatCom Frontier infosite and editorial team.

INNOVATION: ADVANCING SPACE SITUATIONAL AWARENESS THROUGH THE USE OF RF DATA

By Greg Caicedo, Vice President, Kratos Networks and Data Solutions

When U.S. Navy sailors were captured in the Persian Gulf in 2016, many believed the event was caused in part by Iran's 'spoofing' or falsifying U.S. satellite signals.

With spoofing, jamming, and other recent incidents, adversaries have demonstrated their rising sophistication and intent to disrupt space systems. U.S. military leaders have been strongly vocal about the threats to space capabilities, heightening the urgency and need for more advanced Space Situational Awareness (SSA).

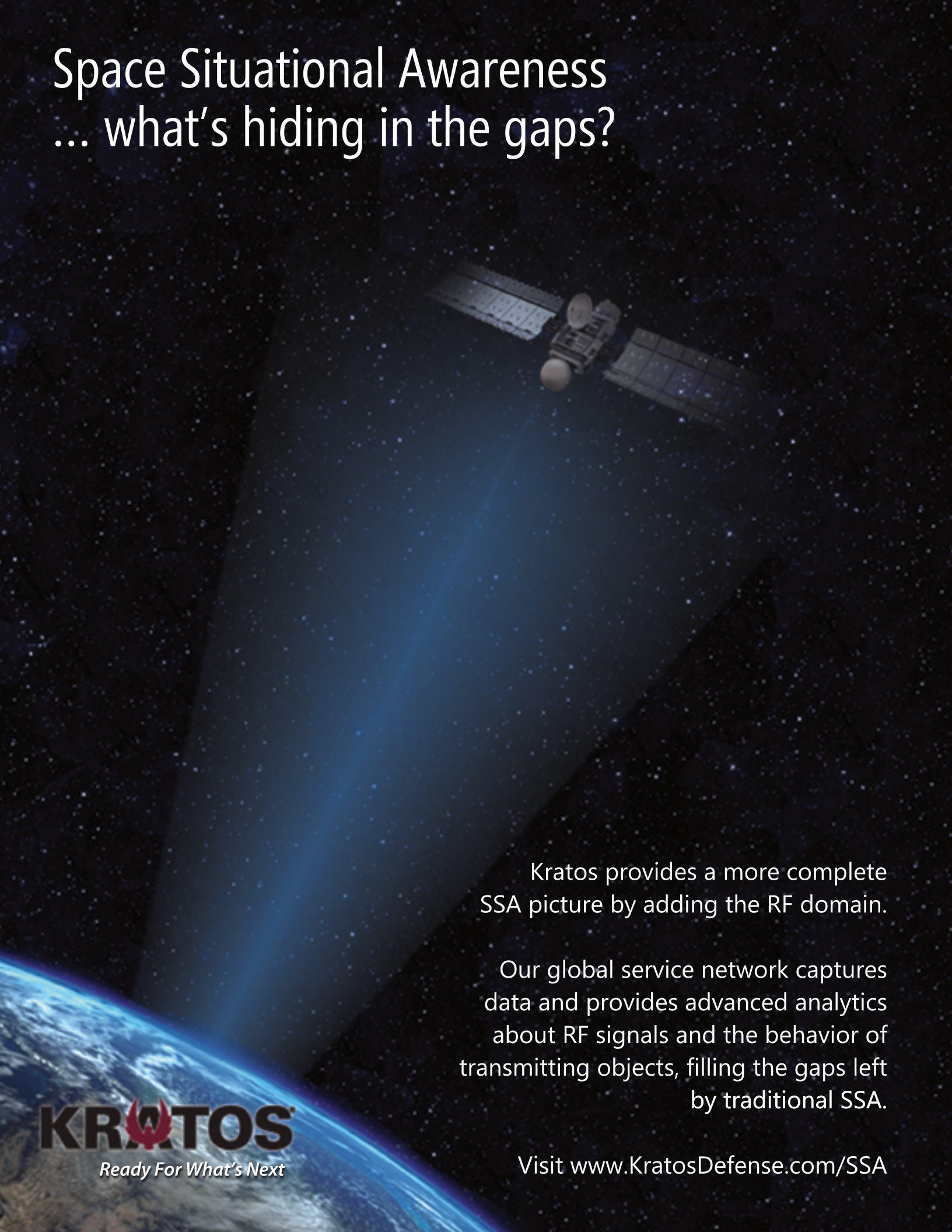
RF monitoring data has long been used to manage signal interference issues; however, RF monitoring can do much more on the SSA front to identify the behavior and performance of the satellites themselves. By leveraging RF data — the information about satellite signals — SSA can better detect, characterize, and attribute threatening space activities. With space evolving to a warfighting realm, RF data can effectively fill the gaps in traditional SSA sensors to provide more timely, thorough, and predictive awareness.

Expanding Beyond Traditional SSA

SSA provides the foundation for managing and maintaining space dominance, from de-conflicting space traffic, to protecting the space assets that are essential to U.S. commercial and national security capabilities.

These SSA functions include the ability to discover, track, and maintain the custody of space objects and events. For example, to detect the risk of high-potential conjunctions as space becomes more cluttered. Further, in an adversarial space environment SSA must be able distinguish and recognize objects, their mission types, and infer whether their intent is benign or malicious. Just as in the ground, sea, and air domains, the awareness or ability to understand space is predicated on completeness of information.

Space Situational Awareness
... what's hiding in the gaps?



Kratos provides a more complete SSA picture by adding the RF domain.

Our global service network captures data and provides advanced analytics about RF signals and the behavior of transmitting objects, filling the gaps left by traditional SSA.

Visit www.KratosDefense.com/SSA

KRATOS

Ready For What's Next

To date, SSA has relied on two main sensor types for data; electro-optical sensors (telescopes), and radar. While each is effective in their own right, they also possess gaps which create blindspots.

For example, few radar systems extend to deep space to track geostationary satellites in orbit 22,000 miles above the Earth. While telescopes can image objects in deep space, they can only do so at certain times and conditions; they're unable to detect objects or maneuvers in the bright light of day, or when obscured by cloud cover.

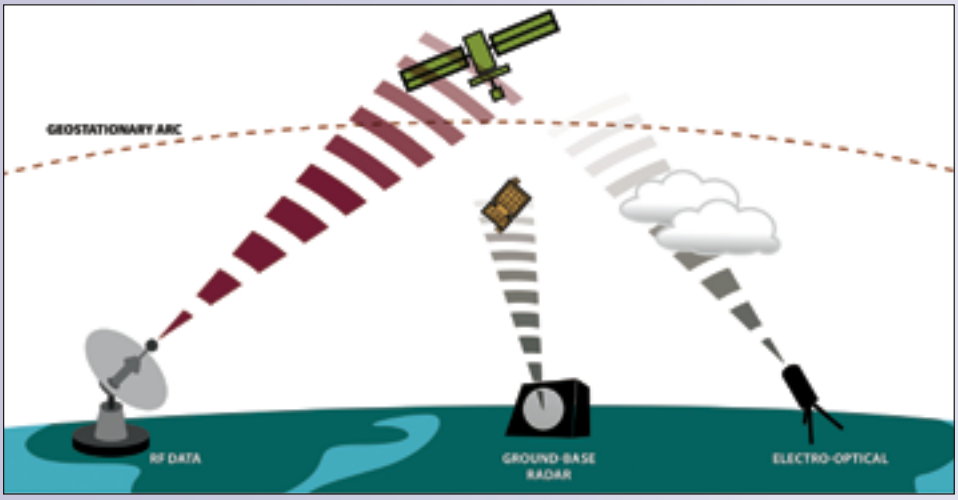


Figure 1. Two main sensor types for SSA data, Radar and Electro-Optical (EO), each offers strengths, but also limitations. RF data can fill gaps to enhance SSA. Image is courtesy of Kratos.

RF as Unique Data Domain

RF, the medium by which satellites communicate, offers a wealth of information absent from other traditional sensors. Whereas a maneuvering satellite can be beyond the range of radar and hidden from telescopes by weather, its RF transmissions can be monitored day or night, in all weather conditions to detect maneuvers and anomalies. Further, because RF data is about the physics of the satellite signals (not their content), it can be used to interpret a craft's payload performance and usage, including the type of traffic and mission it supports. Those insights can help determine whether an unexpected maneuver represents the intent of an adversary or is caused by an onboard system failure. These RF capabilities fill the blindspots in existing sensors, while providing additional knowledge.

RF data has supported space operations for years, from monitoring payload performance to detecting and geo-locating interference. This data always held promise for SSA, but wasn't available at scale due to limited sensor coverage and infrastructure.

Now, with the availability of commercial global monitoring solutions, which can supplement government resources, RF data can be collected for the complete geostationary arc at all times boosting the ability to detect, characterize, and attribute space threats. Combined with advances in data analytics, machine learning, and AI, RF can provide additional insights that elude detection or characterization by traditional sensors. Fused with other data, this offers a more complete and accurate real-time picture of satellites, their activities, and the impact to users of these systems.

Taking strides to advance its space capabilities, the Department of Defense (DoD) launched the ***Joint Interagency Combined Space Operations Center*** (JICSpOC) in 2015 to develop, test, and integrate new tactics and techniques to support its space operations. Located at Schriever Air Force Base in Colorado Springs, this fusion hub, recently renamed **National Space Defense Center** (NSDC) is leveraging commercial RF and EO data in support of the national security space enterprise. In 2018, the NSDC transitioned from experimental to fully operational status.

The Source of RF Data

RF data is the information about the signal externals or waveforms from satellite uplinks and downlinks. Monitored and collected for multiple bands and frequencies by a worldwide network of sensors and antennas, this signal data is represented by over a dozen measures. These include: directional RF power, center frequency, signal-to-noise, carrier-to-noise and more. These metrics can be used to determine the Location, Health, Usage and Attribution of space assets — all of which support the functional requirements of SSA.

How RF Detects Maneuvers and Location

As a satellite moves, its RF signals exhibit a small Doppler shift in its Center Frequency (*please see Figure 2*). This indicates the satellite's positional change and movement. By persistently monitoring these frequency shifts, satellite maneuvers can be detected as they occur in real-time, maintaining chain of custody for systems of interest that can evade other sensors. These RF location updates, combined and correlated with optical and radar sensor data, better support conjunction assessment for satellite collision avoidance and safety of flight.

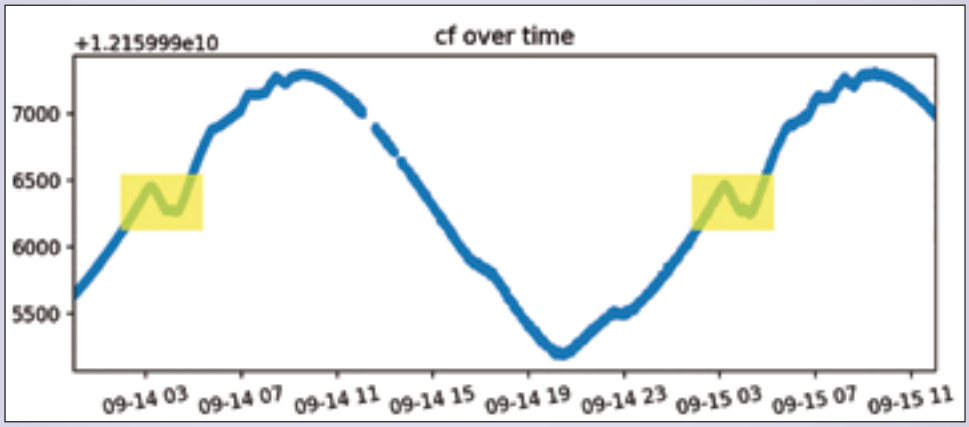


Figure 2. Doppler shifts detected in the RF signal of a satellite indicate its movement at specific times. Image is courtesy of Kratos.

By applying machine learning and pattern recognition algorithms to RF data, the normal 'patterns of life' for space objects can be established. Any deviations or anomalies from these patterns can be detected and alerted for more pre-emptive threat awareness and space traffic management.

RF to Understand Payload Health and Usage

RF data provides numerous insights on payload performance and status, that is: when systems are operating nominally, when they've changed or degraded and to what degree. (*See Figure 3.*) For example, slow, gradual variations in normal measures might indicate equipment wear or changes in user requirements. More sudden or severe RF signal deviations, on the other hand, may uncover a payload system failure, jamming or a directed energy attack.

This ability to detect payload irregularities and their origin accelerates response and resolution. For example, operators would know whether to re-route traffic due to an equipment issue, or to focus on geo-locating an unauthorized broadcaster to eliminate interference.

Data about transponder and communication links also provides an understanding of the amount, type, and nature of payload traffic. For example, RF signal characterization can determine whether an asset's transmission is supporting video conferencing or potentially hostile UAV operations, and whether a large spike in a certain traffic type may be an indication or warning.

These RF insights also provide battle damage assessment. This helps identify the capabilities of friendly, neutral, and enemy space systems, including the impact and effect of offensive or counter-operations. For example, detecting a change in a transponder's signal might reveal its reduced traffic-carrying capacity, and as a consequence, the satellite's reduced mission capabilities.

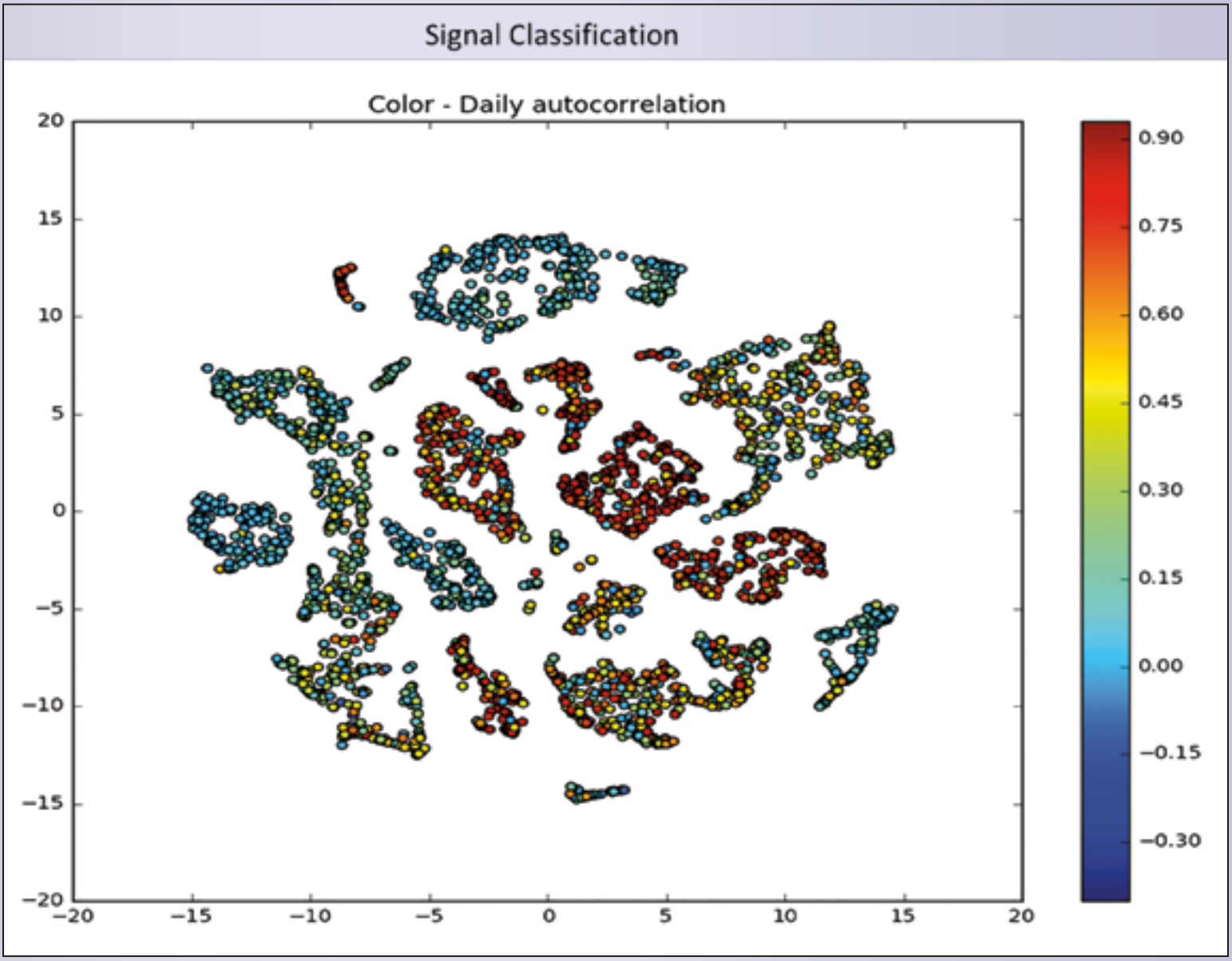


Figure 3. Clustering algorithms classify the types of RF traffic from a satellite. The color-coded bubbles represent the numerous channels and types of traffic being carried. Image is courtesy of Kratos.

