SATCOM For Net-Centric Warfare — July / August 2016

MilsatMagazine

SOTM / COTM — Antennas — Protected Comms

Photo is courtesy of the US Army.

MilsatMagazine
July / August 2016

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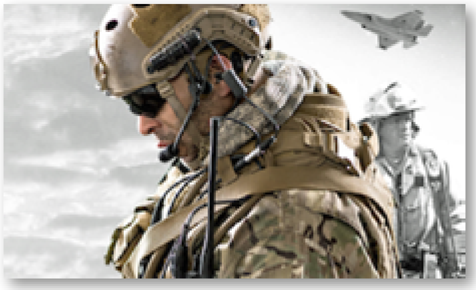
MilsatMagazine is published 11 times a year by SatNews Publishers, 800 Siesta Way, Sonoma, CA, 95476, USA, Phone: (707) 939-9306, Fax: (707) 939-9235

DISPATCHES

Triple Wins For Harris

First, a $1.7 billion contract has been won by Harris Communications for tactical radio solutions sales to overseas clients.



The contract was awarded by US Army Communications-Electronics Command and includes a wide range of radios and associated equipment and is part of the Foreign Military Sales program, which promotes coalition cooperation and interoperability. Included will be tactical communication networks and embedded high-grade encryption solutions that Harris' entire tactical communications offerings.

"*The contract highlights that Harris tactical communication solutions continue to meet the varied needs of our international customers,*" said Chris Young, president, Harris Communication Systems. "*The agreement will add to an already broad range of Harris communications products and services for international customers under the FMS program.*"

Harris then received a $15 million order to provide tactical radios, management systems, training and field support services to a nation in the Middle East as part of an ongoing modernization program.

This contract was awarded during the fourth quarter of Harris' 2016 fiscal year. Harris will provide Single Channel Ground and Airborne Radio System (SINCGARS) radios, which provide the secure voice communications backbone for ground forces in more than 30 countries, and SpearNet™ tactical radios, which enable high-throughput voice and data networking on and off the battlefield.

Then, to top all off, the company received a $27 million order to deliver maritime electronic warfare (EW) payloads for the U.S. Naval Research Laboratory's Advanced Decoy Architecture Project (ADAP) program.

This order was received during the fourth quarter of Harris' fiscal 2016 and is issued under a three-year, $54 million ceiling IDIQ contract received in September 2015.

The contract also includes testing and engineering services to help meet current and future EW mission requirements. The Harris-developed ADAP EW payloads represent an upgrade to the existing Nulka decoy, currently in service with the U.S. Navy, Coast Guard, Royal Australian Navy and Royal Canadian Navy.

"*Decoys are an essential layer of shipboard protection, often serving as the last line of electronic defense,*" said Ed Zoiss, president, Harris Electronic Systems. "*Harris ADAP payloads defeat the most sophisticated RF-guided anti-ship weapons with electronic techniques built upon decades of electronic warfare and countermeasure design experience.*"

harris.com

WelComE's To Continue For UK Armed Forces

More than 132,000 service personnel over the past 16 years have used Airbus Defence and Space' WelComE welfare program for the armed forces of the UK.

Now, the UK Ministry of Defence has renewed the WelComE contract to the tune of £15.7 million until August of 2022.

Delivering welfare communications within a number of operational environments, this service has evolved and has been expanded over the years from the provisioning of satellite phones and associated facilities to full WiFi services and video calling on operational bases.

With communication vital to UK forces deployed overseas, the service brings a sense of comfort to those away from home, according to Steve Kelly, the WelComE Service Manager at Airbus Defence and Space.

Adding his thoughts, Flight Lieutenant Tom Goble, who is the WelComE Service Owner, *"There is reassurance in knowing that wherever British forces are deployed across the globe, there is support in place to ensure a safe line of communication with friends and family at home."*

airbusdefenceandspace.com

Crucial Weather Data Uncertainty

The availability of critical weather data from National Oceanic and Atmospheric Administration's (NOAA) could face some challenges and uncertainties, as specified in a new report from the GOA that was published earlier this month.

As highlighted in the GAO report, the Joint Polar Satellite System (JPSS) program has continued to make progress in developing the JPSS-1 satellite for the scheduled March 2017 launch.

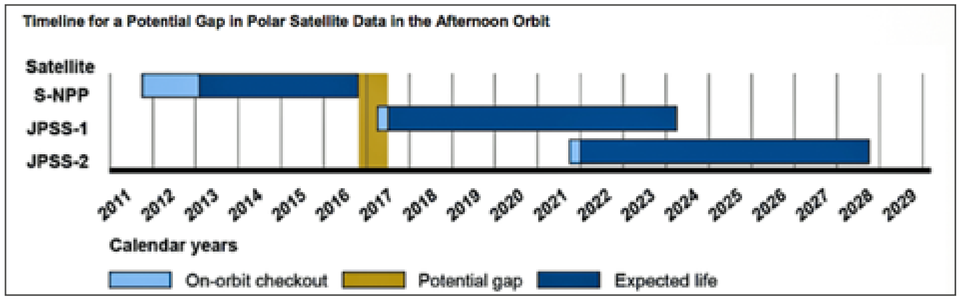
According to the GAO, however, the program has experienced some technical challenges which have resulted in interim milestone delays.

Additionally, NOAA faces the potential for a near-term gap in satellite coverage of eight months before the JPSS-1 satellite is launched and completes the post-launch testing (*see chart below*). NOAA has also started to plan for future polar satellites, but uncertainties remain on the best timing for the launch of those satellites.

This has occurred, in part, due to the potential for some already on orbit satellites to last longer than initially projected.

GAO reported in May 2016 that, although NOAA has established information security policies in key areas recommended by guidance, the JPSS program has not yet fully implemented them.

Specifically, while the program has implemented multiple relevant security controls, the implementation of almost half of the recommended security controls have not yet been fully implemented and the agency did not have all of the information needed when assessing security controls and has not addressed key vulnerabilities in a timely manner.



Source: GAO analysis based on National Oceanic and Atmospheric Administration and National Aeronautics and Space Administration data. | GAO-16-773T.

Note: The afternoon orbit is one of three primary polar orbits providing needed coverage for umerical weather models.

The GOA stated that NOAA did not provide sufficient evidence that the agency had evaluated the costs and benefits of launch scenarios for these new satellites based on updated life expectancies. Until this occurs, NOAA may not make the most efficient use of investments in the polar satellite program.

In the GAO draft report, NOAA published “fly-out charts” that depicted satellite timelines to support budget requests and appropriations discussions. The agency regularly updates their charts when key changes occur.

NOAA also has not consistently documented their justification for chart updates or depicted lifetimes for satellites beyond their design life and has not finalized a policy for updating those charts. As a result, the information NOAA provides Congress on the fly-out charts is not as accurate as such needs to be, which could result in less-than-optimal decisions.

Artistic rendition of the JPSS-1 satellite.

Furthermore, NOAA has experienced 10 key information security incidents related to the JPSS ground system, including incidents regarding unauthorized access to web servers and computers.

Until NOAA addresses these weaknesses, the JPSS ground system remains at high risk of compromise, said the GAO report.

NOAA is preparing to launch the second satellite in the JPSS program in March 2017, but a near-term gap in polar satellite coverage remains likely. Given the criticality of satellite data to weather forecasts and the potential impact of a satellite data gap, GAO added this area to its High-Risk List in 2013.

This statement addresses the status of the JPSS program and plans for future satellites, NOAA's efforts to depict and update satellite timelines as well as the JPSS program's implementation of key information security protections. This statement is based on a May 2016 report on JPSS and a draft report on satellite timelines. To develop the draft report, GAO reviewed agency procedures for updating satellite timelines, compared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timelines to best practices and agency documentation, and interviewed officials.

In the GAO's May 2016 report, they recommend that NOAA assess the costs and benefits of different launch decisions based on updated satellite life expectancies and address deficiencies in their information security program. NOAA concurred with these recommendations. GAO's draft report includes recommendations to NOAA to improve the accuracy, consistency, and documentation supporting updates to satellite timelines, and to revise and finalize its draft policy governing timeline updates.

The GOA report is currently at the Department of Commerce for comment.

Download and view the complete report in PDF format by accessing this direct link...

The Space Fence testing facility is representative of the larger Gallium Nitride (GaN)-based digital array radar system under construction on the Marshall Islands. This innovative system will transform the way the United States Air Force monitors thousands of orbital space objects. The photo is courtesy of Lockheed Martin.

Fence Building By Lockheed Martin

Off a busy suburban street near Philadelphia—and within sight of a popular shopping center—testing is underway for a system that will monitor hundreds of thousands of pieces of junk orbiting the Earth and threatening active satellites and the International Space Station.

The US Air Force's Space Fence marked a major accomplishment earlier this year after a scaled-down version of the end-item system recorded its first track of a satellite.

"*First track is major milestone for us and represents that we have a functioning radar*," said Bruce Schafhauser, Space Fence Program Director for Lockheed Martin. "*It's the first time the end-to-end radar loop is closed and we track real objects in space. The first track and the new test facility means we are one step closer to delivering a dramatic tenfold improvement in space situational awareness and orbital monitoring capability.*"

This is a critical mission. The space station crew has conducted at least 25 avoidance maneuvers to avoid space junk. Space junk traveling at speeds of nearly eight miles per second passed the station four times in 2015.

Long before Space Fence begins S-band radar tracking of objects from its site on a narrow island in the middle of the Pacific Ocean, Lockheed Martin engineers and US Air Force personnel are testing and training on a scaled-down version of the system from the comfort of New Jersey.

The test facility is used for early validation of hardware, firmware and software that will enable the Space Fence system to detect, track, and catalog orbital objects that facilitates the prediction and prevention of collisions in space.

The test site will also provide early lessons learned on installation of the S-band ground-based radar, support maintenance training and allow engineers to test verification procedures.

"***The main objective is to reduce risk of discovering something unexpected in the Marshall Islands—especially because we will be integrating a new radar system on a massive scale***," said Schafhauser. "***Some things as simple as mechanical fit or installation sequence will be much better understood before we arrive on island.***"

Air Force personnel are at the test facility running procedures as well, to prepare for formal acceptance testing the new system.

"*Our strong partnership with the Air Force leads to learning and discovery on both sides*," Schafhauser explained. "*The collaboration in the Moorestown facility drives great efficiencies before the installation and test commences on island.*"

Space Fence will replace the existing Air Force Space Surveillance System, or VHF Fence, which has been in service since the early 1960s.

Space Fence is a scalable solid-state S-band radar capable of detecting much smaller objects than the current system.

Space Fence system's accuracy and its persistent surveillance decreases orbital uncertainty to maintain custody of space objects and to alert operators of changes in the space environment.

By using an open-architecture system, Space Fence can adapt to future missions requiring various tracking and coverage approaches. The inherent flexibility of the digital array radar allows for tasking in deep space simultaneous with un-cued surveillance mission.

Construction continues at the six-acre Space Fence site 2,100 miles southwest of Honolulu. Forty-five hundred cubic yards of concrete now form the foundation of the sensor site and the start of vertical ring walls that will support the air inflated Kevlar roof that provides transparency to radio frequency (RF) transmissions.

The test facility will remain in place so that teams can provide long-term support after the system is operational on Kwajalein in 2018.

www.lockheedmartin.com/us/products/space-fence.html

AGC DataDoors

The Army Geospatial Center Imagery Office (AIO) functions as the US Army's commercial imagery acquisition agent and is designated as the repository of selected commercial satellite/aerial imagery and Advanced Geospatial Intelligence (AGI) data pertaining to terrain analysis and water resources operations.

Efficient management of the research, acquisition, and dissemination of imagery and imagery products is increasingly important as Army units expand their use of remotely sensed data.

With a small AIO team and a large customer base to support—which is ranging from the warfighters to the USACE (United States Army Corps of Engineers) Civil Works/Research community—it is critical that the team operates as efficiently as possible to fulfill their operational requirements.

The Army Geospatial Center (AGC) contracted i-cubed, a US subsidiary of Airbus Defense and Space, to establish the AGC DataDoors Commercial Image Library service providing an online search and discovery web application that allows authorized users to search their image library and extract geospatial data within their local work environments.

In addition to downloading data, streaming services are also provided for both AGC's high-resolution proprietary imagery as well as commercially licensed basemap content, including Airbus Defense and Space SPOTMaps imagery, through OGC compliant endpoints.

As a result, the AGC Commercial Imagery Archive was transformed from over 20,000 pieces of physical media to an online archive that today comprises over 45 TB of multi-sensor, multi-temporal imagery and terrain datasets, which are quality checked, organized and ingested for secure online access by over 1,100 users across more than 500 divisions.

In 2014, i-cubed teamed up with GeoNorth Inc to enhance the data management services provided to AGC.

With the additional DRS (Direct Receiving Station) capabilities, Airbus Defense and Space imagery archives can be accessed and supplemental imagery acquisitions and tasking requests can be made through the same DataDoors web application.

Support for rapid access to newly acquired imagery products (or AOI specific data) is supported through an automated ingest and cataloging service to facilitate distribution during time-sensitive events.

Benefits include...

- ***With DataDoors' geospatial data management and Airbus Defense and Space's streaming capabilities, multiple types of geospatial information can be sorted, ingested and hosted to be accessed anywhere, anytime on any device with an Internet connection***
- ***DataDoors enables organizations to easily share data across their entire organisation while controlling user access to individual datasets***
- ***Users can download data in the best format (GeoPDF, GeoTIFF and other formats) with the specific tiling and projection needed for their project***

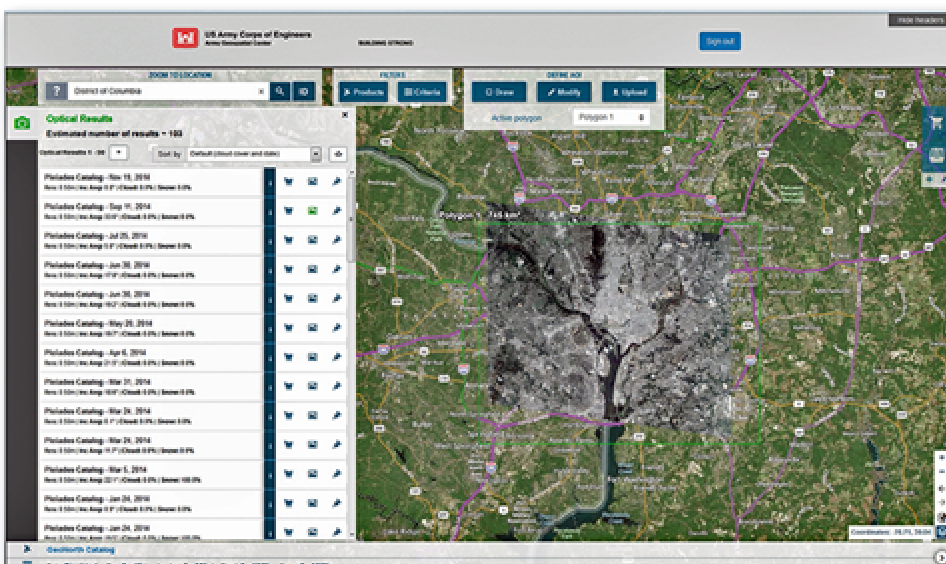


Image above shows a search query from the AGC DataDoors platform..

- ***DataDoors Portals provide a channel to obtain new acquisitions of Airbus Defense and Space optical products to fulfill customer requirements***

As a conclusion, Airbus Defense and Space's DataDoors Portal enables users to manage vast archives of imagery, terrain and map data from multiple vendors as well as their private collections, in one centralized location. This platform offers full control over data, user access rights, processing, data delivery and much more.

www.intelligence-airbusds.com/

IAI Debuts SATCOM Micro-Terminal

Israel Aerospace Industries (IAI) has revealed their compact Phased Array SATCOM for the ground soldiers.

The ELK-1882A "On-the-Move" (OTM) Personal SATCOM micro-terminal provides personal bi-directional voice and data communication for lower echelon ground combatants.

Designed by IAI's ELTA Group, the ELK-1882A micro-terminal comprises a phased array antenna, a Software Design Radio (SDR) module, and an energy module or battery-pack.

Operating in Ku-band via commercial geostationary communications satellites, the unit

complies with ITU spectrum density regulations and commercial communication satellite operator standards.

Optional applications include VOIP, telemetry, SMS, narrowband communication and relay capabilities, such as combat voice network SATCOM backhaul.

In today's dynamic battlefield enabling continuous OTM communication for lower echelon Special Forces and dismounted soldiers, as well as for platoon, company and battalion commanders is imperative.

Operations of independent small forces frequently take place in locations which are Beyond-Line-Of-Sight (BLOS).

At the present time, these fighting forces rely on either Line-of-Sight (LOS) systems which cannot provide continuous and reliable communications, or on mobile or static BLOS systems.

The micro-terminal BLOS OTM system enables the existing gap between legacy LOS tactical radios to be closed and allows for an extension of the current soldier communication network to OTM BLOS.

The system is designed for BLOS operations of either mounted or dismounted ground forces. In addition, the same phased array antenna technology is adapted to combat vehicles and airborne systems, using a conformal antenna system.

Mr. Nissim Hadas, IAI Executive VP & ELTA President, explained that the lack of adequate technical solutions has, up until now, impaired effective real-time sharing of information.

IAI believes that this solution and others of its type will propel land warrior networking capabilities into the 21st century.

iai.co.il/

1st CAP For Pennsylvania NG

The 103rd Attack Squadron of the Pennsylvania National Guard officially reached initial operational capability (IOC) with the recent launch of its first combat air patrol (CAP).

An MQ-Reaper remotely piloted aircraft performs aerial maneuvers. Photo by USAF —Senior Airman Cory D. Payne.

Of the people involved in the 103rd ATKS mission, almost all are Pennsylvania Air National Guardsmen, with the rest being civilian contractors that help maintain the mission systems.

"*With the launch of this first CAP, we can now consider our 103rd Attack Squadron and remotely-piloted aircraft mission operational,*" said the current Air Commander of the 111th Attack Wing Col. William Griffin. "*As National Guardsmen, we face some complications that [a regular] Air Force unit might not face; but, like standing up the unit, we will work through the obstacles and remain an efficient and effective force.*"

A CAP is the term for an individual RPA mission.

"*Basically, a CAP for intelligence surveillance and reconnaissance (ISR) or persistent attack and reconnaissance missions is one aircraft overlooking one area for a specific time period,*" said Col. Michael Shenk, the 111th Attack Wing Operations Group commander. "*My confidence is high that we'll be performing a successful MQ-9 Reaper operation. I'm excited for the Wing and the operations group to be able to finally stop preparing to execute a mission and actually execute the mission.*"

Fulfilling air operations from Horsham AGS again has been a long-awaited function for many of the Air National Guardsmen here.

The installation endured a Base Realignment and Closure that saw the departure of the last A-10 Thunderbolt IIs in 2010. In 2013, the 103rd ATKS received word of their new mission.

Little more than three years later, the 111th Attack Wing is now home to MQ-9 pilots, sensor operators and intelligence coordinators who control the remotely piloted aircraft, as well as a full complement of professional Airman that support the mission.

Launched from austere locations by deployed units, control of the aircraft is then handed over via satellite to the 103rd ATKS.

The missions—whether they are surveillance, reconnaissance, attack or a blend of the three—all occur in overseas airspace.

A vast majority of the time, the Air Force's RPA fleet is used for ISR, not for strike activity.

Upon mission completion, the aircraft is commonly handed back over to the launch and recovery element pilot for landing, refueling, rearming and maintenance.

Not only is the operation of a remotely-piloted aircraft, like the MQ-9, a team effort, so was building the unit that handles the controls.

"*We started off with one person; and we grew an organization that built itself up with the help of most, if not all, of the units on base*," said Shenk. "*Every person on base has had some hand in this.*"

He stated that the 111th Communications Squadron and the 270th Engineering Installation Squadron here proved especially invaluable in realizing the mission.

"*The 270th EIS was selected to lead other RPA units as they convert or stand up*," Shenk said. "*If we'd had any other organization working on our infrastructure aside from the 270th, I don't think we'd be where we are today.*

"T*he 111th Attack Wing Communications Flight superintendent and his team have just knocked it out as far the requirements for communications. Again, I feel if we didn't have the team we do, we wouldn't be where we are today.*"

Shenk also noted that the National Guard Bureau was instrumental in assisting with helping the unit obtain necessary resources.

However, with the excitement of a new beginning comes unfamiliar and unforeseen challenges to tackle.

"*The operations group, specifically the 103rd Attack Squadron, has always been the flying arm of the wing*," said Griffin. "*That arm was chopped off with the BRAC and now it's back--and that's big.*

"Standing up this mission is significant for us and the Air National Guard for many reasons. Not only is the RPA mission considerable in itself, it also brings new dynamics, issues and concerns that we'd never faced before. As a wing, we're going to have to preserve the ability to remain flexible, anticipate barriers and work together to provide sustained air power to the combatant commanders."

Story by Tech. Sgt. Andria Allmond,
Joint Force Headquarters,
Pennsylvania National Guard
111th Attack Wing.

Positive Progress For OCX

Two years behind schedule and costing double the original estimate at $3.6 billion, there is finally some good news for the US Air Force in regard to the Raytheon project for the GPS ground station, OCX—during a recent quarterly review, Raytheon was determined to have made positive progress on the OCX program.

The accuracy of the PNT (Position, Navigation and Timing) signal is supposed to be doubled for OCX when implemented.
Additionally, the incorporation of cybersecurity systems against internal and external attacks and communications with all US satellites is expected.

There was a question as to whether or not Raytheon would be authorized to continue their work due to needed performance improvements by that company, especially when a Nunn-Mccurdy breach occurred due to excessive program cost overruns.

Earlier this year, in order to develop interim solutions for the system, Lockheed Martin received a $96 million award to engage in such work.

The reason for this action was that there was the distinct possibility that at least three GPS III satellites could launch before the ground station system was ready for activation. If this was not undertaken, the advanced capabilities of the satellites would be unavailable for users.

A determination was made that, in spite of the challenges faced by Raytheon, there was no "reasonable alternative" for OCX, so the program was not canceled and the USAF decided to continue the project with the company.

Software automation development, the deployment of the platform, and a significant improvement in the software resulted in program rehabilitation, according to Raytheon.

Expect continued pressure by the US Air Force and the budget folk in Congress on Raytheon to move the OCX project along with, hopefully, no negative quarterly reviews to impede the final implementation.

www.raytheon.com/capabilities/products/gps_ocx/

45th Space Wing Does It Again

The US Air Force's 45th Space Wing has, once again, proven their mettle as they successfully supported the SpaceX Falcon 9 ABS/Eutelsat-2 launch June 15, 2016, at 10:29 a.m. ET from Launch Complex 40 Cape Canaveral Air Force Station, Florida.

A combined team of military, government civilians and contractors from across the 45th Space Wing supported the mission with weather forecasts, launch and range operations, security, safety and public affairs.

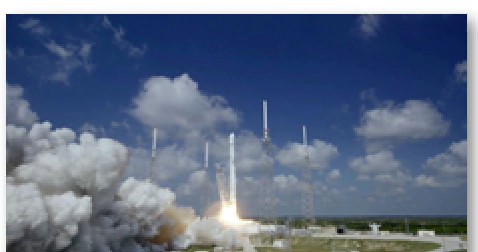


Photo is courtesy of SpaceX.

The wing also provided their vast network of radar, telemetry and communications instrumentation to facilitate a safe launch on the Eastern Range.

www.patrick.af.mil/

GPS Constellation Completed

A United Launch Alliance (ULA) Atlas V rocket successfully launched the MUOS-5 satellite for the US Navy, with the rocket lifting off from Space Launch Complex-41 on June 24 at 10:30 a.m. EDT.

MUOS-5 launch photo is courtesy of United Launch Alliance.

MUOS-5 is the final satellite in the five-satellite constellation, which provides warfighters with significantly improved and assured communications worldwide.

"*We are honored to deliver the final satellite in the MUOS constellation for the US Navy,*" said Laura Maginnis, ULA vice president, Custom Services.

"*Congratulations to our navy, air force and Lockheed Martin mission partners on yet another successful launch that provides our warfighters with enhanced communications capabilities to safely and effectively conduct their missions around the globe.*"

The mission was ULA's fifth launch in 2016 and 108th launch since the company formed in 2006.

That launch is scheduled for July 28 from Space Launch Complex-41 at Cape Canaveral Air Force Station, Florida.

The EELV program was established by the US Air Force to provide assured access to space for Department of Defense and other government payloads.