RF to Illuminate Attribution

RF monitoring immediately detects any disruption to satellite signals whether originating in orbit or on the ground, whether intentional or inadvertent.

There are a variety of threats to satellites, yet unintentional interference is the most common. RF techniques can characterize and identify interfering activities, whether due to the congestion of multiplying VSAT terminals, misconfigured gateways, intruding signals from neighboring satellites, the "blue' or friendly interference that can often happen in naval fleets or on the battlefield. RF can also evaluate the frequency 'noise' of an orbital slot before a satellite moves to it, so it can be prepared to avoid ensuing interference.

RF techniques are becoming increasingly more accurate, geo-locating interference to within a few kilometers. With additional signal characterization, the type of modem can be fingerprinted and the carrier identified to help narrow attribution to an entity or organization. With inadvertent interference, resolution often entails simple coordination with an owner or operator to reconfigure an antenna or terminal; whereas intentional jamming can employ RF capabilities to mitigate and cancel out the interfering beam.

Adding Value with Data Science

Just as RF methods have been honed over the years to support satellite mission performance and interference detection, new RF techniques are being developed to exploit its value for SSA. With the correct RF analytics, machine learning, and AI tools, personnel can characterize the attributes of satellites, predict the maneuvers or actions they may undertake, and discern intentions. For example, the automated classification of bandwidth use, transmission type, and timing can help identify satellite modems, payload activities, and attribute behavior.

This machine-speed data collection and analysis supports more predictive warning, extending lead times and knowledge for appropriate response. For example, early detection of satellite interference from RF, correlated with other events, such as cyber disruptions and upticks in social media activity, could indicate precursors of hostile actions. Fusing RF analytics with other data sources can provide decision-makers the information needed to get ahead of mission threats, such as triggering maneuvers to avert a collision.

SSA for a New Space Era

Space systems are exposed to a growing array of threats; from potential collisions and spectrum interference as more satellites are launched, to adversaries turning over new techniques to disrupt and disable space operations. These challenges have placed urgency on advancing the timely, complete picture required of SSA.

The addition of the RF domain adds new dimensions to SSA, filling in gaps and advancing capabilities beyond what's possible with traditional sensors and data. The unique attributes of RF data to detect, locate, and characterize space systems supports the more predictive and pre-emptive decision-making required for this new era.

For more information about RF data and its application to Space Situational Awareness, read the white paper located at: ***www.KratosDefense.com/SSA***

Greg Caicedo, the Vice President of Kratos Network & Data Solutions, is responsible for EMI Spectral Services, SSA Solutions, RF Data Products, and Network Product Solutions for Kratos, serving both commercial and government markets. His 25+ years of experience in program management, operations, and leadership positions have supported a range of space programs and missions, including National Space, Launch Vehicles, Space Situational Awareness and SATCOM missions. A retired Air Force Officer with 20 years of service, he was involved in Space Acquisition, Operations, and Policy for National and AF programs.

What's Required to Convert RF data into SSA Intelligence?

Kratos operates the most extensive, fully-integrated, commercial global RF monitoring network, which has been helping government and commercial customers detect and resolve RF spectrum challenges for years. This custom developed infrastructure includes:

- *A global sensor network: Consisting of 21 worldwide RF monitoring sites, hosting more than 80 fixed and steerable sensors and antennas in C- and Ku-bands, as well as X-, Ka-, L- and S-bands. Using state-of-the-art sensors, the network is tuned for high-speed, accurate RF signal collection and measurement.*

- *A well-staffed, state-of-the-art RF operations center: The central hub for monitoring and integrating raw RF data from its global sensor network. The NOC incorporates automated workflows, tasking, and visualization that support Kratos' workforce skilled in RF spectrum management and SSA techniques.*

- *Data Science and algorithms: Kratos' advanced analytics and AI tools process RF data for real-time SSA awareness, predictive insights, historical trending, and patterns of life. Fused and correlated with data from optical, radar, terrestrial and space-based sensors, this provides more timely, accurate, and complete SSA.*

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A POLICY PRIMER FOR SMALL SATELLITES

An Aerospace Corporation Focus

In the early days of space, only governments or large government contractors built satellites and rockets. Today, the space enterprise encompasses many players, including not only governments and large corporations, but also small businesses, universities, and even high schools. The proliferation of small satellites (smallsats) has a large number of new players in the space business as well as new paradigms for access to, and the use of, space.

Policy has not always kept pace. The *Outer Space Treaty*,[1, 2] which forms the basis of international space law, was ratified by the United Nations in 1967. In the intervening 50 years, a patchwork of governance has grown up around the evolving space industry, but most of this policy-making has been reactionary, rather than anticipatory.

This is not unexpected — technology advances rapidly, while good policy takes time to craft. But the result is a policy picture for today's space enterprise that is complex and confusing, particularly to non-traditional entrants and missions that occupy policy "gray areas."

A recent white paper produced by The Aerospace Corporation, "*Navigating the Policy Compliance Roadmap for Small Satellites*," discusses the applicability of existing policy, and outlines a process for missions to follow to ensure compliance. Today, navigating the approval process for launch, from compliance with high-level treaties to United States (U.S.) law to agency regulations, can sometimes take longer, and prove more complex, than building the satellite itself.

International Treaties and U.S. National Policy

The Outer Space Treaty of 1967 stipulates that states "*shall be responsible for national space activities whether carried out by governmental or non-governmental agencies*" and requires "*authorization and continuing supervision*" of space operations. Per the Outer Space Treaty, a nation "*on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object.*"

This implies that the U.S. government has responsibility over U.S.-owned objects in space, regardless of whether that object is launched by the U.S. or by a foreign launch provider. Similarly, it requires the government to regulate not only government missions, but commercial and private missions as well.

Within the U.S., *National Space Policy*[3] directs safe and responsible operations in space, including protection of the space environment and the electromagnetic spectrum. The *National Space Transportation Policy*[4] outlines the authorities for military, civil, and commercial launch oversight. Commercial space transportation oversight is under the **Secretary of Transportation**; thus, commercial launches are licensed by the **Federal Aviation Administration** (FAA).

The Responsibilities of the Launch Provider vs. Satellite Owner

The National Space Transportation Policy, true to its name, discusses mainly access to space in the form of launches, rather than operations in space once satellites have separated from the launch vehicle.

In other words, the launching agency, while responsible for "*due diligence*" over the satellites it carries, does not maintain authority or direction over those satellites once they are on orbit. Ownership reverts to the "owning agency" once a satellite separates. *Figure 1* illustrates the general responsibilities of mission partners on a launch mission and *Figure 2* (*next page*) illustrates in more detail how these policy responsibilities break down for a sample multi-payload mission.

The key consideration is, "*who will have control authority over the satellite once it launches*?" Or, more directly, one can ask, "*who has the authority to decide when to execute the satellite's end of life or deorbit procedure*?" So, for example, if the **Department of Defense** (DoD) makes all critical decisions for a satellite after launch, then it is a DoD satellite, regardless of whether it is built, or operated, by a private company.

Similarly, if the **National Aeronautics and Space Administration** (NASA) maintains control of all critical decisions, then it is a NASA satellite, even if it is launched on a DoD-owned rocket. Universities who maintain control over their satellites after launch follow commercial regulations for licensing, even if they receive government grants.

Once the owning organization is identified, the appropriate policies can also be identified. The DoD, NASA, the FAA, and the **Federal Communications Commission** (FCC) all have broad policy directives that flow down from the National Space Policy; these are discussed in more detail in the white paper. An overview of orbital debris policy, spectrum usage, and imaging approvals is presented here.

Orbital Debris Policy

With the prospect that multiple large constellations of smaller satellites will launch in just the next few years, concerns are rising that orbital debris policy needs modernization and better global compliance. The U.S. has published Orbital Debris Mitigation Standard Practices (ODMSP)[5,6,7], which call for such debris

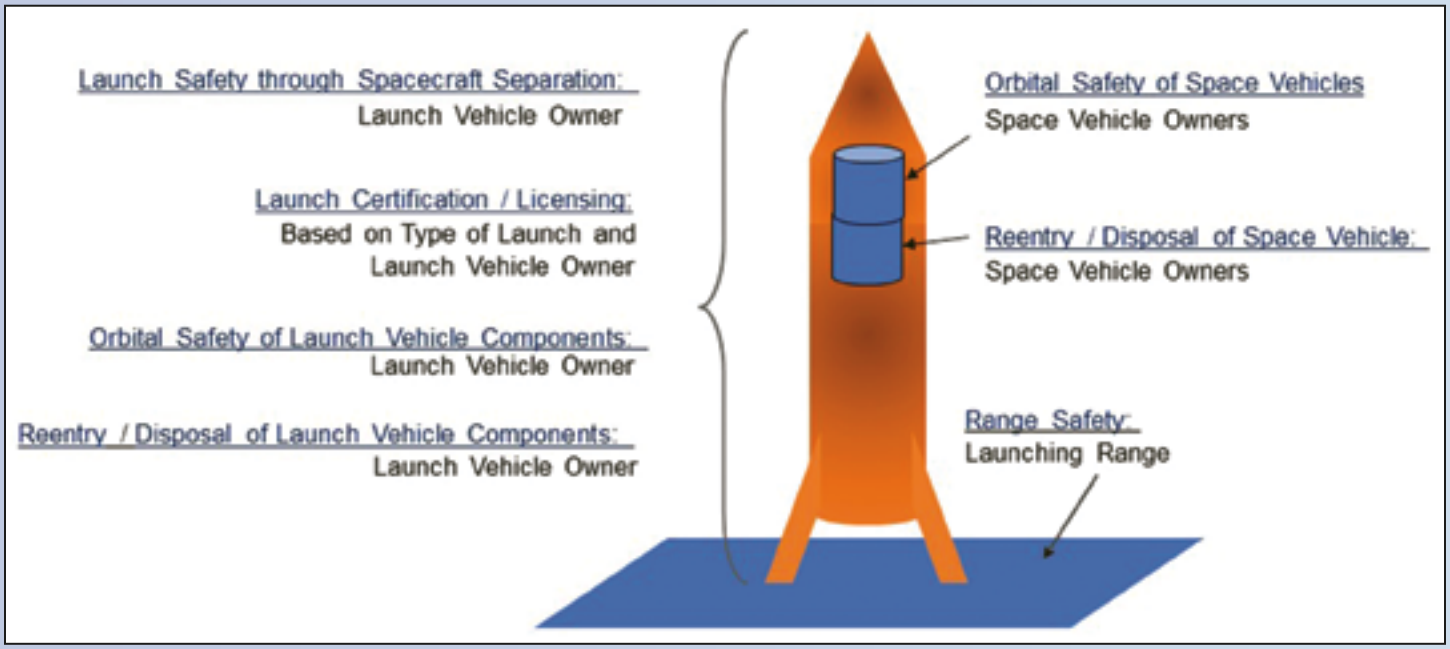

Figure 1.

It is important at the beginning of a mission to clarify this demarcation and the proper policy compliance responsibilities for all satellites involved. Figuring out who owns each satellite is the first step in this process. However, what constitutes ownership?

mitigation measures as timely satellite disposal after the end of a satellite's mission, and limitations on the probability of in-space collision or accidental explosion. NASA and the DoD have their own policy documents enforcing these guidelines. Space debris generated by commercial rockets during launch and reentry are regulated through the FAA's launch licensing processes.

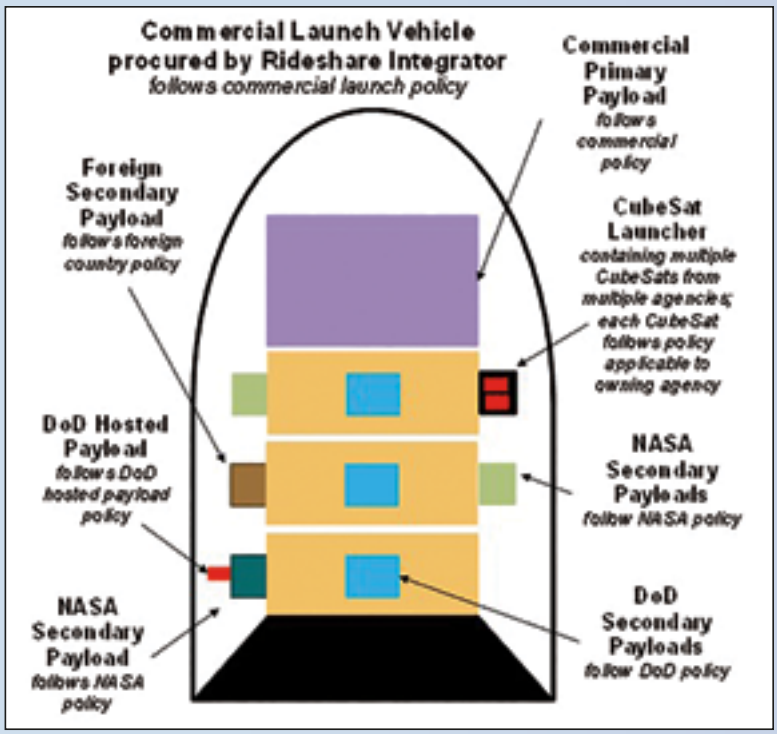

Figure 2.

But who polices debris mitigation for private and commercial satellites after separation from the launch vehicle? The surprising answer is the FCC, through its licensing of uplink and downlink frequencies. *Title 47 of the Code of Federal Regulations*[8] requires applicants for frequency licenses to provide information on their orbits and their plans for orbital debris mitigation.

Regardless of the regulatory agency and approval process, exceptions to ODMSP guidelines require approval at very high levels. Such waivers are increasingly difficult and time-consuming to get as concerns about orbital debris increase.

Spectrum Usage

Nearly every satellite in space needs to transmit and receive data to and from the ground using radio waves. Public law governs the use of the electromagnetic spectrum to ensure that satellites don't interfere with each other, or with ground communications. But different agencies regulate different parts of the satellite industry.

The National Telecommunications and Information Administration (NTIA) regulates frequency usage for federal agencies such as NASA and the DoD. The NTIA documents their rules and procedures in the Manual of Regulations and Procedures for Federal Radio Frequency Management.[9]

Through Title 47 of the Code of Federal Regulations, the FCC licenses frequency use for private and commercial satellites — any satellite not owned by the government will go through the FCC for its frequency license. Both the FCC and the NTIA coordinate spectrum usage with the International Telecommunications Union.

Many small, non-traditional satellite operators use amateur frequencies for satellite communications and no frequency license is required. An amateur radio operator simply coordinates with the FCC and submits a pre-launch notification. However, the FCC is applying increasingly stringent tests to ensure amateur frequencies are preserved strictly for amateur use, and not for operational or experimental use. Satellite owners cannot assume that approval will be automatic, and are encouraged to coordinate with the FCC early.

Imaging Approvals

The National Commercial and Space Programs Act[10] governs imaging approval for satellites owned and operated by commercial entities and civilian academic institutions. This law assigns authority to the National Oceanic and Atmospheric Administration (NOAA) for licensing of imagers. For satellites owned by commercial and civilian academic institutions, NOAA will ensure all imagers also comply with DoD and Intelligence Community requirements for non-Earth Imaging. Government agencies currently have no requirement to obtain licensing for Earth imaging, although it is highly recommended that such agencies seek internal guidance. Non-Earth imaging for operational DoD systems is managed by the Defense Remote Sensing Working Group (DRSWG), but experimental DoD systems fall into a murky policy area, where only interim guidance has been received.

Earth Imaging

Government agencies currently have no requirement to obtain licensing for Earth imaging, although it is highly recommended that such agencies seek internal guidance. Non-Earth imaging for operational DoD systems is managed by the Defense Remote Sensing Working Group (DRSWG), but experimental DoD systems fall into a murky policy area, where only interim guidance has been received.

Additional Approvals

There are other regulations that govern other aspects of satellite launch and operation, but contrary to popular belief, there is little regulation — other than debris mitigation guidelines — that govern where a satellite can go in space, and when it can maneuver.

The policy roadmap for getting to space in the first place is still a source of confusion for new entrants, smallsats and other satellites that don't fit the traditional mold. According to The Aerospace Corporation's Satellite Database, 1,794 satellites have launched since 2010. Of those, 53 percent were from academic or commercial

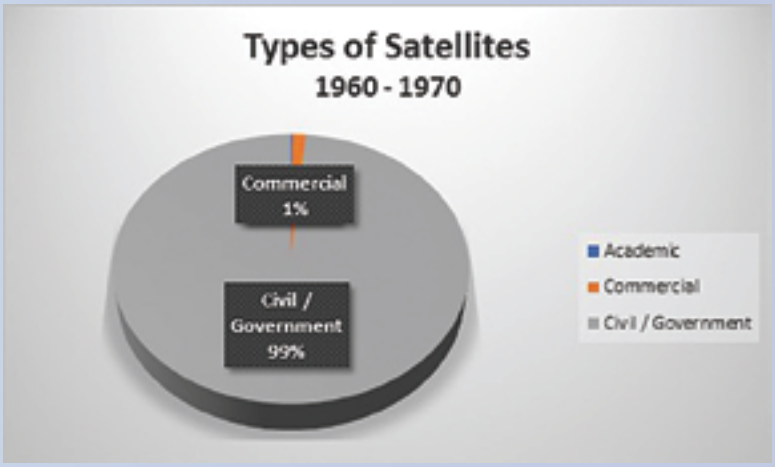

Figure 3.