The commercially developed EELV program supports the full range of government mission requirements, while delivering on schedule and providing significant cost savings over the heritage launch systems.

www.ulalaunch.com

MUOS-5 was the seventh mission to be launched aboard an Atlas V Evolved Expendable Launch Vehicle (EELV) 551 configuration vehicle, which includes a 5 meter diameter payload fairing and five solid rocket boosters.

The Atlas booster for this mission was powered by the RD AMROSS RD-180 engine and the Centaur upper stage was powered by the Aerojet Rocketdyne RL10C-1 engine.

"*I am so proud of the team for all their hard work and commitment to 100 percent mission success,*" Maginnis said. "*It is amazing to deliver our second national security payload from the Cape in just two weeks. I know this success is due to our amazing people who make the remarkable look routine.*"

ULA's next launch is the Atlas V NROL-61 mission for the National Reconnaissance Office.

UTC Aerospace Has A Commitment

Designed to Fix, Track and Assess targets though unit agility and multiple sensing modalities, as well as through the use of broad area search capabilities, UTC Aerospace Systems' MS-177 multi-spectral imaging (MSI) and long-range ISR sensor has won over Northrop Grumman.

Photo of the Global Hawk UAS is courtesy of Northrop Grumman.

A contract has been awarded to the firm that will support the integration and testing of the MS-177 onto the RQ-4B Global Hawk Unmanned Aircraft System (UAS).

The enhancements made to the MS-177 sensor system include a gimbaled optical design, a wide area search mode and a motion imagery mode. These enhancements allow the MS-177 sensor system to collect greater than six-times more area coverage per hour than the current SYERS-2B sensor operating on the U2 platform. MS-177 also has the ability to continuously track a target without having to change the flight path of the UAS.

UTC Aerospace Systems, a unit of United Technologies Corp. was awarded a contract to support the integration and testing of the MS-177 multi-spectral imaging (MSI) and long-range intelligence, surveillance and reconnaissance (ISR) sensor onto the Northrop Grumman RQ-4B Global Hawk Unmanned Aircraft System (UAS).

Adding the MS-177 system to the Global Hawk is part of the US Air Force's planned modernization activities for the platform.

Kevin Raftery, Vice President, ISR, UTC Aerospace Systems, commented that over the past three years, his firm has enhanced the MS-177 sensor system with advanced technology to provides US combatant commanders with unmatched imaging, detailed surveillance and actionable intelligence.

www.utc.com

www.northropgrumman.com

Expanded European RPA Ops

Expanding RPA operations within European airspace is the focus of a new agreement between General Atomics Aeronautical Systems, Inc. (GA ASI) and the NLR-Netherlands Aerospace Center—the result will be to support expanded ops approval for the former firm's RPAs to fly in the aforementioned airspace.

NLR happens to be one of the world's leading experts on the global Air Traffic Management (ATM) system, with particular experience in Europe. GA-ASI will continue to leverage NLR's full air traffic control simulation facility and more than 15 years of experience in RPA systems to help solve the critical questions surrounding the safe and efficient integration of RPA into non-segregated airspace, as the Predator B RPA is currently permitted to operate in segregated airspace..

While Predator B is currently operational in segregated airspace in Europe, this collaboration is intended to expand operations into non-segregated airspace.

Starting in 2012, GA-ASI embarked on a company-funded project to produce a STANAG 4671-complaint configuration of the Predator B MALE UAS. This NATO standard defines a basis for UAS airworthiness certification which is compatible with civil airspace operations in the member countries. The initial flight of the "certifiable" Predator B configuration will occur in 2016.

www.ga-asi.com/

www.nlr.org/

In Case It Gets "Real"...

As a culture, communications are everywhere—cell phones, email and radios are used by members of the armed forces every day without ever having to worry about them... but what would occur if these communication devices suddenly were not available anymore? What happens when disaster strikes and we lose the ability to talk to one another

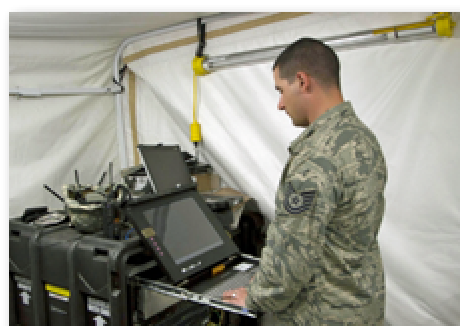
This is the type of situation the Quartermaster Liquid Logistics Exercise prepares all to face.

More than 700 Army Reserve Soldiers are taking part in QLLEX at Fort A.P. Hill, Virginia, this year.

This training exercise is will train troops on how to conduct the major aspects of aide civilian authorities to include water purification, establishment and sustainment of communications as well as fuel and water distribution.

"*We are sent to areas that have been devastated, areas where there is no power or communications, and we're able to set up equipment and immediately have communications that reach up to 40 miles from our location*," said Air Force Tech Sgt. Gregory Mackel, a cyber operations technician with the 910th Communications Squadron out of Youngstown, Ohio.

"*We provide the Joint Incident Site Communications capability which is designed for natural disaster response within the 48 continental United States*," Mackel said.



Tech Sgt. Gregory Mackel, Cyber Operations Technician from the 910th Communications Squadron out of Youngstown, Ohio, reviews information during the Quartermaster Liquid Logistics Exercise 2016. Hailing from Johnstown, Pennsylvania, Mackel is part of an Air Force Reserve group that is providing communications support for the exercise. US Army photo by Sgt. James Bradford, 372nd Mobile Public Affairs Detachment.

The World's
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In previous years, if there was a natural disaster in the US, the National Guard would be activated by the state and possibly the surrounding states in which the incident occurred.

Then, in 2012, the National Defense Authorization Act was passed, which allows for a state government to activate Reserve Soldiers for assistance with civil authorities.

"*Our job is to connect two agencies together*," Mackel explained. "*We act as an interconnecting agency. The civilian agency provides us with a radio, and we take a military radio, and we can cross band them and communicate together.*"

Communications capability during an exercise or a national emergency can use a large amount of bandwidth which puts strain on a network.

"*To have the Air Force come in and provide added signal is invaluable to our mission*," said Chief Warrant Officer Nicholas Chadwick, officer in charge of communications for QLLEX.

"*Without their added support, I don't think we'd be adequately prepared to deal with the bandwidth constraints or worst case, the network going down on our side*," said Chadwick, who is with the 316th Expeditionary Support Command, Coraopolis, Pennsylvania.

Chadwick went on to explain that redundancy in signal, which is providing the same service at the same time, creates a contingency.

"*The support they bring adds a level of redundancy so that if we have issues with our signal, we can switch over to theirs or vice versa*," said Chadwick. "*If radio signal goes down, we can use their cell phone signal.*"

Communication in a time of crisis is a necessity. Crises such as Hurricanes Katrina and Rita in 2005 and Hurricane Sandy in 2012 caused massive destruction. Hurricane Sandy was the first time Reserve Soldiers were called up to respond to a natural disaster.

"*Once we reach a destination, we have a two-hour time window to be fully operational*," said Mackel. "*We use a six-person team to build our operation from the ground up.*"

"*We carry our own shelter and generators with us, so we could essentially be operational indefinitely*," Mackel said. "*We can stay for the long haul if needed or until a larger provider can come in for assistance.*"

Services provided at QLLEX include data transfer, radio communications, video teleconferencing, and commercial and Department of Defense Internet capabilities.

Military Reserve forces have training that must be conducted monthly to maintain proficiency in a troop's occupational specialty. This training allows units to maintain their readiness to be activated.

"*We do training where we activate our satellite connection every month to ensure everything is up to date and working fine*," explained Mackel.

"*The Air Force Reserve Command has six of our units, so if they are spread out appropriately they can all be linked together and create a fully meshed network within a very short period of time*," said Mackel.

Chadwick explained that the Air Force "*has capabilities the Army just doesn't have, so to bring them into this exercise makes them a great combat multiplier.*"

"*We were short on signal assets as is, and we are in two geographically distant areas*," Chadwick said. "*They brought the ability to have video teleconferencing in the field, which is very impressive in itself.*"

Chadwick explained that having the extra assistance also helps significantly in reporting to leaders. "*They get to see how the Army operates, and we get to see how they operate.*"

Story by Spc. James Bradford
372nd Mobile Public Affairs Detachment,
US Army

Warsaw NATO Summit "Show & Tell"

At this year's Warsaw NATO Summit Airbus Defence and Space brought along something to share—their newly developed Mobile General Ground Station (MGGS).

The heads of state and senior NATO and national officials got a good look at the MGGS as well as an explanation as to its capabilities that will offer surveillance, intelligence and reconnaissance over wide areas.

Airbus Defence and Space's newly developed Mobile General Ground Station (MGGS).

Apparently the presentation went well, as NATO has ordered a total of six MGGS units, which will be delivered to its Main Operating Base in Sigonella on the island of Sicily, Italy, and the first one will reach the base at the end of July. From there, the stations can be redeployed to NATO operating units worldwide as and when required.

Col. Pedro Renn, NATO AGS Force Commander explained, "*AGS is the first NATO owned-and-operated ground surveillance system, using state-of-the-art sensors and information knowledge management systems. AGS will be available to all Alliance members and will be a key capability for Alliance strategic anticipation.*"

MGGS is the mobile deployable part of the AGS core, that can be integrated into shelters and easily transported, enables the processing and management of the radar images received, and the communication component ensures the distribution of Intelligence, Surveillance and Reconnaissance data to forward-deployed users, regardless of location or communications infrastructure in-the-field.

The radar images will be acquired by the Global Hawk remotely piloted aircraft and received via a direct or satellite broadband connection.

Additionally, data from all interoperable C2ISR (Command, Control, Intelligence, Surveillance and Reconnaissance) systems operated by NATO and its member states can be received and evaluated.

The exploitation results will provide information about stationary and moving objects on the ground to the local unit's commander and can be distributed as well within NATO forces.

Bernhard Brenner, Head of Intelligence Business Cluster at Airbus Defence and Space, added,"*We are very proud to*

contribute to the AGS program with our knowledge and experience in Intelligence and Surveillance. Almost two hundred engineers and eleven industrial partners from seven nations have supported the development and production of the Mobile General Ground Station. MGGS will provide near-real-time information about stationary and moving ground objects to commanders and troops all over the world to serve as a valuable input for actionable intelligence."

The AGS industrial team, led by Northrop Grumman, includes Airbus Defence and Space, Leonardo and Kongsberg, as well as leading defence companies from the participating nations. The AGS system comprises five remotely piloted aircrafts developed and produced by Northrop Grumman as well as mobile and transportable ground segments developed and produced by Airbus Defence and Space and Leonardo.

airbusdefenceandspace.com

Tracking 36 Years Of NRL Success

In 1941, the National Bureau of Standards (NBS) leased the southern portion of Cedar Point Neck, located in southern Maryland, from the Catholic Church for fuze and ordnance testing.

Originally known as the Blossom Point Proving Ground, the facility was renamed the Diamond Ordnance Fuze Laboratory Test Area after the NBS Ordnance Development Division was transferred to the Department of the Army in 1953.

Developed by NRL to track the Vanguard satellite, Minitrack (Minimum Trackable Satellite) incorporated the Naval Research Laboratory's (NRL) phase-comparison and angle-tracking techniques and utilized a series of fan-shaped vertical antenna beams forming a "fence."

The antennas are seen as rectangular-shaped objects on the field. The system is comprised a chain of stations extending from Blossom Point, Maryland, to Santiago, Chile, with additional stations at San Diego, California, Australia and South Africa.

Minitrack at Blossom Point—Photo courtesy of US Naval Research Laboratory.

The data collected by these stations, telemetered from the Vanguard satellite, were transmitted to NRL's Control Center in Washington, D.C.

In May 1956, the Department of the Navy (DoN) was granted a permit to use 23 acres of the Army facility for project Vanguard—a program initiated to represent the United States in the International Geophysical Year (IGY) and the first American satellite program—as a communications tracking station for satellites.

Located 35 miles south of Washington, D.C., the site was selected based primarily on its isolation from noise and electronic interference, and was named the Naval Research Laboratory (NRL) Cedar Point Neck Site, Blossom Point Research Facility.

By July 1956, the Blossom Point station went into operation and was soon employed as training and testing headquarters for the first satellite tracking system, the 'Minimum Trackable Satellite,' or Minitrack, based on a proposal by NRL researchers John T. Mengel and Roger L. Easton, whom had also co-authored the project Vanguard proposal with NRL electronics engineer, Milton W. Rosen.

The Minitrack system, based on a ground array of antennas with fan-shaped beams making arcs of 100 degrees in the north-south direction and 10 degrees in the east-west direction eventually was comprised of 14 stations, including Blossom Point, each positioned along the 75th meridian, to create a radar 'fence.'

In October 1957 the Minitrack receivers were quickly modified to track the first man-made orbiting satellite, Sputnik I, launched by the Soviet Union, making NRL the first to demonstrate the feasibility of a radio detection and tracking system for Earth-orbiting non-radiating [dark] satellites.

The Blossom Point Tracking Facility (BPTF) campus, located 35 miles south of Washington, D.C., consists of a satellite mission operations center, multiple antennas, and an existing infrastructure capable of providing space system command, control, and management for all customer classes. The facility, operated by the US Naval Research Laboratory, is in continuous 24 hour, 7 day operation and at present supports numerous on-orbit spacecraft. Photo is courtesy of NRL, Jamie Hartman.

Located in southern Maryland, the US Naval Research Laboratory Blossom Point Tracking Facility is a 42-acre complex with a pool of antennas ranging from 6.1 to 13 meters. The station is in continuous operation 24 hours a day. Photo is courtesy of NRL.

The Vanguard I satellite was later successfully launched into orbit, March 17, 1958, and although not the first US satellite launched into orbit, the craft remains the oldest still orbiting Earth.

Based on the results obtained from Blossom Point, NRL proposed a satellite-surveillance system for the United States, and was responsible for the development of the world's first space surveillance (SPASUR) system to detect and track all types of Earth-orbiting satellites, space vehicles, and other orbital objects/debris.

Sixty years later, the site is known today as the Blossom Point Tracking Facility (BPTF) and has undergone a series of evolutions that have culminated in it becoming a state-of-the-art command and control facility, capable of supporting "launch through end-of-mission life" operations.

The foundation for this broad range of capabilities is the NRL-developed and government owned, Neptune Common Ground Architecture (CGA) software system.

Neptune/CGA is government off-the-shelf (GOTS) software developed by NRL to provide a command and control software suite capable of spaceflight support services for automated testing and qualification of space flight articles; intelligent automation of on-orbit assets with minimal staffing or in 'lights-out' operation; contact execution and pre-defined autonomous anomaly response and configuration; monitoring and reporting of the space and ground status and tracking, telemetry, and operation and control of satellites; receiving satellite data transmissions; and monitoring satellite health and data quality.

NRL has optimized the hardware and software architectures over many years to maximize flexibility in integrating new spacecraft programs and ground systems with minimal financial and time impacts.

To date, Neptune/CGA has contributed to the successful launch and mission operations of more than 25 satellite systems that comprise more than 80 different spacecraft.

Today, the BPTF 42-acre campus consists of a satellite mission operations center, multiple antennas, and an existing infrastructure capable of providing space system command, control, and management for all customer classes in every orbit regime.

The facility is in continuous operation 24 hours a day, 7 days per week, and at present supports numerous on-orbit spacecraft.

BPTF provides engineering and operational support to several complex space systems for the Navy and other users, enabling cost-effective solutions for all programs.

The tracking facility provides direct line-of-sight, two-way communications services with spacecraft in multiple bands during all mission phases, including concept, mission, and space segment development, launch, early on-orbit operations, and mission data collection. Additionally, BPTF's capabilities allow coverage through connectivity to worldwide ground station networks.

There are currently 11 satellite antennas supporting every orbit regime. Power is supplied by two uninterruptable power supplies (UPSs) rated at 125 kilowatts (kW). Emergency power is supplied by a set of redundant emergency generators rated at 1 MegaWatt (MW).

The entire system is operated by computers 24 hours every day.

nrl.navy.mil/

Disputed Border To Rely On GPS

More than 8,000 boundary pillars at the Nepal-India border will institute an internationally accepted positioning system using Global Navigation Satellite.

The third meeting of the Nepal-India Boundary Working Group (BWG) at surveyor general level, which concluded in Nepal on Saturday, decided to install the 8,553 border pillars with the Boundary Global Navigation Satellite System, read a statement that was issued by the Nepali government. The GPS system will help finding the location, longitude, height and all positioning of the pillars.

Nepal remains adamant that no map agreement with India will be signed until the Susta and Kalapani differences are resolved.

Nepal and India have erected a total of 8,553 pillars along the border, of which 1,325 are missing and 1,956 damaged. The Boundary Working Group is responsible for the construction, restoration and repair of border pillars, including the clearing of the no-man's land. The mechanism is not mandated to resolve a boundary row in Susta and Kalapani, the most disputed border areas between Nepal and India.

The Boundary Working Group reviewed reports submitted by the Survey Official Committee and Joint Field Survey Teams (FST). Nepal and India in 2014 agreed to settle the boundary row within three years in addition to Susta and Kalapani.

Officials from both the sides have already prepared and agreed 182-sheet strip maps of the boundary through the GPS but have not signed the protocol due to Nepal's denial. The Nepali side said it will not sign the maps until the boundary row in Susta and Kalapani is resolved.

Two technical committees—SOC and FST—reports to the BWG about the repairing, maintenance and the upgrades to the pillars and encroachment on the no-man's land from both the sides. The meeting also finalized the target and schedule for the next field season and decided to prioritize the completion of the backlogged tasks from previous field seasons.

Both sides have emphasized the importance of making local authorities and people living along the border aware of the field work being conducted by the joint teams, said the statement.

Work on settling the boundary disputes was stalled after 2007, but strip maps were prepared, except for Kalapani and Susta.

During Prime Minister Narendra Modi's Nepal visit in 2014, the two sides agreed to expedite efforts to sort out the differences. Then Nepali Prime Minister Sushil Koirala and Modi agreed to direct their foreign secretaries to continue working on the issue of Kalapani and Sustna.

However, there have been no substantial talks between the foreign secretaries. The Indian side has been pressing for early signing of the "agreed and initiated strip maps."

India says that talks on Susta and Kalapani could be continued after signing agreed upon documents. Nepal, however, maintains that all the issues should be resolved together.

Wargames Set In The Year 2026

Recently, US Air Force Space Command started their tenth Schriever Wargame at Maxwell AFB, Montgomery, Alabama.

The Schriever Wargame, set in the year 2026, will explore critical space issues and investigate the integration activities of multiple agencies associated with space systems and services.

The objectives of SW 16 centered on identifying ways to increase the resilience of space that includes our intelligence community, civil, commercial and Allied partners; explored how to provide optimized effects to the warfighter in support of coalition operations; and examined how to apply future capabilities to protect the space enterprise in a multi-domain conflict.

The SW 16 scenario depicted a peer space and cyberspace competitor seeking to achieve strategic goals by exploiting those domains. Scenarios focused on the European Command Area of Responsibility.

They also included a full spectrum of threats across diverse operating environments to challenge civilian and military leaders, planners and space system operators, as well as the capabilities they employ.

The Schriever Wargame team conducted SW 16 on behalf of Air Force Space Command, headquartered in Colorado Springs, Colorado.

Approximately 200 military and civilian experts from more than 27 commands and agencies around the country participated in the Wargame.

US commands and agencies that participated in SW 2016 included:

- *Air Force Space Command*
- *Army Space and Missile Defense Command*
- *Naval Fleet Cyber Command*
- *National Reconnaissance Office*
- *Executive Agent for Space Staff, Air Combat Command*
- *Office of the Secretary of Defense*
- *US European Command*
- *US Strategic Command*
- *Defense Information Systems Agency*
- *Intelligence Community*
- *National Aeronautics and Space Administration*
- *Office of Homeland Security, Department of Transportation*
- *Department of State*
- *Department of Commerce.*

www.afspc.af.mil/

Advantech's New Mil-Grade Modem

Advantech Wireless has rolled out a new AMT-83L advanced satellite modem for the military.

These new military-grade satellite modems from Advantech Wireless continue the line of the AMT-73L, the first worldwide satellite modem to be certified with MIL-STD-188-165A by DISA. These modems were designed to fulfil two-way satellite gateway communication requirements in Defense Satellite Communications Systems (DSCS).

Several thousand units have been deployed in the field on tactical terminals and gateway sites.

Based on Advantech Wireless' Software Defined Radio architecture, the new AMT-83L satellite modem adds a number of advanced features to the DISA certified AMT-73L series. Among these new features there are DVB-S2 with LDPC Coding and Adaptive Coding and Modulation (ACM), IP data interface, GSE encapsulation, Direct Sequence Spread Spectrum (DSSS) spreading and AES 128/256 Encryption.

"The new AMT-83L satellite modem offers advanced and efficient DVB-S2 modulation and error corrections codes full-fledged IP traffic with a built in router, and GSE encapsulation. Equally as important to our tactical and aviation customers, this series of modems supports SATCOM-on-the-move (SOTM) mobility applications with the Direct Sequence Spread Spectrum (DSSS) capability," said Cristi Damian, VP Business Development at Advantech Wireless.

advantechwireless.com

The HPA Corner: Leveraging Commercial Space Capablities

By David Anhalt, Vice President & General Manager, Iridium PRIME, Iridium Satellite

Congressman Jim Bridenstine (R-OK) formally introduced his landmark American Space Renaissance Act (ASRA) to a packed audience at the National Space Symposium in early April, saying, "This is a comprehensive bill, because ensuring that America is the preeminent spacefaring nation requires a holistic approach to the entire American space enterprise."

The national security objectives in this sweeping policy bill are threefold:

- *Build more resilient architectures*
- *Integrate the space enterprise*
- *Leverage commercial solutions*

Five weeks later, the House of Representatives incorporated ten provisions from the ASRA into the National Defense Authorization Act. On the morning after this achievement, the author and sponsor of the ASRA bill, Bridenstine, asked industry on a Wednesday in mid-May to identify the obstacles—cultural as well as procedural—that prevent more efficient use of commercially leveraged solutions to serve government capabilities with greater resilience. Congressman Bridenstine intends to introduce new provisions to future versions of the ASRA to mitigate those obstacles.

This column's question for HPA Members is... ***What additional issues should future ASRA provisions address to leverage commercial solutions such as hosted payloads? What additional provisions to the ASRA will enable the USG to purposefully and deliberately leverage the abundant strength of the commercial space industry to enhance operational missions?***

"I see two significant obstacles that have held back more widespread use of hosted payloads and commercial solutions for government missions. First is the long and complicated process used to consider each architecture change before acceptance.

"It is unfortunate that any individual along this process can derail or entirely stop what might have been an innovative solution. Perhaps a streamlined process might help government take advantage of the benefits that commercial industry can provide.

"The second obstacle deterring the government's use of commercially leveraged solutions is risk. Risk is a crucial step on the road to innovation, and we must encourage the decision makers within our government and space community to embrace opportunities that have a favorable chance at providing a positive outcome.

"NASA became great because it took some of the nation's most audacious risks: sending mankind to the moon, the space shuttle program, the International Space Station, and the first exploration missions of our solar system—and beyond. The US military shares the same heritage, where carefully measured risks are taken in the name of progress, national security and defense.

"For hosted payloads and other commercially leveraged solutions to become more widely accepted, the space community must welcome innovation, and take carefully measured risks for progress' sake."—**Al Tadros**, HPA Chair and Vice President of Business Development, ***SSL***

"Different budget 'scoring' rules would enable longer term leasing space services. These revisions also could facilitate opportunities for DoD to take advantage of long-term hosted payload capabilities that could improve resiliency, responsiveness, and capability.

"Even in a more favorable budget environment, paying the full cost in a single year for services that would be used over many years would be challenging. In today's conditions, it's impossible.

"The Federal Acquisition Regulations (FAR) must change for DoD to use commercial space capabilities and services. The acquisition and oversight bureaucracies are trained to be conservative when it comes to protecting the taxpayers and warfighters.

"Changing the FAR will allow for new ways of doing business and signal to DoD that the existing order of things can and must change. That's what 'renaissance' is about!"—**Gil Klinger**, Vice President, National Security Future Architectures, Space and Intelligence Systems, ***Harris Corporation.***

For additional information regarding the HPA, please visit ***www.hostedpayloadalliance.org/***

The Anik G1 satellite, built by SSL for Telesat Canada, is a Fixed Satellite Services (FSS) multi-mission C-band and Ku-band GEO spacecraft designed to support a variety of applications. Anik G1 carries an X-band government communications payload with coverage over the Americas and the Pacific. Photo is courtesy of SSL.