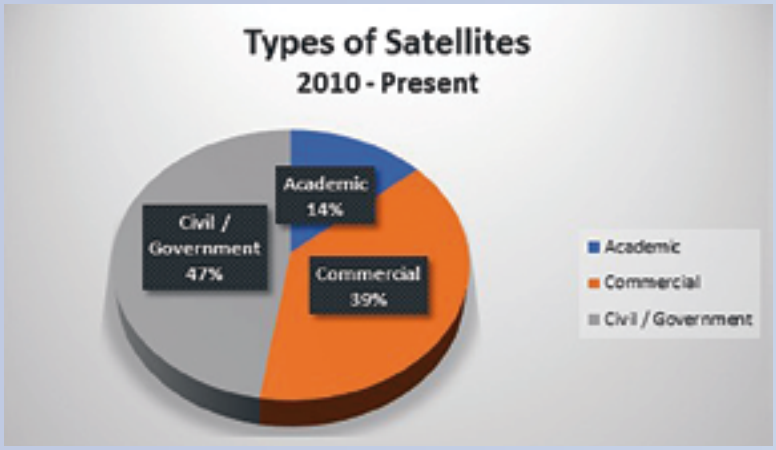

Figure 4.

entities. Compare this to the decade between 1960 and 1970, where 99 percent of the 1,063 satellites launched were government satellites. (***Please see Figures 3, below, and 4, next page.***) Market research projects that this trend will continue.11 Clearly the space business has changed.

With this change has come increased demand for a less opaque, more streamlined process. Universities and new entrants need guidance; commercial entities seek efficiency. ***Figure 5*** is a simple representation of a "one-stop-shop" approach which could help the current process evolve to meet these needs.

In this approach, a centralized government gateway helps satellite mission owners determine into which policy and oversight "bucket" they fall (government, civil, or private), and then facilitates policy approvals by routing paperwork to the correct regulatory agencies. At the same time, government agencies work together to ensure consistent standards where possible. This approach avoids loopholes, ensures "gray area" missions are properly dispositioned, and provides a clearer policy roadmap to space, for everyone.

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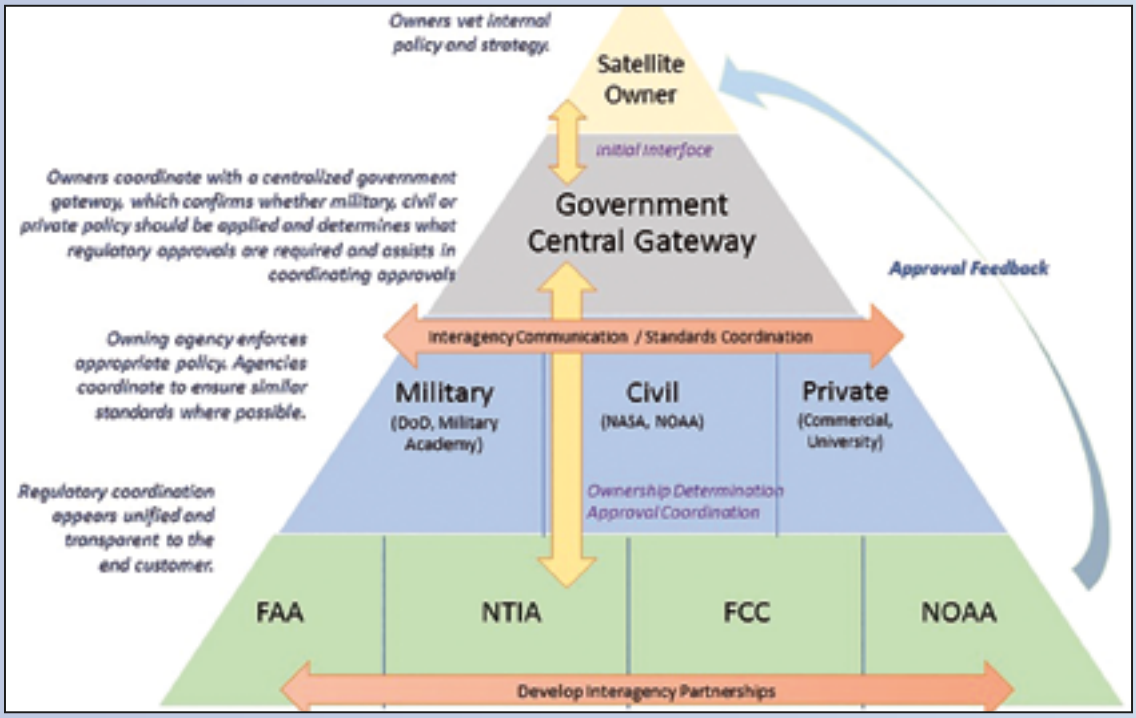

Figure 5: Proposed Government Policy Gateway

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Eleni M. Sims is a Project Engineer in The Aerospace Corporation's Space Innovation Directorate. She provides technical support to the Air Force's Advanced Systems and Development Directorate, specifically the Department of Defense Space Test Program (STP) by architecting cutting edge science and technology missions. She also serves as the corporate knowledge steward for the program. Additionally, she is the lead technical support for three satellites on the STP-2 mission, which is scheduled to launch in early 2018.

Barbara M. Braun received a B.S. in Aeronautics and Astronautics from MIT in 1995, and an M.S. from the University of New Mexico in 2002. She served in the Air Force for a total of 21 years, both on active duty and in the reserves, working on space safety policy for the Air Force Safety Center. She joined the Aerospace Corporation in 2000 and has supported multiple small satellite and rideshare missions for the Department of Defense Space Test Program, the Operationally Responsive Space Office, and NASA.

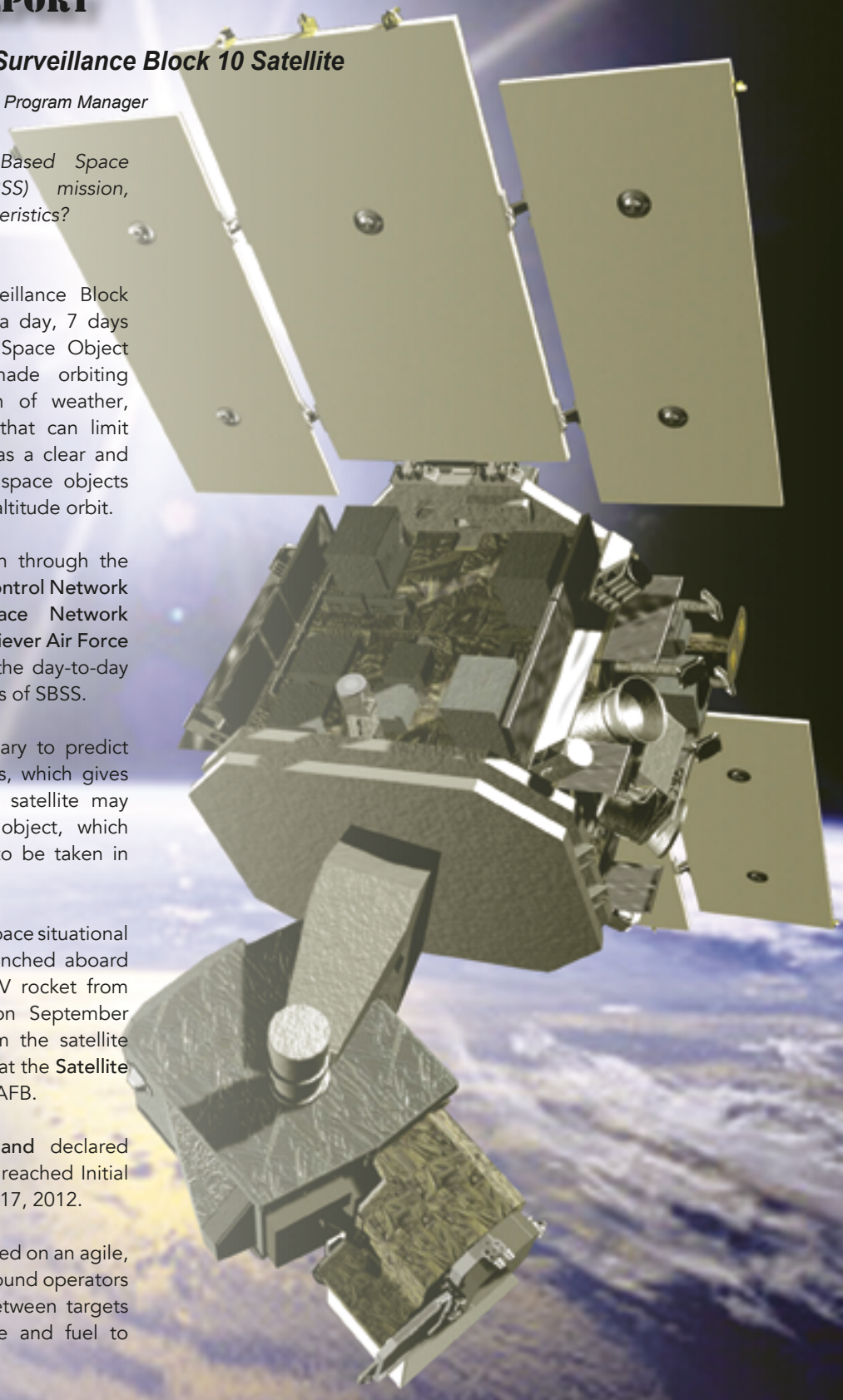
INTELLIGENCE REPORT

U.S.A.F.'s Space Based-Surveillance Block 10 Satellite

With Jeff Veselenak, SBSS Block 10 Program Manager

Jeff, what are the Space Based Space Surveillance Block 10 (SBSS) mission, background and general characteristics?

Jeff Veselenak (JV)
The Space Based Space Surveillance Block 10 satellite operates 24 hours a day, 7 days a week collecting metric and Space Object Identification data for man-made orbiting objects without the disruption of weather, time of day and atmosphere that can limit ground-based systems. SBSS has a clear and unobstructed view of resident space objects orbiting Earth from its 390-mile altitude orbit.



SBSS communicates information through the world-wide Air Force Satellite Control Network and commercial Unified Space Network ground stations and then to Schriever Air Force Base where operators oversee the day-to-day command and control operations of SBSS.

SBSS provides the data necessary to predict the trajectories of these objects, which gives experts an idea if an orbiting satellite may collide with another orbiting object, which allows time for evasive action to be taken in order to avoid collisions.

SBSS Block 10 was a pathfinder space situational awareness satellite that was launched aboard an Orbital Sciences Minotaur IV rocket from Vandenberg AFB, California, on September 25, 2010. The first signals from the satellite were received a short time later at the Satellite Operations Center at Schriever AFB.

U.S. Air Force Space Command declared that the SBSS Block 10 satellite reached Initial Operating Capability on August 17, 2012.

SBSS uses a visible sensor mounted on an agile, two-axis gimbal, which allows ground operators to quickly move the camera between targets without having to expend time and fuel to reposition the entire spacecraft.

Photo of the Minotaur launch is courtesy of Orbital ATK.

Here are the satellite's general characteristics:

- *Primary missions: Space Surveillance*
- *Contractor Team: Boeing*
- *Orbit Altitude: 630 km, sun synchronous*
- *Dimensions: Solar Panels - 201.36" x 92.50"*
- *Length along z-axis: 110.33"*
- *Weight: 1031kg (2277 lb.)*

What is the current status of Space Based Space Surveillance Block 10 (SBSS) program?

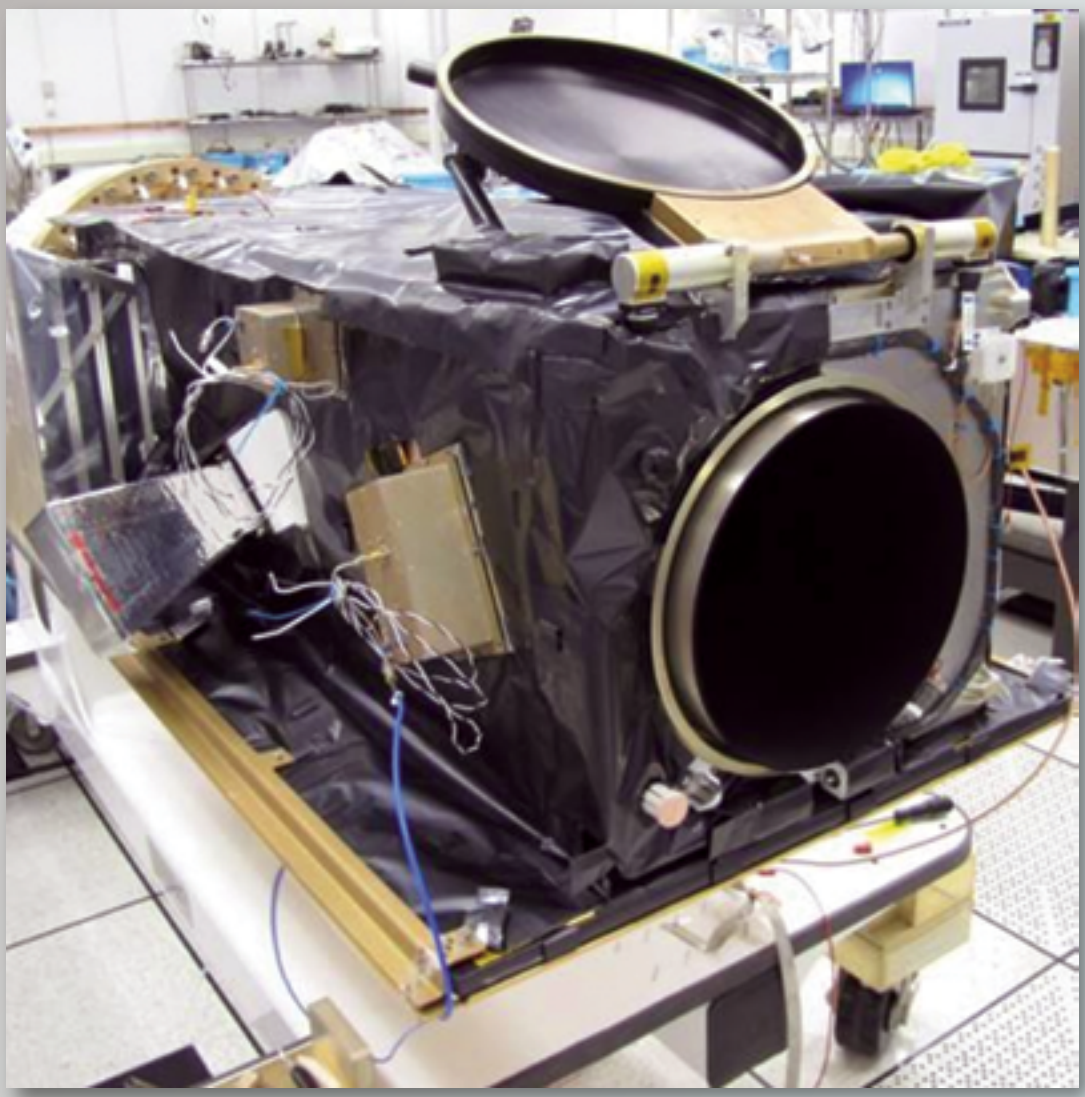
JV

SBSS just passed its design life of seven years and the system is still performing well. Current analyses indicate it will operate for years into the foreseeable future. If the satellite were to stop performing today the U.S. Air Force would be able to say we got our money's worth, but my team and I believe there is still plenty of mission life remaining.

Kudos go out to our integrated Boeing and Ball Aerospace contractors and MIT/Lincoln Lab for designing a system that will not only outlast its design life but also to the USAF team for finding novel ways to leverage SBSS by evolving its mission to meet a dynamic threat environment. From its low Earth, sun-synchronous orbit SBSS provides a clear and unobstructed view of resident space objects orbiting Earth.

SBSS communicates information through the world-wide Air Force Satellite Control Network and commercial Swedish Space Corporation ground stations and then to Schriever Air Force Base, where operators oversee the day-to-day command and control operations. SBSS uses a visible sensor mounted on an agile, two-axis gimbal, which allows ground operators to quickly slew the camera between targets without having to expend time and fuel to reposition the entire spacecraft.

SBSS was launched as a pathfinder satellite for Space Situational Awareness (SSA). Has SBSS met its expectations?



The ORS-5 satellite upon completion of build process. Photo is courtesy of MIT LL.

JV
SBSS has exceeded expectations. The satellite is operating 24-hours a day, seven days a week collecting metric and space object identification data for man-made orbiting objects and space debris without the disruption of weather or time of day.

The system provides the data necessary to predict the trajectories of these objects, which gives experts an idea if an orbiting satellite may collide with another orbiting object.

This allows us time for evasive actions to be taken in order to avoid collisions. It has been so successful that, due to SBSS's performance, we are updating the space catalog to include more reference identification numbers.
SBSS is a pathfinder satellite — what have you learned?

JV
In terms of Space Situational Awareness (SSA), SBSS has provided the foundation for future development. It laid the path for Command & Control (C2) to include tasking and scheduling, space based operations for a sensor, and the development of image processing and data dissemination.

More recent satellite programs have been following SBSS's path such as, Geosynchronous Space Situational Awareness Program (**GSSAP**), Operationally Responsive Space-5 (**ORS-5**) and SBSS Follow-On. The latter is still in the planning stages. Not only have we learned a lot from SBSS, but it has also provided valuable mission data as noted earlier. It's also worth noting that the dynamic environment of space and advancing foreign space operations have motivated the need to use the system in ways not considered during the initial design, such as more flexible and responsive ad-hoc mission tasking.

Space is now not only a congested environment, but it is also contested. To defend it, the U.S. Air Force needs to make sure we command space and that we are able to provide SSA. Future systems will be radically different from the current SBSS due to the complex mission we are trying to accommodate, but there are similarities in what we have learned. SBSS started out with a simple mission of cataloging space debris but has laid the foundation for future requirement developments for space based sensor acquisitions.

The concept of a taskable sensor in space has demonstrated its usefulness, but a lot of things we have learned has been on the ground. Most of the development work has been related to improvements to the ground system, which has enabled better planning, satellite control, image processing, data dissemination, sharing and exploitation. Through the use of the internet, we are now able to take advantage of other Air Force and DoD Agencies for their expertise. We are getting the data in front of the right people as quickly as possible so that it can be analyzed and the right decisions can be made quickly. SBSS and other Air Force systems have led to new developments in acquisition, such as enterprise systems and modularity.

The concept of an enterprise system has led to the development of a modular architecture which will allow for evolutionary as well as revolutionary changes in the way spacecraft and their mission data are managed. The modularity will also help reduce costs by allowing multiple vendors to bid and develop components. SBSS wasn't the first satellite to be designed in this new era of the internet, but it is one of the first to take advantage of it. Future systems will build upon this.

What is the future for SBSS and the follow-on programs to include ORS-5?

JV

The future looks exciting for the U.S. Air Force in the Space Situational Awareness arena. With the launch of ORS-5 [*August 27, 2017 aboard an Orbital ATK Minotaur rocket*] and its likely contributions, we will understand how it and SBSS will complement each other.

Specifically, due to each satellite being in different orbits together they will provide more complete coverage of the geosynchronous belt.

Further, we are developing the next generation of smart satellites and ground systems which can work well with machine learning, and SSA data exploitation.

New satellites are being developed for special applications but when combined together, they can give us a much bigger view of what is going on in space. Ground systems are being developed as robust systems that fuel the satellite architecture.

Additional Air Force entities are now trying to exploit the cloud for enterprise applications. The internet, as noted, has provided us the opportunity to share our data with other organizations. These organization are then able to find new ways to analyze the data and provide information.

Space sensors have also evolved with new technologies that have provided a wealth of information that needs to be processed as well as analyzed. SBSS was the first of a new generation of satellites, and it has provided a very valuable stepping stone. It will most likely be years before the SBSS mission dies, but other new systems are being developed today by some of the program managers who received their first experience on SBSS.

The SBSS Follow-On will continue the expansion of data collection of the geosynchronous belt and will further enable many improvements in space surveillance, data management, distribution, and command and control. As such, SBSS will live on in a new generation through the design and implementation of future systems.

Mr. Jeff Veselenak is currently the Space Based Space Surveillance Block 10 government program manager within the Space and Missile Systems Center's Space Superiority Systems Directorate. He leads a 75 government/contractor team managing performance, cost, and schedule of sustainment operations for a $1 billion on orbit system. He has more than 30 years of federal experience successfully managing military space and aircraft research and development, acquisition, and space operations and sustainment programs.

ON ORBIT SERVICING: PROGRESS & PROMISE

An interview with Dr. Gordon Roesler, Tactical Technology Office Program Manager, DARPA

By Ryan Schradin, Senior Contributor and Executive Editor of SES-GS' Government Satellite Report

In previous Government Satellite Report (GSR) reports, the discussion at a Washington Space Business Roundtable (WSBR — *www.wsbr.org*) event that featured an all-star panel of space experts discussing on orbit servicing of satellites has been reported.

During that discussion, the panel talked about why these capabilities are enticing to military and commercial satellite operators and the steps that industry and government organizations have made towards making on orbit servicing a reality.

Following that discussion, GSR contacted Dr. Gordon Roesler, who has been at the forefront of many of DARPA's (***www.darpa.mil/***) on orbit servicing initiatives and programs.

During this conversation with Dr. Roesler, the objective was to learn more about how far on orbit servicing technologies and capabilities have progressed and to obtain a better picture of what on orbit servicing can enable in the future.

In part one of this two-part conversation with Dr. Roesler the following topics were addressed; the current state of on orbit servicing; what future generations of this technology will enable; and why on orbit servicing is in such high demand. The following are Gordon's responses:

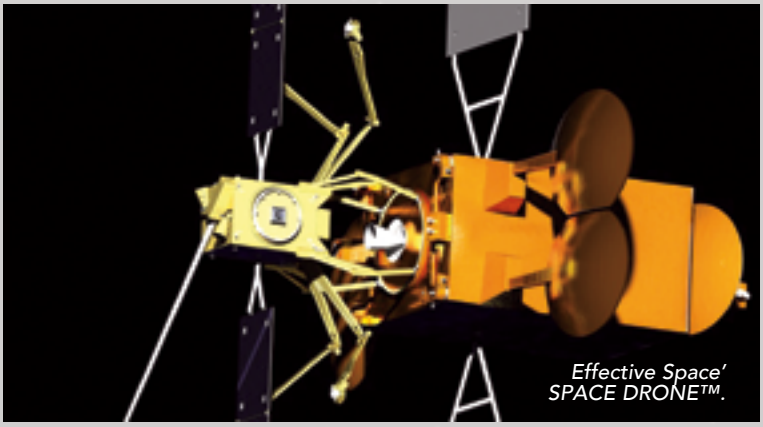
Government Satellite Report (GSR)
Where does on orbit servicing currently stand? Is this science fiction, or are we rapidly approaching a reality where satellites can be refueled and repaired in space? And, importantly, how long until we get there?

Dr. Roesler
As we move forward, there are going to be generations of servicing that offer increasingly sophisticated capabilities.

Generation One is what I call simple life extension and there are already a couple of established players in that field.

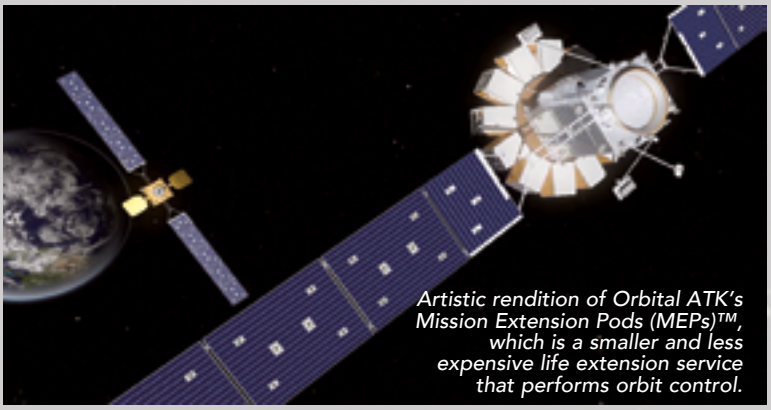
Artistic rendition of NASA's Restore-L spacecraft, based on SSL's 1300 spacecraft bus, with the servicer extending its robotic arm to grasp and refuel a client satellite on orbit. Image is courtesy of NASA.

Effective Space (***www.effective.space/***) is a UK organization that is building satellites that go up and dock with operating commercial communication satellites and help them maintain their positions and conserve their fuel, so that's life extension through fuel conservation.



Effective Space' SPACE DRONE™.

Orbital ATK (***www.orbitalatk.com***) is doing something similar with their **Mission Extension Vehicle** (MEV).



Artistic rendition of Orbital ATK's Mission Extension Pods (MEPs)™, which is a smaller and less expensive life extension service that performs orbit control.

Generation Two is what **DARPA** is working on. We're looking to use very sophisticated robotics to do things beyond just life extension. Using robotics, we're looking to perform ultra close inspections, use robotic arms to repair satellites that aren't functioning properly, or even perform upgrades — such as adding a new module to an operating spacecraft.

In terms of timing, Gen One is slated to launch in the 2018 to 2020 time frame and DARPA's Gen Two servicer is going to launch in 2021.

I should also mention the **NASA Restore-L** effort, which blends Gen One and Gen Two technologies and capabilities. This is a spacecraft that uses a DARPA robotic arm in order to refuel a NASA satellite. That's effectively providing a Gen One service with a Gen Two technology.

GSR

What are the commercial benefits of on orbit servicing? Why are commercial satellite operators interested in this capability?

Dr. Roesler

Let's look at this in terms of the same Gen One and Gen Two breakout. When it comes to Gen One, life extension is a big reason for commercial interest. Life extension will provide an operator with fleet flexibility. Take, for example, SES, which has around 50 [satellites] in operation; if they can keep one of those on orbit longer than was expected, they can shuffle the fleet around and provide services in a much more flexible way.

Simultaneously, this offers the benefit of minimizing capital expenditures by filling any gaps that might occur in the fleet without having to build an entirely new satellite — the Gen One services are very valuable to commercial satellite operators.

Gen Two [on orbit servicing] provides even more opportunity. Think about being able to bring up a new payload and attaching it to an existing satellite. Rather than having [to build] a new satellite to provide that capability, the operator only has to build a new payload. Not only does it defer capital expenditure, it actually reduces it.

This kind of idea of replacing payloads on orbit also allows the operators to keep up with the needs of the terrestrial customer base.

A satellite's estimated life is around 15 years. That's a long time to predict and understand what your customer base is going to look like or need. The ability to easily adjust the payloads in sync with customers can help keep the business case for that satellite alive.

Then there's this idea of being able to perform repairs. About once every two years, a commercial satellite goes up and has some sort of deployment anomaly. If that could be repaired, not only does that allow you to recover the satellite capability faster than by building and launching a new spacecraft, but it also reduces insurance claims payouts. It's really a win-win — there's a host of benefits from the development and introduction of Gen Two capabilities.

GSR

How do those benefits compare with the federal government and military? Are the benefits for them the same? Are there other reasons why they're interested in this?

Dr. Roesler

Every one of those benefits that I mentioned also pertains to the U.S. government. The fleet flexibility and the reduced capital expenditures. We don't have insurance companies — our insurance is from the taxpayers, so if we can save them the cost of a new satellite by repairing an anomaly, that's a benefit as well.

There is also the ability to protect and provide resilience to our government satellites. An ultra close inspection with a robotic arm can help operators differentiate between an engineering flaw and a hostile act and that could help to maintain rational behavior. When things fail and we don't understand why they fail, we tend to be suspicious — that's just the nature of it. This could alleviate that suspicion.

There is a strategic benefit to this ultra close inspection. Also, there's the benefit of being able to include new capabilities for protection of our existing satellites, as well as all the other benefits in terms of longevity and flexibility and repair.

GSR

Gen One and Gen Two on orbit servicing has been covered; however, what does the future after those two generations resemble?

Dr. Roesler
With the introduction of Gen Two capabilities, we'll have access to dexterous robotics that can make something such as changing out a reflector to address a new service area [will be] something that's relatively easy to do.

For example, the **Dragonfly Project**, a NASA-funded program, is intending to take reflectors and put them in place with a robotic arm on a commercial communication satellite. If you can put that in place with a robotic arm, you can also take it off again and put a different reflector on. That will give operators the ability to change the property of the satellite payload on orbit. To better enable that, there are some easy things we could start doing to our new satellites that would allow us to take more advantage of robotic capabilities.

For example, **NASA Goddard** has developed a refueling quick disconnect. Today there are still many steps required to refuel a satellite, but this quick disconnect greatly cuts down that number of steps. That quick disconnect would have to be integrated into the satellite design before launch, but it's not a painful installation and it could greatly facilitate the ability to transfer fuel.

Another new addition we should be considering adding to satellites during design and construction is the equivalent of a USB port that most have on their laptops. This is something DARPA has developed for the servicer, but it can also be installed on satellites prior to launch.

With a USB port, you can plug in to a thumb drive or hard drive and it recognizes what the component is and it provides new services.

DARPA's port will be used to hold the robotic tools on the servicer, but it also has power and data feeds just like a USB port. You could bring up a new payload, plug it in, and take advantage of the power and communications of the host satellite.

That's when you're starting to get into **Generation Three**, which we haven't discussed yet — **modular satellites**.

There is a tremendous amount of research and development that still needs to be done to create a truly modular satellite. But that research and development is extremely valuable because, if you have a modular satellite, you can take advantage of a lower cost, and more prolific launch systems that are being developed.

Modular satellites would be assembled on orbit from components sent up on low-cost launches, or modules could be replaced in the future on a satellite that you have already built and launched. That said, there would be a lot of testing that would need to be done on the ground and a lot of progress needs to be made.

The other revolutionary Gen Three capability is the assembly of large structures, such as antennas and telescopes, in orbit. NASA is working on an orbit assembly for future astrophysics missions, on the premise that something large, such as a 20 meter telescope, must be assembled on orbit, due to the massive size of the hardware.

In those instances, there is no way you could fold it into a single launch fairing — so [the hardware] would need to be assembled robotically in space.

In the same way, being able to assemble the largest reflector or antenna possible would give communication service providers significantly more flexibility.

GSR
Looking back at Gen Two capabilities and the addition of payloads to existing satellites, what types of payloads and capabilities could be added to a satellite in space with this technology? Why is this an attractive option for the military? For commercial operators?

Dr. Roesler
There would be many different possibilities.

For example, one simple thing operators could do is to add cameras that provide the satellite the ability to see around it. In geosynchronous orbit, these satellites are 22,000 miles away and it's difficult to see small objects. If these cameras could see small objects close to the satellite, it would give operators the ability to react appropriately.

One other capability that could be added is space weather sensors. I mentioned earlier the consequences of not knowing what caused an outage. If you built a space weather sensor and attached it on orbit, you'd have an indication of whether or not an outage was related to a solar event. There are also other ways of detecting nearby satellites that could be integrated into a small payload and attached.

The advantage of an attachable payload is that you don't have to integrate it with a propulsion system and attitude control system. The cost is lower, it's available for use faster, and the opportunities to get it on orbit are more numerous.

For example, DARPA has developed a capability called **PODS** — which stands for **Payload Orbiting Delivery Systems** — that could carry a wide variety of separable mass elements to orbit — including attachable payloads — aboard commercial communications satellites. With 15 commercial launches to GEO a year, we can take advantage of such methods to get small payloads up there without having to buy entire launch vehicles.

In terms of commercial offerings for attachable payloads, many have told me that they are excited about the opportunity to host some of these payloads. It will produce a revenue stream for them for sure, but it also allows them to start thinking about other approaches for fleet flexibility. This is also an entrepreneurial opportunity. There are people out there who want sensors for applications like agricultural use or environmental data collection, and some of these things can be done from GEO.

GSR
Something often heard reg timing concerns — not having payloads built in time for launch — which are a main reason why some agencies shy away from hosting payloads on commercial spacecraft. Could you see a reality where military or government payloads are placed on commercial spacecraft on orbit? Could this help alleviate some of those concerns and drive up adoption of hosted payloads?

Dr. Roesler
You really hit the nail on the head. Sometimes, secondary payloads, hosted payloads — or even the payloads for the primary mission — aren't ready in time. The ability to add them after launch should be extremely freeing for the whole space enterprise and adds a tremendous amount of flexibility.

GSR
During the panel discussion, the panelists touched on the possibility of constructing satellites in space. Why would it be attractive to literally build or construct a satellite in space? What would that enable us to do that we can't do with our current system of building satellites on Earth and launching them already constructed?

Dr. Roesler
One of the huge advantages is the reduction in testing and design requirements. If I'm going to launch something in pieces, I don't have to worry about whether the entire assembly survives during launch — I only have to worry about whether the individual pieces survive. By testing at a lower level of integration, I'm saving costs and I'm saving time when I put them together on orbit.