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NECESSITY IS THE MOTHER OF INVENTION...

By Paul Seguin, Senior Technical Advisor, C-COM Satellite Systems

Apparently the source of this well-known phrase is open to conjecture—some say the statement came from Plato, some indicate this an old English saying (*"Need taught him wit,"*)... Wherever the phrase originated, this is most definitely a true adage for the Satellite Antenna world.

The vast majority of the developments over the years have been driven by a need, a need to get online faster, a need to push more data, a need for cheaper bandwidth and now a need to operate within a moving vehicle.

In the early years, the only option for satellite communication was large fixed antennas using C-band carriers. While this worked well, the size of the antennas made for difficult use in a 'field' environment.

Power levels on C-band satellites were quite low, which required transmitters (BUCs) to be quite large. In turn, the higher power output meant the power supply needed to produce more power and, in a portable environment, a larger generator was required.

Trying to use the large C-band reflectors in a mobile application was a challenge, as the reflector size was, in some cases, larger than the vehicle itself. That necessity created the advent of foldable wings, whereby the edge of the antenna would fold in to allow the reflector to fit within the width of the supporting vehicle.

These systems were motorized in some cases, but needed to be pointed by hand by an operator. This solution worked well but still required a large vehicle, a large power supply and a technically trained person for operation. Once the world tasted communication from the field, a more portable solution was requested.

The necessity for more bandwidth on one satellite produced the advent of the Ku-band, which offered users several benefits. Ku-band meant smaller reflectors were needed to provide the same, or better, bandwidth. Additionally, less power was required on the transmitter and that translated into less power being needed from the generator.

Smaller reflectors also provided for an easier alignment as the beam width was much larger and, therefore, the ability to locate the satellite manually became much easier. This development would change the

landscape of the field environment and large C-band systems were slowly replaced with smaller Ku-band solutions.

Due to the larger capacity on the Ku-band transponders, the availability of Ku-band bandwidth was greater than the 'always in short supply' C-band. A typical C-Band transponder offered in the range of 24MB of bandwidth, whereas a Ku-band transponder offered 54MB. As new satellites were deployed and older units replaced, the amount of Ku-band bandwidth became greater and was available far more readily.

The question of security was also addressed in the then, new, Ku-band environment. As new Ku-band modems hit the market, security was bolstered with the inclusion of DES Encryption as a standard for the data which was being transmitted up to, and down from, the satellite. In some modems, that security could be augmented to include FIPS level of encryption. This provided a secure method of communications and a level of confidence that was welcomed by all users.

The requirement to 'hand point' antennas when needed was still an issue and so, again, the necessity to automate that process created the solution in the form of 'Auto-Deploy' units. These systems were equipped with an Automatic Controller Unit (ACU) and a set of motors and sensors which could point the reflector in the correct alignment. This allowed a transmit and receive signal to be passed with almost no effort required by the operator.

This invention eliminated the need to use trained individuals to construct, align and operate the system in the field. Now, a minimally trained person could simply open a box, press a button and start to communicate.
These Auto-Deploy systems were a blessing to those users who needed mobility, ease of operation and quick deployment. However, the portability of the units continued to need improvement.

Most of these systems were designed to be mounted and deployed on a vehicle—in the military environment, most of these units were transported in cases and deployed from the ground. A typical antenna would be a 1.2 meter or perhaps a 1.5 meter system and, while easily moved in a truck, the cases were large, heavy and cumbersome. Easily moved in a truck but not completely portable…

A request was issued for a smaller, lighter version of the Auto-Deploy system that would make carry and setup far easier. Once again, this necessity was answered with the Fly-Away system.

The Fly-Away solution uses an Auto-Deploy system mounted on a tripod, easily carried, with setup accomplished in just a few minutes with no tools. With a single press of a button, within a couple of minutes the operator is connected to the satellite. As these systems were operated in the Ku- or X-band segment, the transmitters were quite small and the reflectors reasonably sized.

The Flyaway systems seem to be the perfect solution to the issue of portability and performance. At the same time, human nature is rarely satisfied with current technologies. This resulted in the request for an even more portable solution that could delivery true battlefield portability. The concept of the 'ManPack' was born: a complete unit that would fit in a backpack, to be carried and setup by one person.

In keeping with that request, a manual point, carbon fiber solution was developed. Unfortunately, the manually pointed system required a trained operator to use and setup the antenna. The portability issue was addressed, but at the expense of the automation. To some users, this was a good trade-off. To others, this was seen as a step backwards.

To quell those who objected to the loss of automation, a new Auto-Deploy system was offered. This antenna required a second backpack or case to hold all of the extra equipment and the weight of the automated solution. Other than perhaps being able to shrink the size of the bits and pieces, this seemed like the perfect solution.

What's important to mention is that all of these systems required the user to STOP—the antennas could not connect to satellite while the user was in motion. Comms-On-The-Halt (COTH) or Comms-On-The-Pause (COTP) remained the only solutions available, as the technology had not been yet harnessed to work with systems in motion.

In today's battlefields, vehicles must travel into unfriendly areas where constant communication is a requirement for safety. The action of stopping

and deploying an antenna to connect to friendly operatives was now a much more dangerous option. Any stoppage creates a potential hazard to those within the vehicle. The request then arrived for a system that could be used while the vehicle was moving.

This request necessitated a complete change in the thinking about the physics required to build auto-deploy antenna systems. A large, moving reflector would become nothing more than a target and likely would have a short life span in the field. The call went out for some new thinking that would produce a workable solution to this crucial mobility issue.

The initial attempt at providing a SATCOM-On-The-Move (SOTM) solutions involved taking a standard reflective antenna and mounting that antenna on a gimbal and then allowing the reflector to stay aligned to the satellite as the vehicle moved. This solution works well—the only drawback tended to be the size of the radome (think multiple feet tall and multiple feet in diameter) that was used to house the system.

These types of antennas are used mainly in the marine environment where overall size is not the main concern. They were tried on aircraft, but their large size was not conducive to the aircraft market and other solutions were developed.

A small, gimbaled solution was developed based on the need for a system to fit into the close quarters of the aircraft and one that could handle the vibration and speed of turns. These systems work extremely well but, due to their demanding engineering requirements, they have a tendency to be quite expensive. Given the high cost, these solutions have been relegated to the aircraft world and they have not broken into the land-based vehicle market.

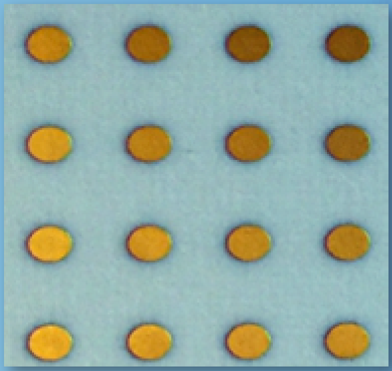
The necessity to have a SOTM solution for land use remained unresolved. To address SOTM needs, engineers began the design of a smaller solution that used a wave accumulation system in an effort to produce a flatter, thinner antenna that was efficient in spite of the physical size.

While the system was shown to have worked relativity well, it needed to use Spread Spectrum bandwidth (think fairly expensive) as its ability to remain pointed accurately was less than desirable. In the military arena, using Spread Spectrum was not such a big problem but, in the commercial world, such was detrimental and limiting.

The requirement of a simple, standard bandwidth, tough, reliable and reasonably priced SOTM product still remained unfulfilled. In an effort to address this need, the C-COM engineering team focused on developing new systems that would tackle these requirements and offer a solution that was also highly affordable.

With the ubiquity of Ka-band, which is bringing to the user a lower priced bandwidth offering, the company selected to build a SOTM antenna around that technology. These efforts are starting to bear fruit and the company will demonstrate their first Ka-band SOTM product in Amsterdam during the upcoming IBC2016 trade show.

C-COM's long term efforts are being directed at the development of a Phased Array antenna system that uses new science developed in conjunction with a leading university. These efforts have produced and range tested the first 4x4 sub-array of engineered material, which will become the building block for a new generation of products.



The ultimate goal is to offer a variety of solutions that all incorporate this game changing technology for land, sea, air, wearable technology and so much more...

If ***Necessity truly is the Mother of Invention***, then we should call on all necessities to continue their advance.

www.c-comsat.com

Paul has worked with C-COM Satellite System Inc. since January 2007, for the past 4 years, acted as Senior Technical Advisor, prior to that he was Senior Application Specialist. Paul's current position requires him to travel the world assisting C-COM Resellers in providing their clients with the best possible solutions available for data, voice, radio and video applications over the iNetVu line of products.

BEST PRACTICES FOR END-TO-END PROTECTED SATCOM

By Steve Williams and Chris Badgett, RT Logic, a Kratos Company

Numerous systems, capabilities and technologies exist, or are in active research and development, toward the end goal of protected SATCOM.

Many are already in dual DoD/Commercial use, or are rapidly converging for use within both domains. Many align with best practices for end-to-end protected SATCOM. These include:

- *Designed-in Protection*
- *Ground System Protection*
- *Signal Monitoring*
- *Signal Geolocation*
- *Training*
- *Self-Testing*
- *Integrated Solutions*

DESIGNED-IN PROTECTION

RF (Radio Frequency) link protection starts long before satellites are launched or ground stations are designed. Channel Simulators, Transponder Simulators and Satellite Signal Emulators can generate nominal and worst-case SATCOM test signals within a controlled lab environment. Using these instruments, engineers can then design, tune and test their firmware, software and hardware for unimpeded communications even under degraded signal conditions.

In the laboratory, Channel Simulators and Transponder Simulators create physics-compliant signals indistinguishable from their real world counterparts. These signals include propagation effects modeling, motion-related Doppler shift, atmospheric and multipath fading, path delay, and atmospheric noise profiles. Furthermore, these systems can simulate spacecraft equipment effects, duplicating amplitude and phase response and introducing linear and non-linear signal distortions.

These simulators, augmented with SATCOM Signal Generators, create full realism by supplying anything from perfect signals, to those impacted by multiple instances of advanced static and dynamic interference, both accidental and intentional. These instruments also generate signals perturbed by unexpected flight paths, attitude or antenna pattern issues.

High fidelity Satellite Signal Emulators accurately represent complex uplink and downlink signals, and are valuable tools for system developers, testers and trainers. These devices fully emulate complex wideband communications systems found on the emerging generation of channelized, multi-beamed HTS (High Throughput Satellite) systems, such as the WGS (Wideband Global SATCOM) constellation.

These instruments give SATCOM hardware, firmware and software designers a huge advantage during the design and test process, enabling them to develop and test equipment that will be tolerant of natural signal degradation and resilient to a broad variety of attacks on the signal.

GROUND SYSTEM PROTECTION

IP traffic between ground system components and sites must be fast and reliable. However, wide area IP networks exhibit traits that can degrade performance: dropped packets, indeterminate latency, variable jitter, and packet duplication and reordering.

For most users, TCP/IP (Transmission Control Protocol/Internet Protocol) masks these problems and delivers data acceptably. However, many mission critical applications cannot tolerate TCP/IP's retransmit and acknowledge behavior when attempting to deliver consistent data at required rates.

To repair dropped packets, the PFEC (Packet Forward Error Correction) and IRP (Intelligent Retransmission Protocol) protocols should be used. Both protocols allow high throughput with low latency across lossy, long-haul links and give the user the flexibility to choose the best solution for each situation. Ground systems must provide extensive network performance analysis and diagnostics in addition to robust traffic protection.

Cost-effective antenna site diversity capabilities for weather conditions (e.g., rain fade), and disaster recovery are also needed. These capabilities should precisely align signals received and packetized at two different locations within just several nanoseconds to enable seamless switching between antennas, at any separation distance, without losing modem lock.

Digital IF (Intermediate Frequency) architectures enable site diversity and resiliency by digitizing spectrum from geographically separated antennas. The digitized spectrum is then transported via IP (Internet Protocol) networks to modems at a centralized hub or processing center.

Additional capabilities for real-time network health monitoring and reporting are an important aspect of any ground station protection mechanism. Additionally, cyber-attack detection and real-time reporting via a NIAP-certified (National Information Assurance Partnership) SIEM (Security Information and Event Management) is highly desirable.

SIGNAL MONITORING

With well-designed and tested SATCOM systems enhanced for link protection, the first operational line of defense is continuous and advanced monitoring of the received and transmitted signals. Automatic signal monitoring must go beyond simple spectrum analyzer mask analysis of bandwidth, center frequency and power level. In-depth and real-time signal analysis must also include blind determination of modulation type, data rate, coding scheme, MER (Modulation Error Rate), EVM (Error Vector Magnitude) and BER (Bit Error Rate).