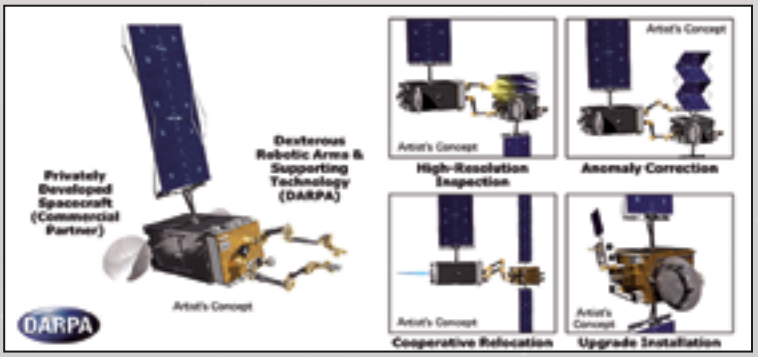
Another thing that approach lets you do is change your mind. Say you're building numerous satellites and you have a choice of payloads and maybe you have a choice of power systems. If you have a modular architecture, you can change your mind about what a particular satellite is going to be in real-time. That's basically unheard of now.
And, as I mentioned earlier, there's this idea of taking advantage of smaller launch vehicles. There's a group of investors today that are developing launch vehicles of much lower capacity than available medium-lift ones.

Similarly, DARPA is working on a launch system called XSP, which stands for Experimental Spaceplane, which is going to put 3,000-5,000 pounds into LEO. That mass range fills a gap between the very small launch vehicles and the larger ones. By taking advantage of that emerging launch infrastructure that has a lot more variety to it, we get another reason to consider building satellites in orbit.

GSR
When it comes to all of these technologies and capabilities — on orbit refueling, on orbit servicing, adding payloads to existing satellites, building satellites in space — who is taking the lead in the development of these solutions?

Dr. Roesler
In the case of Gen One — life extension — it's primarily industry. In the case of Gen Two — on orbit refueling and on orbit servicing — it's definitely DARPA.

RSGS is a very large program dedicated to building a GEO robotic servicing vehicles and getting it on orbit quickly. When I say that, I should also mention our commercial partner, SSL, who is building the bus and the ground segment and will eventually operate the satellite. I should also mention the Naval Research Laboratory, which is responsible for all the advanced robotic work that's leading to this capability. The technology is government-initiated, but we know that commercial players are eager to participate.



Looking at Gen Three, I would say it's a combination of DARPA, NASA, and industry. DARPA has some small projects centered around on orbit assembly and also the idea of putting a persistent platform into GEO. One where payloads can come and go.

The analogy I like to use for such a platform is the antenna tower that you see along the highways. When you look at one of those towers, you'll see a number of devices — cellphone antennas, point-to-point microwave, public safety radio antennas — all hanging on it. That's because it's less expensive to pay rent to the tower owner than it is to buy land and build a tower.

Obviously that makes sense in GEO as well. If you can just send up a payload to a persistent platform, you don't have to worry about propulsion and attitude control. You have all that provided by the platform and you pay a fee to the platform operator for hosting your payload. *That's really a win-win.*

It could also provide flexibility, being able to swap the payloads more frequently and not have to worry about what the market is going to be like a few years from now.

For additional information on DARPA's on orbit servicing programs, please view ***www.darpa.mil/program/robotic-servicing-of-geosynchronous-satellites***

This article is republished, courtesy of The Government Satellite Report (GSR) and Executive Editor ***Ryan Schradin****. He is a communications expert and journalist with more than a decade of experience and has edited and contributed to multiple, popular, online trade publications that are focused on government technology, satellite, unified communications and network infrastructure. His work includes editing and writing for the GovSat Report, The Modern Network, Public Sector View, and Cloud Sprawl.*
His work for the Government Satellite Report includes editing content, establishing editorial direction, contributing articles about satellite news and trends, and conducting written and podcast interviews. Ryan also contributes to the publication's industry events and conference coverage, providing in-depth reporting from leading satellite shows.

HOW DISASTERS MAKE NEWS

SSPI's "How Satellites Make A Better World"

Disasters make news — whether the catastrophe is an act of nature or humanity, we want to see it with our own eyes and share the experience of the people whose lives are turned upside down.

We watch with a horrified fascination that is part curiosity and part compassion. Through the miracle of moving pictures, we are connected to the lives of people we have never met and may be moved to help them.

How, exactly, do disasters become news? That is, how does video coverage get from disaster zones to your television, your computer or your phone?

In hurricanes and floods, warfare and terrorism, one of the first things to collapse is communication. Sometimes the networks themselves are damaged — as when 2011 Japanese tsunami wiped out wired and wireless communications in the Sendai region — and sometimes they are simply overwhelmed by the number of people trying to use them. Some catastrophes take place far from any broadband connection or optical fiber line.

Since the 1980s, the solution to delivering news from the worst places in the world has been satellite. In 1984, an entrepreneur named Stanley Hubbard, a TV station owner and member of SSPI's Hall of Fame, assembled a team to create the world's first "satellite truck" to deliver live news from the field.

That innovation created a global industry, worth an estimated US$1.2 billion today, now referred to as digital newsgathering or DNG. DNG uses a mix of satellite, cellular telephone, microwave and wired broadband to transmit news from the field to the news center, where it is edited into stories or put live on the air. The broadcasting equipment rides on trucks or cars, in suitcases or backpacks, and it makes reporters, wherever in the world they may be, into integrated members of the news team.

Offering Context

Bringing live coverage of terrible events to a viewing audience is a tough job. On September 11, 2001, executive producer *Susan Zireinsky*, of the CBS news program "*48 Hours*" was tasked with producing the primetime coverage of the first day and night after the fall of the World Trade Center in New York City.

"*Especially on that day*," she recalls, "*you were just going to whomever had a piece of information. You were getting cameras up, you were putting people in place, you were trying to wrap your brain around it. You wanted to step back and synthesize some of the information, which is what we were trying to do. At that point, we thought there were many more dead, and it was still a search-and-rescue mission. It was a very, very complicated day to try to give context to.*"

When the infamous Capiapo mine collapsed in Chile, NHK of Japan arrived early and stayed until after the rescue. *Roger Hawkins*, president of the satellite services company **Disaster Truck**, recalls working for the network.

"*When the rescuers completed a hole about 18 inches in diameter to send down food and water, NHK sent down a video camera*," he said. "*We showed the miners how to use it and for two and a half weeks, they were able to interview each other and record messages for their loved ones, who were waiting for them to be rescued.*"

The same video footage, transmitted by satellite, transfixed people the world over.

Mr. Hawkins was also present after a 7.0 magnitude earthquake struck Haiti in 2010. CBS did not have any equipment of their own close enough to Haiti to rush to the scene — Disaster Truck got the call.

After installing their portable satellite terminal into place, however, they could not find a generator to power it. The stakes were high. American journalist *Katie Courec* was due to arrive to handle the reporting assignment, so Hawkins' team wired up two Haitian taxi cabs to produce enough power for the satellite terminal and the camera. The coverage went live on schedule.

Uniting the World

Reporting live from the field does more than satisfy the idle curiosity of viewers. In many terrible situations, such field reporting provides the first reliable information from the field and marshals the concern and support of millions of people, who are moved to donate online.

Red Cross officials reported that they raised US$488 million from the public for disaster relief in Haiti. When the tsunami struck Japan in 2011, donations to the Red Cross added $700 million to the massive disaster relief effort of the Japanese government.

Field reporting also brings the realities of war, terrorism and disaster into the homes of those lucky enough to be safe from such events. The reporting can make us feel less safe, but can also unite us in powerful ways.

When the United States pushed Iraqi forces out of Kuwait in 2003, the world saw live coverage from the **Bloommobile**, a satellite-equipped vehicle that **NBC News** put into the field. The truck was named for correspondent *David Bloom*, who became a household name by reporting on the move as tanks and trucks rolled across the desert. Sadly, Mr. Bloom died of a pulmonary embolism in Baghdad soon after those broadcasts.

America's Iraqi mission started with live TV coverage and ended in the same fashion. NBC News assigned the Bloommobile back into action in 2010 to cover the last U.S. combat brigade pulling out of Iraq.

The motivation then was the same as in 2003, according to *David Verdi*, Vice President of NBC News. "*We asked ourselves what our audience expected from us in our coverage of the conflict. The unanimous answer was that our audience expects to see this war live.*"

The digital newsgathering toolkit has an ever-expanding range of technologies to capture and deliver news to a TV, computer or phone. When journalists need to deliver that news from some of the most dangerous places in the world, only satellite is up to that formidable task.

This article was produced for SatNews by Space & Satellite Professionals International (SSPI).

See more stories and videos of satellite making a better world at ***www.bettersatelliteworld.com****.*

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Opening photo is courtesy of the UK Department for International Development, Flicker Creative Commons.

ACCELERATING MILITARY SPACE APPS

Cubesats and COTS can streamline this process

By William Hosack, Chief Executive Officer, Orbital Micro Systems

A large share of satellite and space technology can be traced to military development and deployment activities — ranging from GPS to communications to Earth Observation (EO), space-based systems have, over time, taken on military and commercial or public uses that permeate everyday life.

While these capabilities have been important to national security and military strength, and a tremendous boon to commercial enterprises, they were developed mostly with virtually unlimited resources. However, an era has now been entered where military budgets are closely scrutinized for the value delivered for each dollar invested. Just as commercial enterprises have focused on profitability and efficiency, government and the military are also looking for the biggest bang for every dollar — even in space technology.

The U.S. military has extensive experience with small satellite (smallsat) technology and has the ability to launch whatever is required into orbit. The question being asked today is: *Are there better ways to get the job done*?

The rapid commercialization of smallsat launch opportunities and platforms — particularly for cubesats — has ushered in a new option for placing military technology in orbit quicker, cheaper, and with less effort.

Military-Commercial Collaboration

Military-Commercial collaboration is not a new concept. There are numerous present-day examples of cooperative programs that work well. While there were teething pains with some of these efforts, the goal of correct-sizing to deliver the right value has generally been achieved.

Leveraging a Commercial Service: In new operational theaters, military units often rely on commercial telecommunications networks to augment non-secure connectivity requirements while building out their own infrastructure. This facilitates operational readiness in forward areas with limited cost and manageable risk.

Leveraging Commercial Expertise and Infrastructure: Much of the logistics support for moving U.S. military materiel around the world is currently provided by commercial firms. Commercial freight forwarders, transportation providers, and logistics experts have proven to be more efficient and less costly.

Leveraging Public Data Sets: Military units responsible for weather observation and reporting, augment data collected from their own sensors and systems with that provided by NOAA, MET Office, and other public resources. This enables better weather intelligence without the need to fly additional space-based sensors.

While these examples don't rise to the level of pure COTS (Commercial-Off-The Shelf) integration in the manufacturing stream, they demonstrate the confidence military organizations have engaging commercial enterprises to improve performance and/or reduce cost.

COTS Cubesat Systems Accelerate Advances

Military and government organizations have a long history of COTS utilization; however, it is important to remember that it's no small task to shift from internal development to relying on outside manufacturers and suppliers.

COTS implementation can pose threats to programs, and these threats must be mitigated from the outset. Key risk vectors that must be addressed and managed include multiple source options, strict version control, and iron-clad supply chain management to prevent introduction of counterfeit parts.

Once accomplished, the use of COTS materials in cubesat-based applications sets up a cost- and time-efficient scenario that will accelerate deployment capabilities and advance both military and commercial goals. In this scenario, the military maximizes efficiency by focusing on the payload, while commercial partners provide transport and operational expertise. Hardware costs are reduced, and personnel and operational expenses can be outsourced at competitive rates.

While the military is not likely to outsource all its space-based initiatives to commercial enterprises, there is an opportunity to leverage commercial efforts in particular areas that meet operational and tactical needs — without exposure to additional risks.

As a result, the potential of using COTS products — such as CubeSat chassis or buses — for military payloads could become a win-win situation.

Cubesats and Military Payloads

Hundreds of commercial Cubesats were placed in orbit in 2017. As this trend continues to accelerate, economic forces are driving standardization, leveraging economies of scale and scope. This results in lower costs for all markets. In addition, with the growth of the commercial cubesat industry, comes growth in technical expertise and experience which can lead to both military and commercial advancements.

There is a rich history of the military leveraging dual-use commercial and military COTS products. Extending this model to cubesat applications can be achieved with a moderate level of cooperation between the parties involved.

There are many potential benefits to military organizations beyond cost reduction. Standard bus architectures and designs would facilitate a modular approach for developing and deploying systems.

A COTS bus, which can carry a range of payloads, would enable procurement and deployment of reserved systems both on the ground and on orbit. In addition, using standard bus and operational platform modules, single function, or narrowly-defined payloads can be easily deployed and tasked in very short timeframes to support new missions and theaters.

The practicality of placing a maneuverable deployment craft into orbit, equipped with cubesats held in low-power stasis, is quite reasonable. Responding to the catastrophic failure of a satellite, a reserve unit can be quickly tasked and deployed to take over a mission.

The relative low cost also enables frequent technology refreshes that can leverage the most up-to-date capabilities. Furthermore, these reserve units serve for rapid deployment in response to critical situations that require additional observation and monitoring. Whether for monitoring natural disasters or in war theaters, where these assets could provide essential intelligence for warfighters on the ground.

The simplification of mission parameters for individual cubesat units, provides flexibility in tasking and performance. Disaggregation of on orbit instrumentation and resources lessens risk, while providing inherent resilience and reliability.

It's an over simplification, but it is much easier to knock out one very large satellite than dozens of tiny satellites. The time and cost to replace a large multi-function satellite is untenable when compared with the flexibility to launch or commission one or 100 cubesats.

Commercial Datasets and the COTS Model

The volume and value of observational datasets beamed down from these on orbit resources will enhance operational capabilities and planning in multiple sectors.

A starting point for military-commercial collaboration can be found in the realm of data collection and analysis. Commercial EO intelligence datasets can be procured and processed to enhance military capabilities. There is some incongruity between a classical COTS model and datasets, but the resulting benefits should outweigh the need to stretch the definition.

Datasets are not a physical item, such as a bearing, windshield, or fuel tank, that can be given a part number and stocked in a supply depot. However, datasets can be managed and treated much in the same manner as any service.

Military weather units use public datasets, and military units leverage commercial telecommunications services when needed. Combining these concepts, and treating datasets, such as a constant stream of weather intelligence data from commercial satellites, as a COTS service, is a fairly easy model to comprehend.

Collaboration in Weather Observation

Extending on the current model for tactical weather observation and planning by military weather units, such as the **557th Weather Wing** of the U.S. Air Force (557th WW), use of commercial datasets gathered from cubesat constellations can improve weather intelligence accuracy and value.

The 557th WW operates several weather observation technologies, including ground-based systems, aircraft onboard and deployable systems, and powerful data processing and analytics platforms. The unit's mission is to "*maximize America's power through the exploitation of timely, accurate, and relevant weather information; anytime, everywhere.*"

The 557th WW uses weather datasets from public sector space assets, but as these systems are primarily tasked to collect observations of areas of interest to the sponsoring governments, data for other world regions may not be as timely or detailed as needed. In some parts of the world, the interval between weather observations from public platforms can be as long as 18 to 24 hours.

One of the benefits of cubesat-based weather observation systems is the use of constellations that can provide observations from multiple satellites, enabling data collection at intervals approaching 15 minutes. These relatively inexpensive systems are poised to deliver weather intelligence datasets nearing the lowest practical intervals.

For example, one solution comprises 36 to 40 operational cubesats in pseudo-random low Earth orbit, using microwave radiometry to accurately measure temperature, humidity and precipitation at up to eight altitudes.

Providing this level of weather intelligence at the 557th WW's High Performance Computing Center can have an immediate effect on the unit's mission to deliver authoritative environmental intelligence to decision makers across the spectrum of global operations.

In this model, weather intelligence data is treated as a COTS service, subject to the same supply chain requirements as any other COTS element. It roughly parallels streaming media services or satellite communications services utilized by consumers and businesses worldwide. However, as there is no physical device to be manufactured, the adoption and deployment of such a program could be accelerated. Effectively, this becomes a military-commercial

U.S. Air Force 557th Weather Wing at work. Photo is courtesy of the 557th WW.

collaboration scenario that improves performance, with limited expense and effort for the military.

Potential Outcomes

Each military branch and unit can access the weather intelligence to serve differing missions and requirements, with a number of compelling outcomes:

Improved Predictive Analytics for Aircraft Maintenance

Analysis of in-flight atmospheric conditions such as icing, extreme turbulence, and airborne particulates can inform better preventative maintenance decision-making. Harsh operational conditions can accelerate maintenance needs. Data-driven predictive analytics help ward off in-operation failures that may occur in advance of typical time-driven maintenance schedules. This could assure operational readiness while streamlining maintenance functions.

War Theater Weather Intelligence

Bad weather and intense precipitation can be assets as well as risks for military units. Access to timely and accurate weather intelligence, including precipitation rates, wind speeds, and cloud density enables better mission planning and execution.