Monitoring tools that support such analysis should mathematically decompose the signal of interest, searching for unauthorized signals within the protected bandwidth that could degrade QOS (Quality of Service) as shown in *Exhibit 1* on the following page.

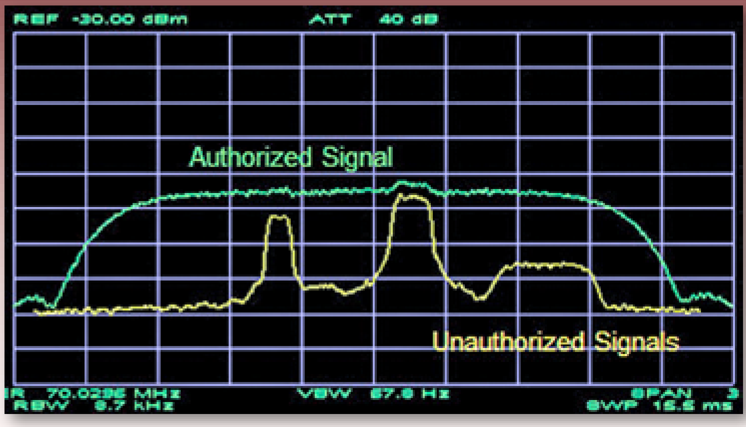


Exhibit 1: Advanced Spectrum Analysis with covert and overt interference detection and characterization capabilities.

Once these real-time measurements are complete, the monitoring system should match the results against expected values for each signal. Modulation type, data rate, center frequency, and power level differences between measured and expected values must be tolerable to the SATCOM system and the monitoring system within the boundaries of the SAA (Satellite Access Authorization).

All SATCOM modulation types should be supported by the monitoring system over high and low amplitude ranges, and narrow and wide bandwidths. This includes TDMA (Time Division Multiple Access), spread spectrum, and others, as well as the usual array of PSK (Phase-Shift Keying) (*e.g.*, BPSK, QPSK, 8PSK, APSK, etc.) and quadrature amplitude modulation (*e.g.*, 16QAM, 32QAM, etc.) signals.

Ideally, the monitoring system should be field-adaptable to detect and characterize new modulation types, emerging interference types and evolving intentional interference techniques.

In the case of RF signals, when received or transmitted signals do not match parametric expectations, or are determined to be impacted by interference, automatic alerts and data logging must take place. This assures that already time-crunched operators are not relegated to constant vigil or control over the monitoring system.

SIGNAL GEOLOCATION

The fastest and most accurate geolocation systems today receive SATCOM signals via two Earth-Satellite-Earth paths. High-accuracy geolocation systems typically look at four signals during a geolocation—the interfering signal and a reference signal from a known location both passing through a primary satellite and a nearby secondary satellite in a side lobe, as shown in *Exhibit 2* on the previous page.

TRAINING

Until SATCOM networks become fully self-healing, human operators and analysts will remain those who interact with ground equipment and link protection systems, interpreting their results and taking corrective restoral actions based on their indications. Operator familiarity with these systems and the threats to them dictates how quickly and correctly they can identify and resolve problems.

As shown in *Exhibit 3*, SATCOM, Signals and EMI (Electromagnetic Interference) training can be conducted via software-only packages for classroom instruction, self-study "what if" experimentation, and/or war-gaming involving multiple, linked students and instructors.

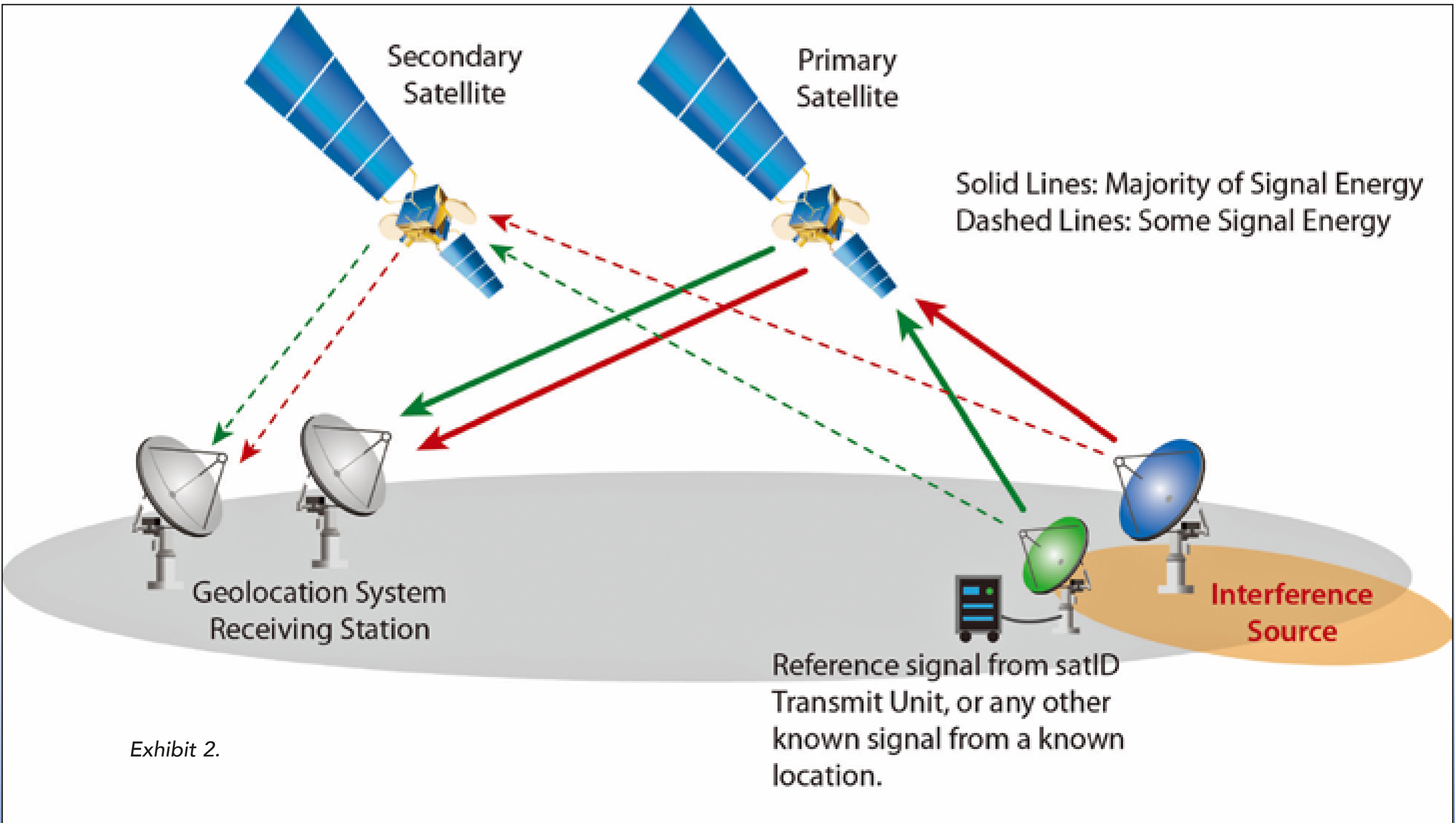


Exhibit 2.

By enabling deep, repeatable and continuous training strategies, operators can study SATCOM, signals, EMI and network issues, to understand exactly how their equipment will perform under challenging signal and network conditions, giving them valuable experience to hasten recognition of issues, differentiate causes, and restore operations.

SELF-TEST

At the command of human operators, and under computer control, Channel Simulators, Transponder Simulators, Signal Generators and SATCOM Signal Emulators can be switched into receiving system inputs where amplified antenna signals normally appear. These simulators can rapidly step through a series of pre-determined normal and degraded signals, adding interference if desired, and presenting these signals to link protection system inputs instead of the usually received SATCOM signals.

As these signals are presented, self-test software can check that each injected anomaly was properly detected and identified by the link protection capabilities. This assures proper functionality of link protection systems and algorithms, and can be an important differentiating step in isolating equipment faults, operator error, or actual link disruption.

Similarly, Geolocation Signal Simulators can be switched into geolocation system inputs in place of their usual antenna feeds. These simulators can then cycle through various combinations of satellites, ground stations, antenna patterns and other conditions to ensure anticipated geolocation results.

INTEGRATED SOLUTIONS

An integrated solution combines primary equipment functions (e.g., a modem), with Protected SATCOM capabilities (*e.g.*, signal monitoring and test/training, etc.) as depicted in *Exhibit 4*.

With a spectrally aware modem, CR (Cognitive Radio) capabilities can be pursued further. CR has applications in Ka-band HTS, and in numerous other areas. Cognitive approaches offer fresh ideas to increase spectrum utilization and efficiency. Ongoing research looks at CR applications to service future high density fixed satellite services while minimizing interference to existing users.

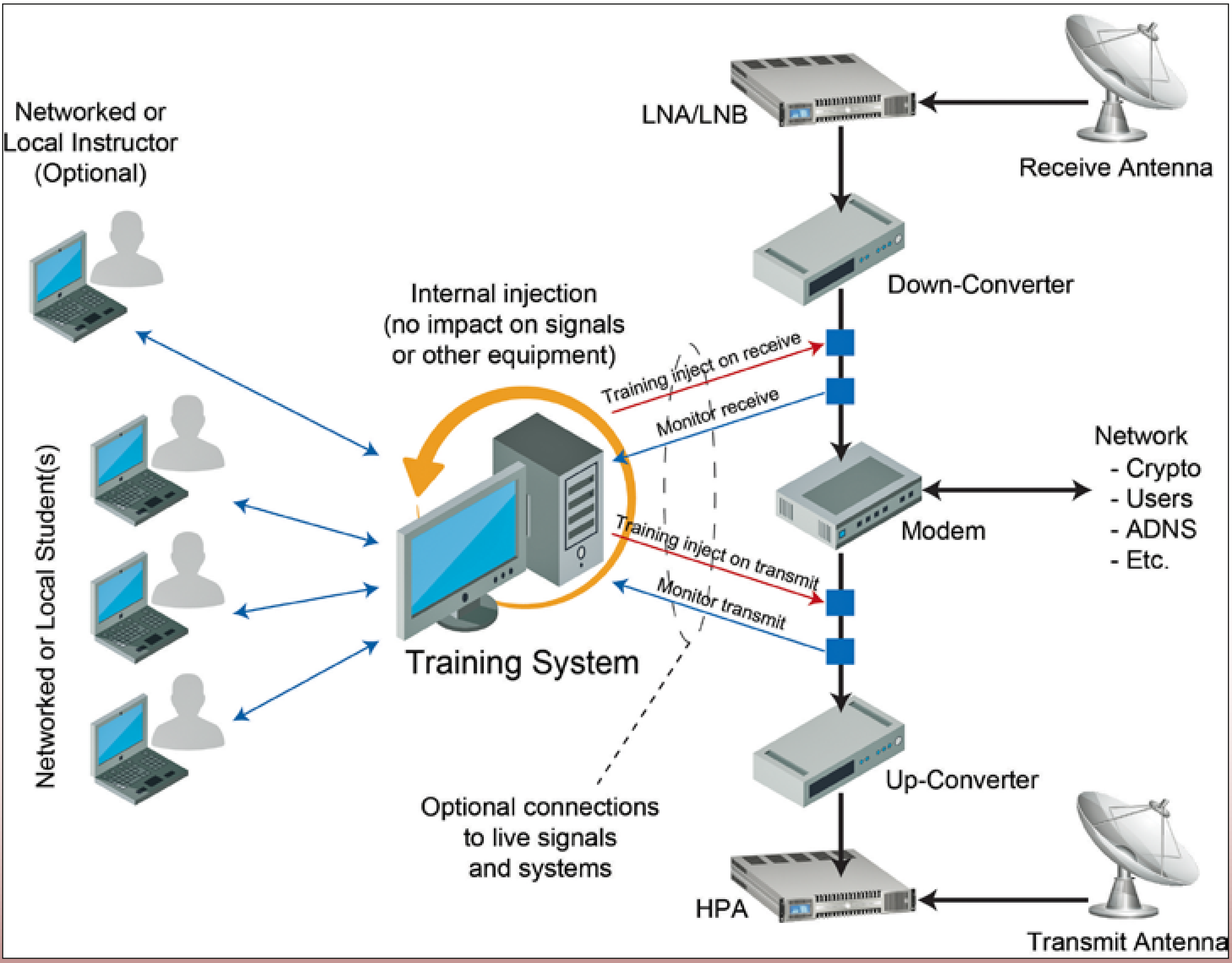


Exhibit 3: Effective training systems can be used stand-alone, or can be connected to actual SATCOM equipment for realistic downstream equipment and systems training.

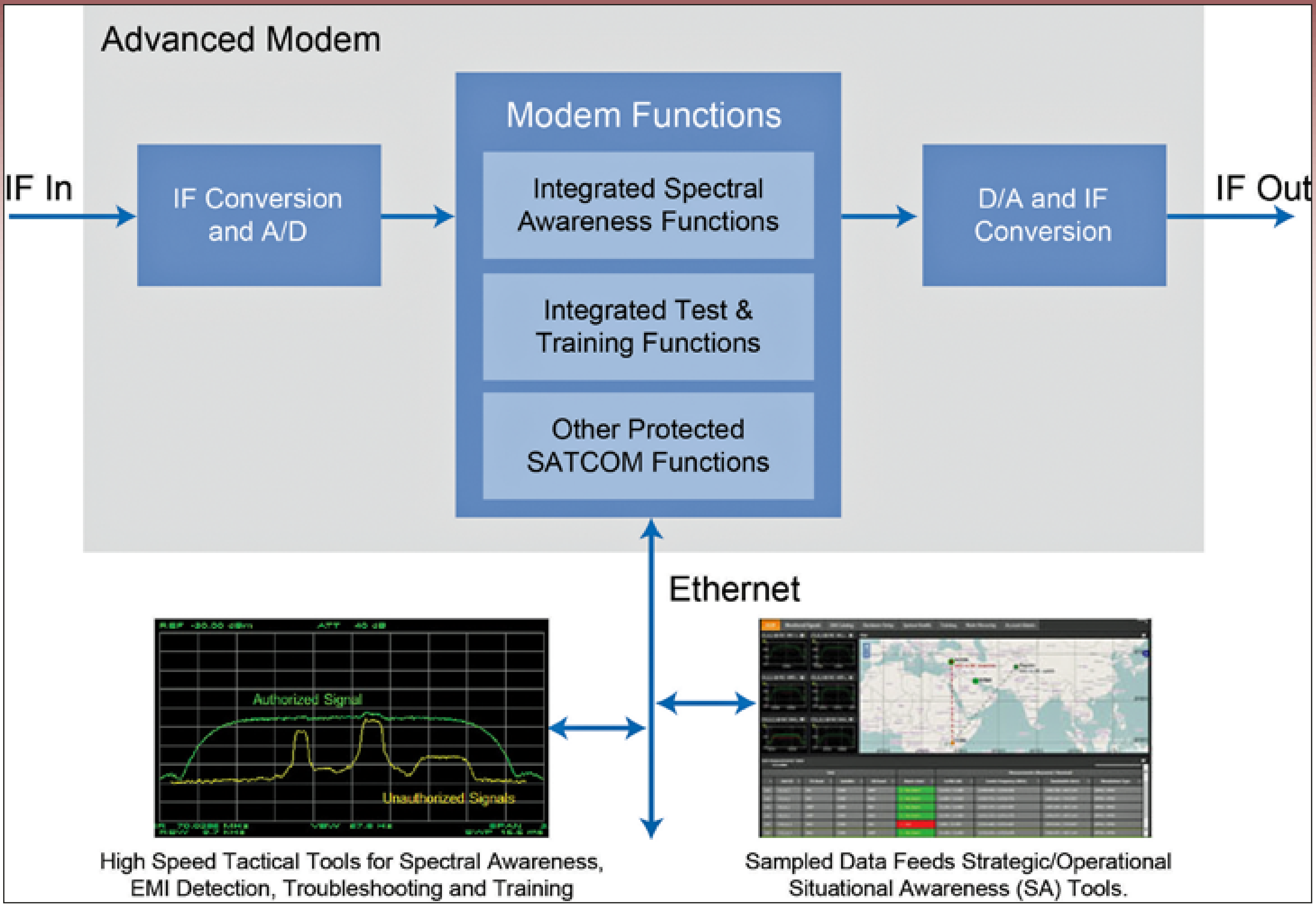


Exhibit 4: An advanced modem integrates multiple Protected SATCOM functions.

Protected SATCOM covers a wide area of need, with a broad set of existing and evolving solutions that leverage capabilities from and to DoD and Commercial applications.

SATCOM is a vital infrastructure element in commercial, as well as military C2 (Command and Control) and data transport applications. Due to their mission-critical nature, the function and performance of these links must be protected with great diligence, constancy and attention to detail.

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RT Logic, a subsidiary of Kratos, is the leading supplier of ground-based equipment for space/ground communications, supports 90 percent of US-based space missions.

SOTM & SOTP: SATISFYING VMES REQUIREMENTS

*By Rohit Murthy, Technical Director, SATCOM On-the-Move and SATCOM On-the-Pause, and,
David Svesko, Deputy Program Manager of Engineering, SATCOM On-the Pause,
both are with General Dynamics Mission Systems*

In the US for Ku-band, the FCC defines specific pointing error requirements and antenna Effective Isotropically Radiated Power (EIRP) spectral density limits for Vehicle Mount Earth Station (VMES) systems.

Outside the US other regulators impose typically higher EIRP spectral density limits, but always some limit to protect adjacent satellites. Other frequency bands are subject to limitations on EIRP spectral density which can be radiated towards adjacent satellites, but the VMES requirements provide an ideal example of how to maximize broadband SATCOM performance. Because of that, a description of how to satisfy the VMES requirements is just as applicable on other frequency bands and in other countries with various regulatory requirements.

A VMES system operates from motorized vehicles that travel primarily on land, receive from and transmit to geostationary FSS Ku-band space stations and operates within the US. VMES terminals can include military SATCOM-On-the-Move (SOTM) applications as well as stationary satellite news gathering (SNG) terminals also referred to as SATCOM-On-the-Pause (SOTP). Alternative licenses exist, but a brief summary of high-level VMES Ku-band FCC requirements will be the basis for this article.

VMES Classification

Classification A: Each VMES transmitter shall maintain a pointing error of less than or equal to 0.2 degrees between the orbital location of the target satellite and the axis of the main lobe of the VMES antenna. If met, the vendor is qualified to receive an All Satellite license (ALSAT) with no restrictions.

- Transmitter must abide by VMES EIRP spectral density limits.
- All emissions from the VMES shall automatically cease within 100 milliseconds if the pointing error of the VMES antenna exceeds 0.5 degrees, and transmission shall not resume until such angle is ≤ 0.2 degrees.

Classification B: Each VMES transmitter shall declare a maximum antenna pointing error that may be greater than 0.2 degrees provided that the VMES does not exceed the required off-axis EIRP spectral density limits, taking into account the antenna pointing error.

- The vendor will receive a limited license.
- All emissions from the VMES shall automatically cease within 100 milliseconds if the pointing error exceeds the maximum declared pointing error and shall not resume transmissions until such angle is less than or equal to maximum declared pointing error.

Transmitter EIRP Spectral Density Limitations

The requirement by the FCC limiting a transmitter's EIRP spectral density can be affected by three parameters:

- *Antenna Transmit Gain (antenna specific)*
- *Antenna Uplink Power (antenna/modem specific)*
- *Carrier Bandwidth and Spread Factor (modem specific)*

Antenna transmit gain is fixed by aperture size and cannot be modified after the antenna design is complete. The remaining two variables are dependent on the end-user application.

In order to meet EIRP density limits, the user can either: (1) manage total uplink power or (2) change the uplink modulation by modifying modulation type and/or FEC coding or additive spreading to increase the modem's spreading factor and leave total uplink power unchanged.

Uplink power is directly correlated to uplink data rate, whereas carrier bandwidth is directly related to space segment cost. A 3dB reduction in uplink power results in a 50 percent reduction in data rate, assuming the same modulation format, while a 3dB increase in spreading results in a doubling of leased bandwidth cost.

Since the future of technology is driving data rate demands higher and higher and apertures as small as SOTM terminals are constrained by EIRP spectral density rather than total uplink power, the user community is more likely to pay for additional bandwidth cost rather than reduce the transmit uplink power and reduce the data rate. If pointing error exceeds 0.2 degrees, the user is forced to back off on uplink power and compensate by increasing the modem spread factor. Therefore, pointing error performance must be addressed in order for the customer to be aware of the total life cycle cost of a multi-node network terminal and understands the impact of various terminal parameters.

What Is Pointing Performance?

Pointing performance of any SATCOM antenna system is defined by the unit's ability to keep the antenna dish pointed directly to the satellite during operation. For SOTM applications, this requirement is challenging due to the complex engineering required to steer the antenna's transmit beam to the satellite with high availability during vehicle motion.

Typically, a SOTM antenna is under a radome so wind is not an issue. However, for SOTP operation, the challenge exists in holding an antenna position during heavy wind gusts and the general difficulties incurred with pointing antenna positioners that are often engineered to meet low cost targets.

Search, acquisition, stabilization, scanning, tracking, and coasting are all parts of the pointing function. Pointing error, a measure of the radial angular error from the satellite, comes directly from the state variables of the control system.

Measuring Pointed Performance

Various methods can be used to ascertain pointing error of an on-the-move terminal. An effective, unit under test (UUT) agnostic method utilizes two independent large aperture terminals to measure adjacent satellite interference. The UUT transmits an RF signal to the target satellite, being monitored by large antenna #1, while large antenna #2 monitors the signal level of the adjacent satellite.

The procedure measures adjacent satellite interference (using signal information from both large antennas to correlate atmospheric signal drops) and back calculates pointing error within 0.05 degrees of resolution (well within the VMES limits). *Figure 1* illustrates the test method setup where data shown in *Figure 2* is actual measured data from an off-road pointing error test.

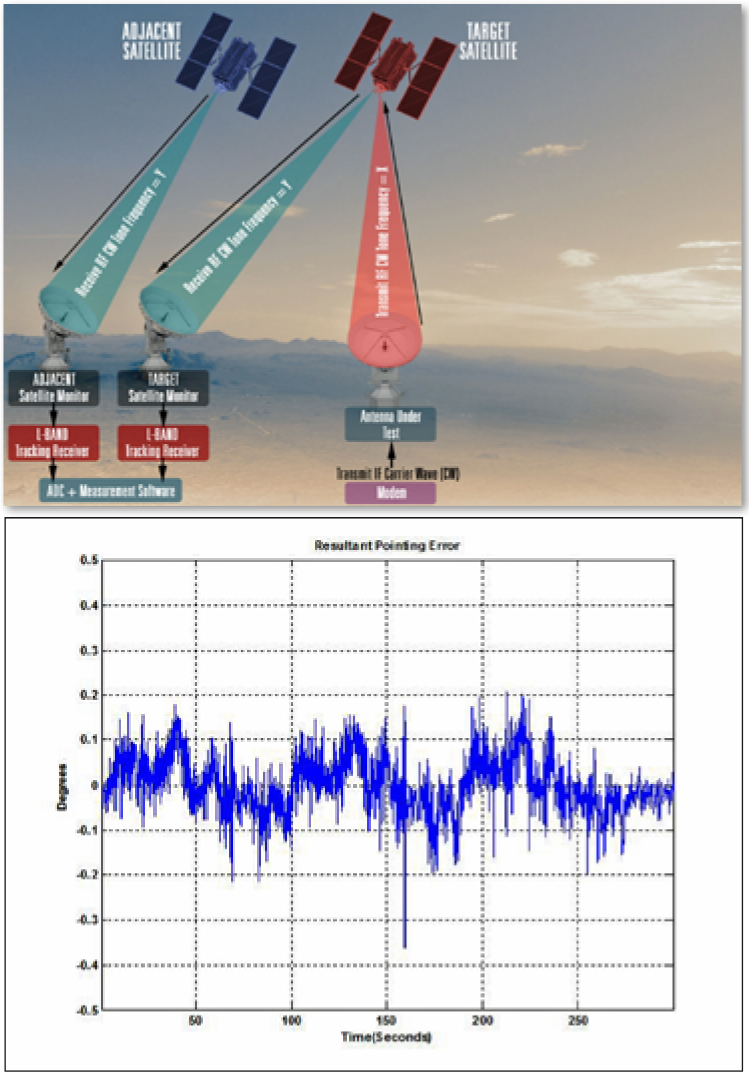

Figure 1. Pointing Measurement Setup & Measured Results.