Reduction of Inter-Service Redundancies

Global weather intelligence datasets could reduce the need for each service and unit to deploy observation resources in a region or theater.

This can eliminate redundancies, and unnecessary costs, during developing situations and in active observation zones.

Learning and Growth Process for Both Parties

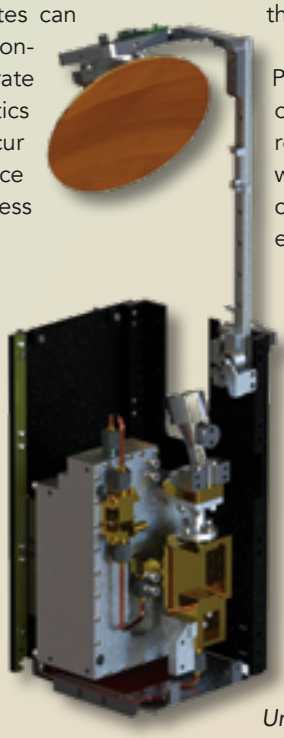
Implementing COTS solutions to address military needs in space is in its most nascent stages. The process will take time and effort from both military and commercial players to map out a value chain that delivers for all parties.

The pieces are here today. The military are experts in knowing how to identify and address threats. The commercial sector has the capacity and capability to deliver cost-effective resources in orbit, as well as provide datasets as a service — with limited capital investment from the military.

Predicting where the market will head is in the hands of entrepreneurial enterprises. Opening the doors to relatively simple applications —such as using commercial weather intelligence datasets — could be a foundational catalyst for innovation that will substantially improve the efficiency of military space missions.

www.orbitalmicro.com

William Hosack serves as Chief Executive Officer for Orbital Micro Systems. His extensive aerospace background includes 28 years of supply, production, and senior management experience, executive management consulting, expertise in strategic business development in Asia, and as a compliance expert for export and ITAR in Southeast Asia. Mr. Hosack studied Aeronautical and Space Management Operations at Embry-Riddle Aeronautical University. He is also an IFR Certified private pilot.



Orbital Micro Systems MiniRAD.

A MOBILE SATELLITE USERS ASSOCIATION LEADERSHIP INTERVIEW

with Brian Aziz, Director of SATCOM Solutions, Thales Defense and Security

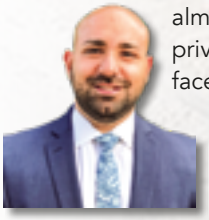
By Catherine Melquist, President, MSUA

Catherine Melquist (CM)

Thank you Brian for agreeing to share your views on the satellite mobility market with MSUA's Mobility News readers. Let's start by talking about you. How long have you been in the satellite industry and what's your role at Thales Defense & Security?

Brian Aziz (BA)

Thank you for the opportunity. I have been in the satellite mobility market for almost 10 years and I've had the privilege of working in several facets of the industry.



Thales is entering the satellite mobility market with the introduction of VesseLINK™ and MissionLINK™, both of which will operate on the brand-new constellation being launched by Iridium.

As the Director of Satcom Solution, it's my job to manage the overall sales and marketing of this new product line, including recruiting new distributors and implementing business strategies that will ensure our products are well received in the marketplace.

CM

What part of the satellite mobility market are you focused on and how would you describe the evolving data needs and challenges of these users?

BA

I'm involved in the evolution of the L-band market. L-Band has been around for a long time and has been sought after for its reliability and mobility; but the demand for new applications and higher bandwidth has grown.

Problems experienced with L-band include lower bandwidth speeds, higher latency, and higher costs. With the launch of Iridium NEXT and the new Thales terminals, customers will finally have a faster, more efficient, and more cost-effective options.

CM
Imagine yourself an interviewer for Mobility News, what fellow MSUA member, industry colleague or customer representative would you like to interview and what would you want to know?

BA
I recently saw an announcement by Iridium that Comsat has become the exclusive provider of Iridium Certus services to the U.S. Department of Defense (DoD). I'd love to interview the technical leads at Comsat to learn more about their latest developments and the innovation they plan to introduce to the U.S. DoD market.

CM
What mobility innovations (actual or conceptual) are of greatest interest to your target users?

BA
Thales's VesseLINK and MissionLINK products, which are being launched this year, will deliver a simple, easy-to-use, easy-to-install mobile terminal that operates from pole to pole. This capability will cater directly to the needs and requirements of our target users.

CM
What mobility innovations are you most interested in learning about as you travel to various trade show?

BA
I'm looking forward to learning more about companies that are planning to launch new satellite communication networks in the near future. I'm also interested in learning about new value-added products that are being developed to enhance the experience of mobile satellite users.

CM
How important is system interoperability to your users and if important, what forms (e.g., frequency, altitudes, commands) are your customers talking about?

BA
When we decided to enter a new commercial market, we spent the first two years doing market research, and learning from our distribution partners and end-users.

We learned that in both the land and maritime markets, customers want to do more with less. Based on this feedback, we proceeded to develop products that are feature-rich and deliver interoperability between VSAT, L-band, Cellular, and Land Mobile Radios.

CM
My final question is the same one I typically ask all interviewees — mobility takes us all kinds of place and allows us to do a lot of things. What's your personal favorite form of mobility (e.g., biking, parachuting, dog walking….)?

BA
I enjoy going to a boxing or MMA class several times a week, when I have the time.

CM
(She laughs) Okay, "mobile fists"! I can safely say no one has yet given that answer. So, well done! Brian thanks for taking time to give us your perspective on the satellite mobility business.

President of the Mobile Satellite Users Association, Catherine spearheads the group's mission to promote mobility market development and mobility innovation. With over 25 corporate and small business members representing all levels of the satellite value chain as well as end-users, MSUA collaborates with conference organizers around the world to facilitate panels and keynote speakers that decipher mobility market dynamics including: growth opportunities, strategic partnership, barriers to progress, application aspirations, adjacent market influences and more.

Catherine Melquist is a strategic marketer with more than two decades of experience developing marketing and public relations strategies for global companies in the satellite and space-based market.

www.msua.org

THE DISASTER RECOVERY ACID TEST

A GLOBECOMM Focus

By Dwight Hunsicker, Executive Vice President and General Manager, GLOBECOMM

The hurricane season of fall 2017 will be remembered for a long time. The major hurricanes Harvey, Irma and Maria, roared through the southeastern United States and the Caribbean. Lives were in jeopardy as observers wondered how they could help.

Supply routes for much-needed water, food, medicine, clothing, fuel and other commodities were almost nonexistent, particularly in the Caribbean. How could these regions be helped when the outside world didn't know what critical supplies were needed most?

Many companies and government agencies rushed to help. Reestablishment of communications to these areas became crucial to redefining the supply routes. One company, in particular, was one of first responders to make this happen — GLOBECOMM.

GLOBECOMM has been a leading supplier of disaster recovery products and services for decades. Recently, after Hurricane Maria in Puerto Rico, GLOBECOMM partnered with Vanu to start the process of reestablishing communications across the island. This was accomplished with a small cellular base station made by Vanu covering about a three mile radius. The base station is plugged into a satellite dish installed by GLOBECOMM that connects back to a soft switch located at GLOBECOMM's New York headquarters facility. The soft switch then connects to local carriers, providing much-needed cell service to the population. The response was phenomenal; cell phones started ringing like a flash mob concert.

The GLOBECOMM soft switch was established at GLOBECOMM in 2010 to provide small carriers in remote locations with an economical way to start their business without the initial expense of the switch. The soft switch was shared among small businesses as their customer bases grew. The added benefits of versatility and economics have shown the service to be an important part of any disaster recovery response.

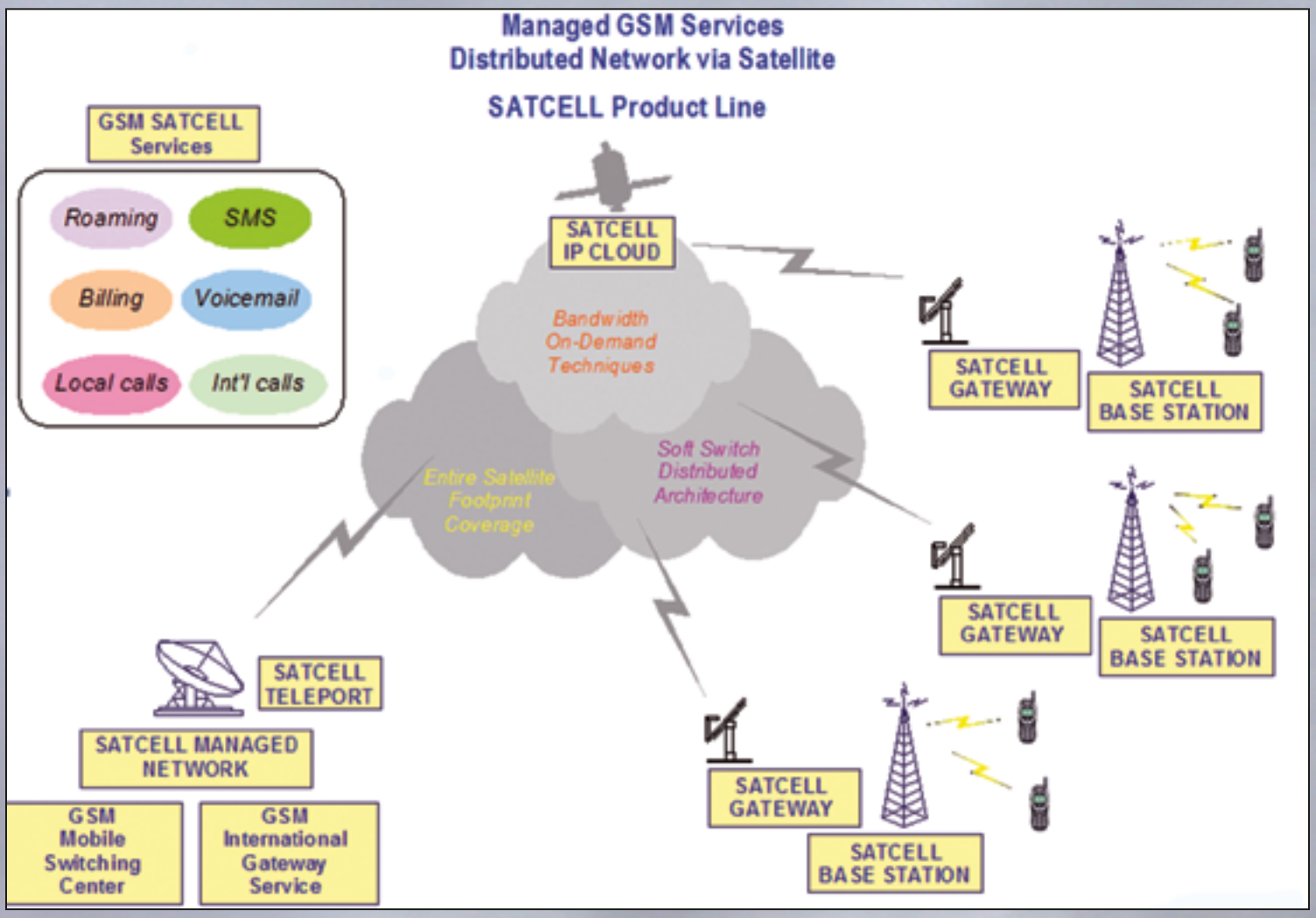


Figure 1. GLOBECOMM's soft switch adds benefits of versatility and economics for Disaster Recovery response.

GLOBECOMM's excellent capabilities are a result of close cooperation with additional companies and government agencies to expediently react to any disaster. Another example is GLOBECOMM's efforts to support a government disaster response agency.

GLOBECOMM maintains an operations center in the Washington, D.C., area that supports the warehousing and deployment of IT and communications technologies and assets utilized during disaster response.

Supply operations in the Caribbean. Photos are courtesy of GLOBECOMM.

Photo of the GLOBECOMM teleport in the Nethrlands is courtesy of the company.

GLOBECOMM also has staff deployed in the contiguous states, as well as outside the continental United States, providing additional support, including technology refresh and upgrades as well as quick deployment anywhere.

When a disaster occurs, GLOBECOMM submits a detailed plan that addresses infrastructure, existing/available communications, available power and/or limitations, primary and secondary means of communications, transportation, security, contact lists, and billeting. The company's field team has valid passports, up-to-date immunizations, required training and can deploy within four hours.

During the 2017 hurricane season, GLOBECOMM sent engineers and/or equipment to Barbados, Haiti, the Bahamas, Antigua and Barbuda, Saint Maarten, Curacao, Dominica and Guadeloupe.

GLOBECOMM's support efforts extend beyond disaster recovery. With the flexibility of satellite communications, the company's products and services are used in a variety of circumstances and have been selected time after time to design and implement enterprise and morale, welfare and recreation (MWR) networks for the nation's armed forces as well as for the U.S. government foreign affairs community. The GLOBECOMM global network of satellite and fiber allows us to provide remote connectivity, anytime, anywhere under any conditions.

GLOBECOMM terminals in Afghanistan.

On-the-job training for the Royal Netherlands Army. Photo courtesy of GLOBECOMM.

GLOBECOMM supports physical and logical Internet Protocol (IP)-based global networks that government enterprises domestic and abroad, as well as MWR networks, have implemented for personnel to keep in contact with their friends and families.

Recently, GLOBECOMM's European arm delivered two 1.2m SATCOM antenna systems, including iDirect X7 modems, outdoor GPS, Cisco ATAs and telephones, to the 43rd Mechanized Brigade of the Royal Netherlands Army.

The systems are used in the field at remote locations where the brigade has no other means of operating its SAP software system, which is necessary for ordering spare parts for the equipment maintained by the 43rd Maintenance Company. The firm's VSAT service supports connectivity back to headquarters.

Figure 2. GLOBECOMM VSAT service beam coverage

GLOBECOMM VSAT Service has been designed to furnish reliable, cost-effective connectivity services between users across the globe. This may entail connecting remotely situated users, systems to a corporate network for business or M2M purposes, to the internet for work or entertainment, or any combination of these. The ability to support land-based users and mobility and beam switching for maritime and aeronautical users are key attributes of the service platform.

GLOBECOMM VSAT coverage to remotely situated users is achieved via satellite communications (SATCOM) using 24 Ku-band beams generated by 17 satellites that are accessed from nine worldwide teleports, three of which are owned by GLOBECOMM. The beams are depicted in ***Figure 2*** on the previous page.

The GLOBECOMM International Network (GIN) links these and an additional five teleports with a carrier-diverse gigabit Ethernet SONET/SDH network. The GIN interconnects the teleports and provides peering points at 10 international carrier hotels.

These peering points may be readily accessed by GLOBECOMM VSAT customers to achieve connection to their WANs using local loop services. Thus, global SATCOM and fiber connectivity allow us to connect remote users anywhere in the world to their enterprise WANs or to the public internet.

The company's VSAT service was commercially launched in October 2015. Precise coverage for any individual site will vary based on user terminal size, BUC power level, user data requirements, and look angle available based on user location. The significant hub architecture investment made by GLOBECOMM provides ample capacity for growth and expansion of additional networks.

The company's other key activities and achievements that ensure customers' mission success include the following:

- *U.S. Federal Law Enforcement Agency: GLOBECOMM supports one of the world's largest law enforcement organizations that is charged with keeping terrorists and their weapons out of the U.S. while facilitating lawful international travel and trade. As such, it has an extensive communications network and GLOBECOMM provides a satellite network that backs up the terrestrial network.*

- *U.S. Federal Aviation Agency (FAA): The FAA controls the U.S. airspace that facilitates the safe and orderly movement of more than two million air travelers each day. This control requires an extremely complex and expansive communications network that necessitates high reliability and availability. As such, the primary terrestrial network is backed up with a satellite network that GLOBECOMM provides and supports via a subcontract to the Harris Corporation.*

- *Dutch Ministry of Defence: The Dutch military has always been good at global citizens and dispatching its military personnel throughout various parts of the world to support global peace and prosperity. Deployed Dutch personnel rely on GLOBECOMM for communications back home. GLOBECOMM networks enable them to talk and email friends and families and even partake of video teleconferences for holiday gatherings.*

- *U.S. Department of Defense (DoD): Unfortunately, everyone is aware of the global threat of a multitude of terrorist activities around the world. GLOBECOMM is supporting the "war on terror" through partnering with various entities within the DoD, providing a wide array of our products and services. GLOBECOMM has more than 15 projects, tasks and contracts in which it is providing important, and in many cases, unique solutions that have been critical to the success of the DoD missions.*

- *Afghan Telecom (AFTEL): AFTEL is the telephone company in Afghanistan appointed by the Afghan Ministry of Communications to provide telecommunications services throughout the country. One of its largest networks in the Village Communications Network, a 1200-site VSAT network that provides basic telephony services to the most remote and rural locations throughout the country.*

Government and military organizations require a communications provider to take an acid test to assess its ability to deliver data accurately and securely to the most difficult and hazardous areas in the world.

Through a total solutions orientation, global network and engineering superiority, GLOBECOMM has consistently demonstrated the ability to deliver remote communications connectivity under the most trying circumstances.

Provisioning of networks and associated equipment and services takes program management rigor as well as an overall strategic perspective in terms of having the correct equipment, appropriate access to various satellite operators and trained, agile field engineering teams.

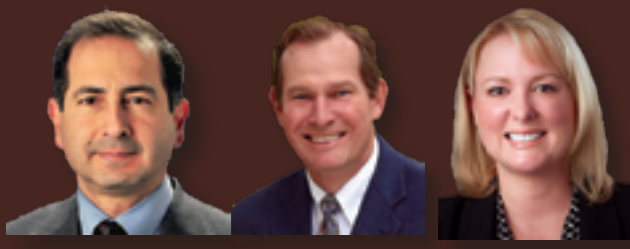
www.globecomm.com

The author, Dwight Hunsicker, is the Executive Vice President of the Government Solutions division at Globecomm

THE NEXT STAGE FOR HPA

The HPA Corner

By Al Tadros, Bryan Benedict and Hayley McGuire, HPA Officers



With a sense of accomplishment and pride, the leadership of the Hosted Payload Alliance jointly authors this month's HPA Corner to announce our milestone transition.

Since the establishment of the HPA in 2011, this nonprofit industry alliance has served as a bridge between the commercial space industry and the U.S. government for communicating, brainstorming, debating and progressing the vision of hosted payloads for mutual benefit.

HPA has provided numerous forums for open discussion and sharing one-on-one with Congress, the DoD, NASA and throughout the U.S. government the many benefits of the frequent, affordable and reliable hosting options on commercial missions.

With persistent encouragement from industry, the USAF Hosted Payload Office at the Space and Missile Systems Center (SMC) generated enough momentum to establish the Hosted Payload Solutions (HoPS) Indefinite Delivery Indefinite Quantity (IDIQ) contract with more than a dozen companies. Unfortunately, no hosted payloads have been contracted through HoPS over the past four years.

Hosted payloads are just one of many innovative solutions the USAF has been hesitant to adopt — but this is starting to change. Although much slower than expected by industry and many U.S. government leaders, the use of hosted payloads and other innovative approaches are being seriously considered within multiple missions in future architectures.

As the current HoPS IDIQ is set to expire in mid-2019, it is our sincere desire that it be extended to allow more opportunity for commercial industry to more readily serve U.S. government needs.

We no longer have to point to the single USAF CHIRP hosted payload as the sole proof of concept. The adoption of commercial hosting by NASA and the FAA continue to demonstrate the model. NASA is regularly leveraging commercial space missions to host high-value payloads as well as technology demonstrations and experiments.

Recent launches of the FAA's Wide Area Augmentation System (WAAS) and NASA's Global-scale Observations of the Limb and Disk (GOLD) missions on commercial GEO satellites, the start of NASA's GEOCARB hosted payload program and the imminent contracting of NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) hosted payload are key examples. These missions verify the cost-effectiveness, reliability, sustainability, security and mutual benefits offered by hosted payloads.

We anticipate, encourage and look forward to more momentum across the U.S. government leveraging the growing U.S. commercial space industry.

Over the past seven years, as a focused, stand-alone body, HPA has achieved many of its goals. As we enter 2018, the HPA membership is considering how best to continue our mission in serving commercial and U.S. government space interests.

The HPA membership has decided that the best structure to continue this mission of service would be in conjunction with another industry association focused on the wider value that commercial space industry brings to the nation.

We are in the midst of this transition now and will be able to describe the new structure in the next issue of the HPA Corner.

Your HPA Officers;
Al Tadros, Bryan Benedict, and Hayley McGuire

www.hostedpayloadalliance.org/

The liftoff of the Ariane 5 rocket from the Guiana Space Center in Kourou, French Guiana, on Thursday, January 25, 2018, with the SES-14 satellite and NASA GOLD hosted payload aboard. Photo is courtesy of Arianespace.

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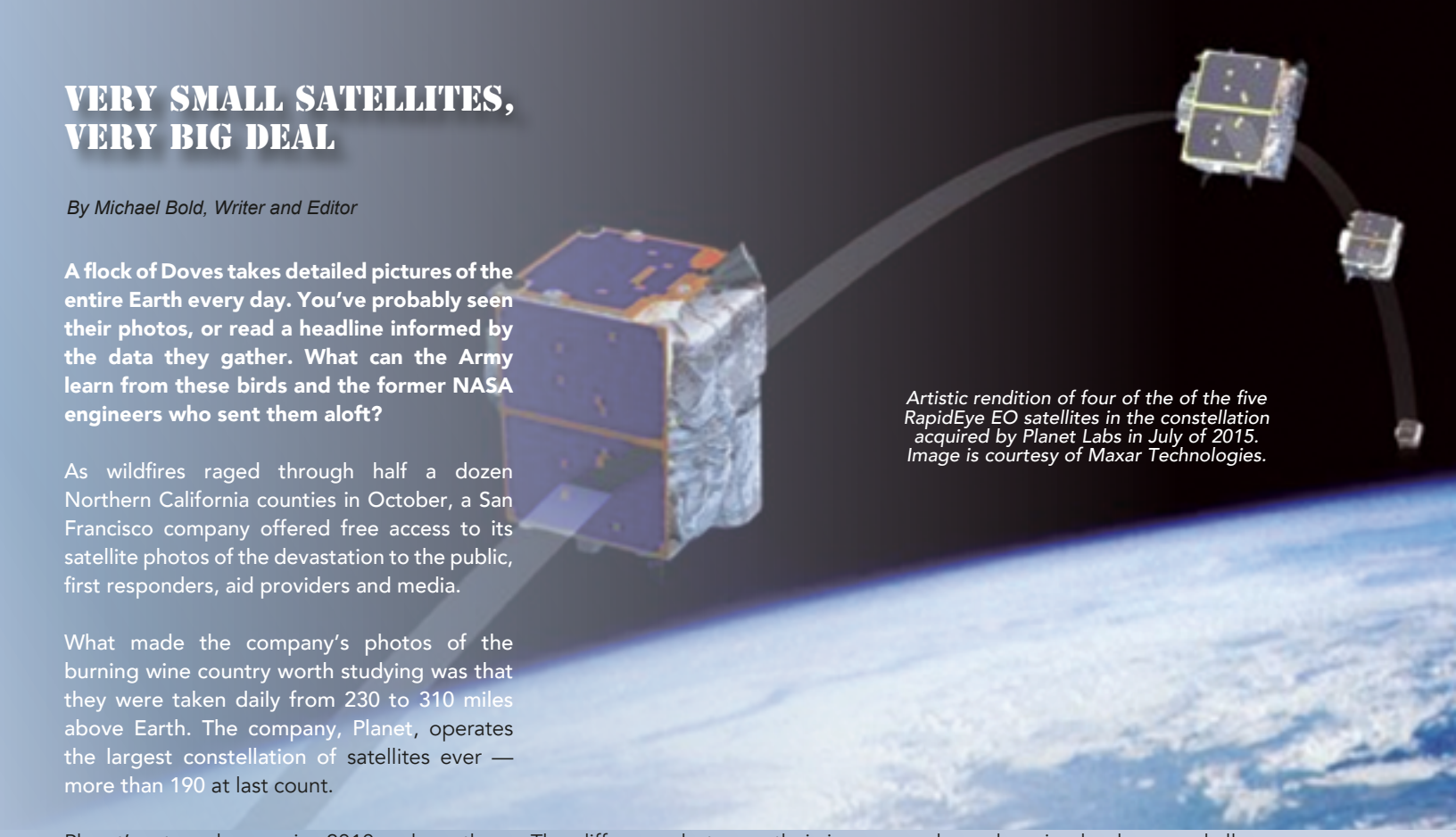
VERY SMALL SATELLITES, VERY BIG DEAL

By Michael Bold, Writer and Editor

A flock of Doves takes detailed pictures of the entire Earth every day. You've probably seen their photos, or read a headline informed by the data they gather. What can the Army learn from these birds and the former NASA engineers who sent them aloft?



Artistic rendition of four of the of the five RapidEye EO satellites in the constellation acquired by Planet Labs in July of 2015. Image is courtesy of Maxar Technologies.

As wildfires raged through half a dozen Northern California counties in October, a San Francisco company offered free access to its satellite photos of the devastation to the public, first responders, aid providers and media.

What made the company's photos of the burning wine country worth studying was that they were taken daily from 230 to 310 miles above Earth. The company, Planet, operates the largest constellation of satellites ever — more than 190 at last count.

Planet's story began in 2010, when three aerospace engineers left the **NASA Ames Research Center** in Mountain View, California, to start an audacious business: a private satellite company.

The trio — American *Robbie Schingler*, Briton *Will Marshall* and Australian *Chris Boshuizen* built their first prototype satellites in Schingler's garage, basically taking apart a cellphone and adding a telescope, extra battery power and some other features. They moved their lab to San Francisco in 2011 and founded Planet Labs Inc., now known simply as Planet. (Boshuizen left the company in 2015.)

Their idea was revolutionary. Satellites typically weigh more than 3 tons and are about the size of a bus, take a decade or more to design and build and, by the time they're deployed, are running on obsolete computing systems for the 10 or so years they're in use.

What Planet does is turn all that on its head. Each of their satellites (called **Doves**, and launched in **Flocks**) is roughly the size of a large shoebox and is built using commercial off-the-shelf technology.

They're constantly being upgraded with the latest available technology (the Dove is on its 14th iteration) for the roughly three years they'll be in orbit. They take continuous daily photographs of Earth.

The difference between their images and, say, Google Earth's, is that Planet's images are updated daily, rather than every few months, and are compiled into a cloud-based database, allowing users to compare changes to areas both large and small over time.

The satellites, as Planet describes it, "*act like a line scanner for the planet.*" Custom automation software allows Planet's Mission Control team to schedule imaging windows, push new software in-orbit and download images to 30 ground stations worldwide. The constellation of 190 plus satellites is akin to what the U.S. Army foresees as the organization pursues networked swarms.

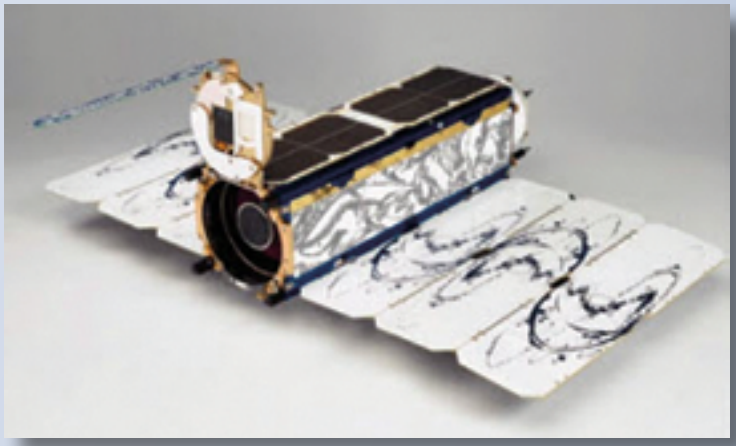
However, it's once all those images get back to Earth that the real magic begins. Planet has developed analytical algorithms that produce an array of products for:

Agriculture—Planet's continuous images of their fields allow farmers to understand changes in soil, crops, irrigation and disease, allowing them to farm more efficiently, profitably and sustainably.

Governments—Planet's imagery lets local governments track urban growth, unpermitted building and changing land use, and allows them to better manage regional transportation budgets, land use policy, economic development plans, disaster response, crisis management and humanitarian aid, such as in the case of the Northern California fires and Hurricanes Harvey and Irma.

Intelligence and defense—Planet provides transparency into global events, constantly photographing broad swaths of Earth and targeted areas of interest. The images allow for monitoring of man-made and natural disasters; ports and shipping; and population shifts. Planet's images after the recent North Korean nuclear test showed widespread landslides in the area surrounding the test site, suggesting to experts that the explosion was much larger than originally thought.

Forestry—Images allow for improved monitoring of forest health, tracking of illegal logging and planning of timber-harvesting operations.



A Planet Dove smallsat.

Planet also offers products for mapping; energy and infrastructure; and finance and business intelligence.

Other companies, known as analytics-as-a-service companies, use their own algorithms to sort Planet's data, and many of them, in turn, have partnered with Planet. A Jakarta-based analytics company, **Dattabot**, used satellite data from Planet to help secure loans for Indonesian farmers.

Planet is at the leading edge of an exploding wave of space privatization, its satellites having hitched rides on U.S., Indian, Russian and private rocket launches. Planet and other satellite startups, including **UrtheCast Corp.**, **DigitalGlobe Inc.** and **Orbital Insight,** are making Earth imaging resources once reserved for governments available to businesses and the public. Companies such as *Elon Musk*'s **SpaceX**, **Orbital ATK** and **Blue Origin**, owned by Amazon founder *Jeff Bezos*, are launching their own rockets into space.

Planet's medium-resolution Dove satellites (in the aerospace industry, satellites are commonly called "birds") got the name because they are "*peace-bringing satellites, enabling commercial, humanitarian, and environmental applications at a scale that has never been attempted before,*" according to the company website.

Also in Planet's constellation are five medium-resolution **RapidEye** satellites, acquired when it bought BlackBridge in 2015; seven high-resolution **SkySat** satellites acquired when Google sold its Terra Bella subsidiary to Planet in February of 2017 (as part of which, Google acquired an equity stake in Planet and entered into a multi-year agreement to purchase SkySat imaging data); and six SkySats launched in October.

Not that the private satellite business is without its risks. In October 2014, an Antares rocket, whose payload included 26 Doves bound for release from the International Space Station (ISS), exploded shortly after launch off the coast of Virginia. In June 2015, a SpaceX Falcon 9 rocket broke up during takeoff from Cape Canaveral in Florida; eight Doves were aboard.

While Planet is most definitely a business — according to a **Bloomberg Business** article from June 29, 2017, Planet has raised more than $180 million in venture capital and is valued at more than $1 billion — it sees its mission as making the world a better place by changing the way we understand, and ultimately manage, the Earth's resources.

"*Whether you're measuring agricultural yields, monitoring natural resources or aiding first responders after natural disasters,*" says its website, "*our data is here to lend businesses and humanitarian organizations a helping hand. Planet believes timely, global imagery will empower informed, deliberate and meaningful stewardship of our planet.*"

Robbie Schingler, Co-Founder and Chief Strategy Officer, Planet

Schingler, 38, Planet's Co-Founder and Chief Strategy Officer, spoke with Army AL&T late last year. He worked for 10 years at NASA, where he helped build the **Small Spacecraft Office** at NASA Ames and pursued new business opportunities for the **Transiting Exoplanet Survey Satellite**, a planned space telescope that's part of NASA's **Explorers Program**.

Schingler later served as NASA's open government representative to the White House and as chief of staff for the Office of the Chief Technologist at NASA. He received an MBA from Georgetown University, an M.S. in space studies from the International Space University of Strasbourg, France, and a B.S. in engineering physics from Santa Clara University. He was a 2005 Presidential Management Fellow.

Army AL&T

Planet Labs can photograph nearly all of the Earth's surface every day, which is something not even the U.S. government can do. To what purpose?

Schingler

The purpose for us is to do a global monitoring mission at this spatial resolution [how small an object you can see]. So that's important. … Actually, just to correct you, the U.S. government is mapping the whole Earth every day with the MODIS satellite, which is 500 meters per pixel. One satellite. But what we do is image the whole world every day at 3 meters per pixel. And that spatial resolution allows for us to build a data set that lends itself to analytics. So when you apply the analytics technology to this data, you can come up with some really interesting insights.

We are a commercial-first company — we have a lot of customers in agriculture and in finance sectors, and they're interested in making a better decision on either a trade or when to plant and cultivate. And [with] the spatial resolution and the temporal resolution [the precision of a measurement with respect to time] that we have, they're able to measure economic stops and flows on the planet.

Now, it turns out from a government perspective... the same pixels and the same analytical capabilities can be used to modify our government's workflow as well, on the civil side and on the military intelligence side. On the military intelligence side, the time-series nature of this—the term of art has been "activity-based intelligence," or patterns of life. When you can classify that change, that pattern of life, and identify a signature that then can become an early indication of something about to happen, then you can better allocate your scarce resources — either high-resolution capabilities, pixelated aircraft or human — in order to then anticipate what's about to happen and, in some cases, mitigate something from happening.

Army AL&T

You guys made it big by going small, by building not only very small satellites but a lot of them. Is there a lesson for DoD and the Army about going small and about using off-the-shelf technology?

Schingler

Absolutely. I believe that the future of space is to continue to have very, very high value, unique, one-of-a-kind assets — whether they're flagship astrophysics missions or they're used for national technical needs. When it comes to things that are a bit more operational, that have commercial utility, I think the Army and the government in general should be really adoptive, should embrace these newer technologies and allow for [the government] to then, on the space side of things, focus on the harder things, and focus further out. Something that gives them an offset.

Now, lessons specific for the Army, around using small satellites, is just: Get on with it. You know, this is actually a really, really good training capability for young [engineers]. Give them the ability to innovate within a box, you know, whether it's size or whether it's cost or whether it's time, or all three, and see what they can do. By treating the satellite like a robot, which is what it is, rather than something up on a pedestal — that maybe you influence one appliance or one component within one subsystem within one mega-satellite over a decade — you have a different relationship with it as an engineer.

By iterating on that relatively quickly, you really understand the system dynamics of the hardware, which then allows you to think about the system dynamics of the entire system. It's not just the sensors that you launch into space, but you think about the entire value chain. Ultimately, the reason why we're going into space is to collect unique information — and, with that unique information, to allow for people to make better decisions. We also go to space for other signals like PNT [positioning, navigation and timing], and for [communications], but largely for all the other applications, it's really about getting unique information to make better decisions.

The faster that we can speed that up, from asking a question to getting an answer... is really smart. There are places to innovate — not just on the hardware that goes into space but on the network of the ground stations. Then also the data exploitation platform that allows for an end user to ask a question and get an answer.

What's very interesting about this trend of small satellites is the growing proliferation of unclassified and commercial imagery we see and military users want to use this imagery more tactically rather than strategically and can now get access to space. That's one of the beauties of our constellation [of satellites'] capabilities. By remaining unclassified, it means that you don't have to have four stars on your shoulder to get access to what was once an extremely strategic capability. It now can be done in more of a day-to-day operational modality.

Army AL&T

The satellites get all the attention, and rightly so. They're very sexy. But what about the analysis of that data? The possibilities seem to be almost limitless. And in fact, you're partnering with a number of companies that take your data and analyze it differently than you do. Talk about that.

Schingler

OK, that's a great question. And I'm glad that you brought up a number of our partners and customers, because it's absolutely key for this to really grow the market and allow for something, again, that was once strategic use for government to actually make its way into better decision-making tools in the economy. And that's what we're absolutely focused on doing, growing the number of users who can get access to this information.

Our industry, remote sensing, is a very special theme-strategic industry that was primarily driven by the intelligence community for decades. And we called it the tradecraft, being able to exploit … and promote remote-sensing information. You know, you had to have a master's and a Ph.D. in order to understand what you were looking at. I think what has evolved over time is [that] the IT [information technology] companies of the world have really commoditized … cloud-based technology. And that begins to open-source a variety of computer-vision and machine-learning algorithms. And machine-learning algorithms need data. They need data in order to actually train those algorithms so that they become more accurate.

At Planet, we see ourselves as collecting unique information and bringing that unique information with other spatially explicit information to analytics. When you add data plus analytics, that's really what our product is, it's a platform that has core machine-learning analytics baked into it.

We're trying to decrease the barrier for our users to ask questions and get answers. In order to do that, we partner with a variety of companies that have access to our data and core analytics in order to allow for them to build a product that focuses on the customers' needs.

You know, we have customers that are building applications specific for farmers or specific for a commodity trader or that is specific for an insurance provider or for a small holder in agriculture capability. We have hundreds of customers. Our customers operate in over 100 different countries and are really focused on actually building businesses, building a product that can scale and that will really solve the problem. So we see ourselves as more of a platform and an enabler that allows for people to come up with new products and services that were not possible before.

Because we're doing a lot of the hard-core remote sensing work to get all of that data co-registered, co-aligned, activated to the cloud, then also with the core machine-learning analytics that allow for our users and customers to build novel products and solutions. So that's the reason why we partner with a lot of people that actually are building applications that are derived from Earth Observation (EO) data.

Another program, I think, that's really specific and useful for the Army and the government in general is that we are an unclassified and commercial company. And there are many workflows and use cases that we aren't aware of that the government has and truly needs. So we have a partner program for system integrators and for companies that exist to help the government solve their problems. And they are able to take this new commercial tool and then customize elements of it so that they can modernize internal workflow within the U.S. government.

That's something that I think is just beginning. It takes quite a bit of time in order to modify a workflow. By blending in some automation, you can really increase the ROI [return on investment] of the people and the assets that are already deployed to solve government needs.

Army AL&T

Let's talk for a minute about failure. It seems like a certain amount of failure is built into your business plan. You've lost satellites when rockets exploded on the launch pad. Your satellites have a life span of about three years, but you're constantly tinkering and upgrading and changing.

Schingler
We test, learn and iterate on our technology constantly, whether it's a new sensor or a new technology in space, or whether it's how we manufacture our satellites or how we build out our ground stations or build out our automated mission control and our data pipeline and our analytics. We abide by the popular principle of a highly aligned and loosely coupled organization. That allows for each of those nodes to be constantly upgraded over time. That then ends up increasing the value that comes out in the end for the user and for the customer. That's how we actually develop the technology.

The way that we operate the technology is to be reliable, because what comes out in the end is we want to have a service-level agreement that we can live up to and that our customers can expect. And so those two things, being agile and being reliable, are two values that we have in the company. You can't really have one without the other if you want to keep inventing new technology. But then you also want to anchor in that type [of] project in the world, in the market.

That same methodology fits all those in the company: We really wanted to be able to build satellites in a very different way and to iterate on the learnings of the technology and to pull into the satellite new chips and components when they just come out on the market. And knowing specifics in space, you can take those chips and components and actually build out a system that can then work well in space today.

We have a very, very robust, high-performing satellite in a 5-kilogram package. Part of the reason we wanted to go small, too, is so the launch costs are less per satellite. If the launch costs are less per satellite, then the total cost of the system is less. If the total cost of the system is less, then if you lose one or two or three [satellites], that's part of doing business. But if you lose one or two or three, then that means that you'll take a bigger step with the new technology that you develop. And so by taking a bigger step, that means that you actually are bringing the future forward even faster. You can see how that's a positive feedback for accepting risk, and reasonable risk.

That being said, you know, when we launched 88 satellites, that's kind of putting a lot of eggs in one basket. And so, of course, we accepted that risk but we hedge it by buying insurance. There are ways that you make sure that these things aren't catastrophic for the organization.

I think that's the main thing, is you don't ever want to have an existential thing that's out of your control actually impact the viability of an organization. And so in space, we always want to launch more than we need so that we can basically degrade [as satellites go offline].

Army AL&T
Is there anywhere you would draw the line in terms of working with the government?

Schingler
Planet is a commercial organization. We see the federal market as the largest market in geospatial today. And so we definitely need to service that market by selling a commercial service to them. But that's very different from going inside the government and being a systems integrator or being a contractor.

Our reason for being is to bring global change to the enterprise and to bring geospatial into a workflow of business at the speed of business. That's how we've chosen to focus, and it's different from going inside to the government and being one custom solution for a very, very large, important problem. But the ecosystem is much larger than that. So we're purposefully selling the same thing to the federal government that we would sell to an agriculture company or to a financial data services company.

Army AL&T
You worked for the government, for NASA, for 10 years. What, if you were put in charge of NASA tomorrow, would you change?

Schingler
I would invest in small launch, number one. Number two is I would do procurement reform in order to allow for the government to be a good customer, rather than only seeing industry as being a contractor. And number three is I would have a portfolio of projects that allows for my creative engineers and younger engineers to prototype and integrate and invent new technologies for government-specific needs.

Army AL&T
Is there anything you would like to add?

Schingler
I actually want to highlight what this is going to mean for the Army mission. You guys have a global mission. And a lot of it is used to keep the peace. And many missions today are done with collaboration, with our allies. And one of the unique things that really comes out of this commercial space revolution, and coming up with these unclassified data sources, means that you could get data just as fast. The person in the field can get it and share it and collaborate with an allied partner at the same rate that the intelligence community gets it or that the strategic community gets it.

So this is a game changer. It allows for people to have fresh, unique information. It's unclassified and shareable, so you can come up with interesting and custom workflows. And it means that it speeds up the decision-making process. So the people on the ground will have greater situational awareness and understand what's about to happen probabilistically. So I really do encourage your leaders to take stock of the direction where this is going, because it really is going to, I think, change the day-to-day workflow of people in the field.

Michael Bold provides contract support to the U.S. Army Acquisition Support Center. He is a writer and editor for Network Runners Inc., with more than 30 years of editing experience at newspapers, including the McClatchy Washington Bureau, The Sacramento Bee, the San Jose Mercury News, the Dallas Morning News and the Fort Worth Star-Telegram. He holds a B.A. in journalism from the University of Missouri.

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INNOVATION FOR THE SPEED OF SPACE

A RUAG Space Focus

By Chrystal Morgan, Director of Communications, RUAG Space USA

Lower cost. Increased flexibility. Less lead time. These are more than just buzz words in today's space environment, these are goals that the industry is demanding, needing, running toward — and while changes in an already successful production process can seem intrusive, RUAG Space has actually found its niche in this element... a niche that addresses the crucial needs of commercial, as well as agency/government.

The company advances processes to bring customers to the forefront of the industry.

A prime example lies within the manufacturing of the firm's payload fairings. RUAG Space can boast a history of fairing production with a 100 percent mission success rate and has solidified its role as a global leader in carbon structures for launch vehicles.

In terms of reliability, RUAG has that covered. However, for our customers to continue to meet the demands of the industry, the company saw the need to push for more.

To that end, RUAG dove in, focusing efforts on making access to space more affordable — and the company became one of the pioneers in Out of Autoclave production.

In 2016, RUAG opened a new state-of-the-art production facility in Emmen, Switzerland. It was at this location that RUAG inaugurated the new process that used an industrial oven instead of an autoclave, allowing the massive carbon fiber components — which constitute one-half of a payload fairing's — to be economically produced in a single piece.

The ambient pressure of the oven hardens the composite structures, as opposed to the autoclave process of excess internal pressure.

The cost savings from such an industrial oven, enabled us to go bigger. A bigger oven means bigger pieces.

RUAG increases the performance of electronics products with COTS components. Image is courtesy of RUAG.

Non-destructive inspection machine. Photo is courtesy of RUAG Space.

Entire half-shell pieces can be cured at a time, eliminating costly and time consuming vertical integration of numerous shell elements. The new process reduces throughput time by 50 percent and enables RUAG to increase the delivery volume and sequence for payload fairings.

Other major elements in the process, such as laser-assisted layering, the completely automatic nondestructive testing and the ergonomic horizontal integration station all contribute to the new, leaner, faster, better process that RUAG Space is now known for completing.

RUAG's first Out of Autoclave fairing made its successful debut in June of 2017 on an Ariane launch — the Vega fairings flew next.

Meanwhile, in the U.S., RUAG was opening doors on their new facility in Decatur, Alabama, which was designed to replicate Emmen, but with even leaner process updates and boasts an even larger oven, with the ability to cure a fairing up to 8.5 meters in diameter.

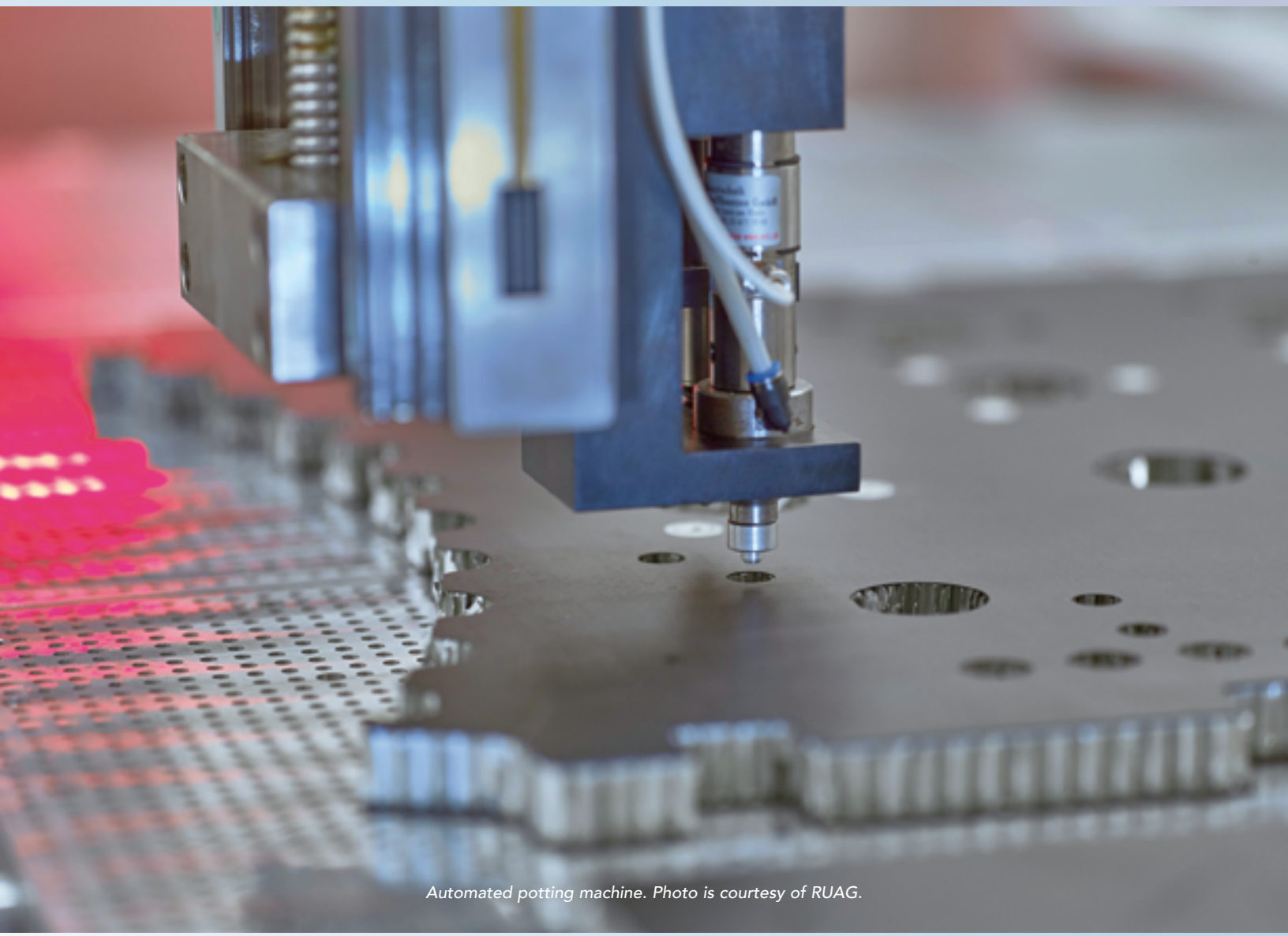
The ability to have these lean, Out of Autoclave processes on both sides of the ocean provides increased cost savings to the firm's customers, now in the U.S. as well as in Europe, and avoids costly transportation fees.

This is representative of RUAG's dedication to meeting new space demands and a willingness to be in close proximity to customers.

Just this month, as the 100th RUAG fairing on Ariane 5 is prepared to take flight, the first major milestone in the production of American made fairings is also underway.

The company's willingness to innovate and grow within the new space environment does not begin or end with fairing production advancements alone. The culture of RUAG Space, led by Chief Executive Officer *Peter Guggenbach*, extends to all product groups within RUAG Space.

Take, for example, the building blocks for on-board satellite and launcher computers. In an effort to meet the needs of the customer



Automated potting machine. Photo is courtesy of RUAG.

in terms of performance and cost, RUAG Space is making use of standard components for the design of these computers.

By using Commercial-Off-The-Shelf (COTS) electronic components and qualifying them for space — rather than expensive, specifically designed for space components — RUAG Space is bringing lower-cost options to the space industry. The use of COTS components generates 10 times the performance, reduces the lead time by a multiplier of 20 and costs 50 times less to build.

In terms of speed? The Automated Potting Machine (APM) that RUAG Space brings to the industry automates the process of insert placement into composite sandwich panels for satellites. With complex satellite sandwich panels that can require more than 800 inserts per piece, the original process could take as long as a month for completion.

This machine, along with RUAG's patented insert, can place as many as 15,000 inserts per day, reducing the lead time on satellite panel production down to one day. RUAG is about to install the second of these machines in the Titusville, Florida, facility.

This automated manufacturing process for satellite panels lowers throughput time, significantly reduces cost, and raises quality for our customers with precision insert placement. It also provides an increase in flexibility for customers to modify insert patterns later in the process, and lessens the need for compound glue additives. Less time, less weight, less money.

Examples can be found across all product groups of RUAG Space as to how innovative thinking and the improvement in processes is second nature to the company's culture. This is what enables the company to meet the demands of today's industry and what makes us RUAG Space.

www.ruag.com

Chrystal Morgan is the Director of Communications for RUAG Space USA. She has worked in the public, private, and education sectors in the field of Communications, most notably as Director of Research Communications for the University of Alabama Huntsville and at NASA's Marshall Space Flight Center in mission operations as a Payload Communicator.

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