What Impacts Pointing Performance?

Many system performance criteria affect a terminal's pointing performance. These include:

- *Operational mode and inertial navigation system (INS) selection*
- *Sensor and stabilization performance*
- *Antenna stiffness*

Since the VMES specification limits antenna EIRP spectral density limits to mitigate adjacent satellite interference (ASI), pointing error and antenna EIRP spectral density are directly related. Pointing accuracy also impacts bandwidth cost and the overall cost of ownership. Each of these latter effects is detailed in the subsequent section.

Operational Mode & INS selection

SOTM and SOTP antenna terminals primary responsibility is to close a satellite link and provide maximum traffic bandwidth while functioning in on-the-move and on-the-pause applications, respectively. Closing this link can be performed in two primary modes of operation:

1. *Open-Loop Positioning (Point Mode) where the antenna is paired with an INS to continuously position the antenna's line-of-sight (LOS) vector to the target*
2. *Closed-Loop Tracking (Track Mode) which uses the receive signal from the satellite to keep the antenna LOS vector oriented correctly during system-level operation*

Open-Loop Positioning involves closing the antenna's gimbal position control loops around the gimbal position sensors. Typically, an antenna control unit (ACU) uses the satellite coordinates, vehicle GPS location, and INS information to calculate accurate gimbal position commands.

The accuracy of the INS data and effectiveness of antenna calibration techniques are direct drivers of pointing accuracy and acquisition time. High precision INS are usually the most cost intensive as they require very accurate internal sensors (gyroscopes and accelerometers) in determination of vehicle attitude during stationary and dynamic on-the-move operation.

Closed-Loop Tracking is a control function that keeps line-of-sight on the target satellite using the satellite's receive signal. The antenna's gimbal position control loops are now closed around a tracking receiver instead of the gimbal position sensors.

Track Mode can commence in various ways, but tracking antennas still require some attitude solution (INS, magnetometer, tilt sensors) that are relatively accurate such that acquisition and re-acquisition times are minimized. The level of precision drops from the high precision variety as does the procurement cost.

In Track Mode, once the satellite signal has been detected and adequate carrier-to-noise has been achieved for Track Mode to commence, the INS solution is "let go" for azimuth and elevation purposes as the LOS vector is oriented strictly from the satellite receive signal. FSS Ku-band operation, as linear signal polarization is used, does require a polarization axis, thus pol stabilization, where the vehicle's pitch and roll information is used for polarization (pol) alignment and cross-pol isolation. The topic of cross-pol isolation is beyond the scope of this article but is an important criterion in selecting the correct SATCOM terminal.

Point Mode and Track Mode differences are illustrated using a six degree-of-freedom, non-linear antenna simulation to characterize performance. Point Mode performance is shown for both precision and low-cost INS, while Track Mode is shown paired with a low-cost INS. In all cases, the antenna configuration and base motion inputs (off-road course) are identical. The red circle illustrates the 0.2 degrees VMES pointing limit while the blue trace is the antenna LOS pointing vector during operation.

Each plot provides notable detail in regard to antenna mis-pointing, system performance, VMES compliance, and overall cost of ownership. First and foremost, the terminal operating in Point Mode with the high precision INS, Terminal 1, has the smallest pointing error compared to the other operational configurations. In reference to the VMES specification, Terminal 1 would fall under Classification A.

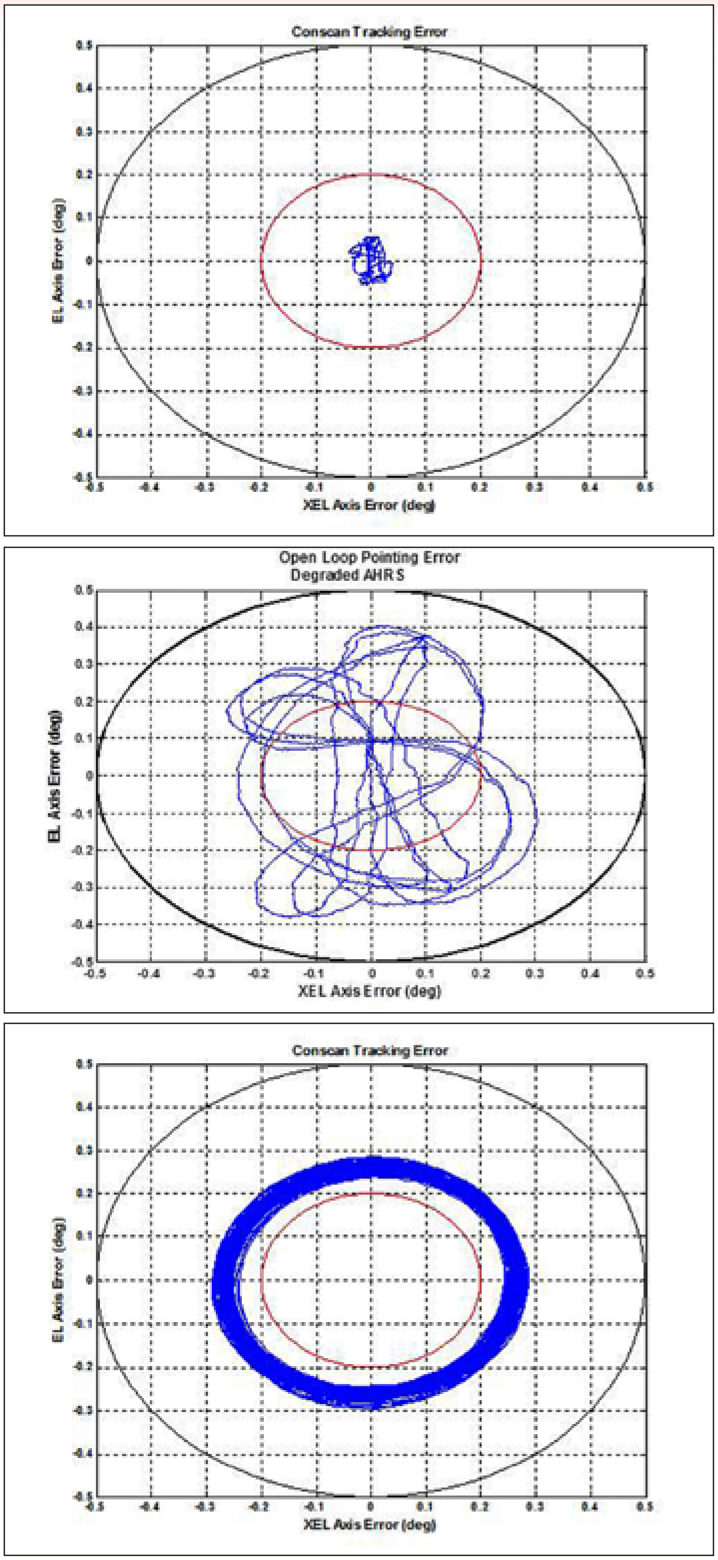

Figure 2. Operational Mode Comparison.

The terminal in Point Mode with low-cost INS, Terminal 2, is able to point within 0.4 degrees. Lastly, the terminal in Tracking Mode with low-cost INS, Terminal 3, is tracking within 0.3 degrees and is using the same INS as Terminal 2. Terminal 2 and Terminal 3 fall under Classification B.

Antenna terminals using high precision INS, Terminal 1, often have the largest procurement costs but result in overall reduction in leased bandwidth cost due to the limited spreading required by the modem to meet the EIRP spectral density limits. Total cost of ownership is mainly dictated by the bandwidth requirements of a satellite network and will be further detailed.

The data also illustrates that Track Mode operation is often preferred over Open-Loop Pointing with a lower-cost INS option. Many communication platforms where a high precision INS is cost prohibitive have antenna terminals that are considered tracking-only terminals. As stated, the drawbacks of these terminals involve the impact on space segment cost.

Sensor & Stabilization Performance

A sensor (also called detector) is a converter that measures a physical quantity and converts it into a signal which can be read by an observer. A servo (i.e., servomechanism) is a device used to provide control of a desired operation through the use of feedback.

SOTM and SOTP antennas use servo architecture to provide line of sight control. Feedback is provided by sensors that are mounted to the pedestal and positioner. The antenna design is dictated by customer specifications that detail the concept of operations (CONOPS).

CONOPS for SOTM terminals include road course dynamics, power requirements, travel ranges, wind speeds, and other factors that fall under servo, stabilization, and pointing. These are the primary drivers that impact sensor and servo selection.

SOTM antennas optimized for limited dynamic motion scenarios will often have difficultly handling rugged off-road terrain that is typical for military environments. Conversely, SOTM terminals built for off-road conditions with significant base motion are over-designed for commercial and "improved" road conditions.

This is for the benefit of the customer that the terminal is built for the desired application. A design that is either over or under designed will have long term cost and link availability implications. The same is true for SOTP terminals in terms of identifying the CONOPS and designing the system accordingly.

Antenna Stiffness

Overall antenna system stiffness is another key contributor for both SOTM and SOTP terminals and their ability to point and track. Antenna system stiffness is the rigidity of the sum of each of the sub-system contributors. These sub-system contributors can be structural or mechanical and consist of components such as the main reflector, sub-reflector (if applicable), reflector support structure, feedboom (if applicable), feed, gimbals, and vehicle mounting interface.

Typically, values such as spring rates, torque constants, backlash, and windup are either calculated or measured and are required inputs to determining how well an antenna will be able to point and track either dynamically or statically in the wind.

A detailed discourse on these values and how they are calculated or measured is beyond the scope of this article.

However, as mentioned above, understanding the CONOPS of a system is paramount to the proper selection of the correct system components such as motors, gearboxes, and drive systems, as well as determining how structurally rigid a system is required for implementation. The level of positional accuracy of a gearbox or bearing determines the accuracy required in a position feedback sensor. Just like sensor selection, increasing a system's stiffness is achieved by adding material which translates to weight and cost. A system that is over-designed to its CONOPS will unnecessarily drive up the cost due to excessive material and high performing components. The takeaway from this is to understand the required system CONOPS in order to optimize performance per cost.

Total Cost Of Ownership

Pointing performance has an immediate impact on the cost of leased bandwidth and overall cost of ownership for a multi-node network. The space segment cost of a multi-node communications network includes the following:

- *Procurement cost of antenna terminals*
- *Lease cost of carrier bandwidth for desired data rate*

The procurement cost of an antenna is dependent on many factors and is beyond the scope of this article. The lease cost associated with carrier bandwidth is directly related to pointing error. *Table 1* illustrates the following:

- *EIRP spectral density is limited by pointing error per the VMES specification*
- *The impact on the spreading factor assuming fixed uplink power and antenna gain*

Pointing Error [°]	Allowable EIRP Density [dBW/4KHz]	Spreading Factor (Modem Function)	Leased BW for x Mbps [MHz]	Cost of x Mbps ($K) per month [$1k/MHZ]
0.0	14.7	1.0	1.3	1.3
0.1	14.7	1.0	1.3	1.3
0.2 (Terminal 1)	14.7	1.0	1.3	1.3
0.21	13.3	1.4	1.8	1.8
0.3 (Terminal 2)	12.7	1.6	2.1	2.1
0.4	12.1	1.8	2.4	2.4
0.5	11.5	2.1	2.8	2.8

Table 1. Cost of Leased Bandwidth as a Function of Pointing Error (20-inch Aperture)

- *Cost associated with different grades of pointing error*

The costs detailed in the table are generic and are used for illustrative purposes only.

Using the simulation results from the operational mode analysis, a total cost of ownership comparison is completed for Terminal 1 and 3. Rarely is Terminal 2 used for operation. Cost estimates for Terminal 1 and 3 are $100K and $50K, respectively. The cost of bandwidth is assumed to be $1K per 1 MHz of bandwidth.

Terminal 1 incurs a larger procurement cost due to the high precision INS. Terminal 1 uses a spread factor of 1.0, resulting in a leased bandwidth cost of $1.3K per month. Terminal 3, using a spread factor of 1.6, would incur a monthly lease cost of $2.1k. This is approximately a 60 percent rise in leased bandwidth cost due to a 0.1 degree increase in antenna mis-pointing. A space segment cost analysis was completed for a ten node network over a ten year span using Terminal 1 and Terminal 3 for comparison—see *Figure 3, which* shows that after approximately six years, Terminal 1 with the higher initial procurement cost, will be a more cost effective network solution. Of

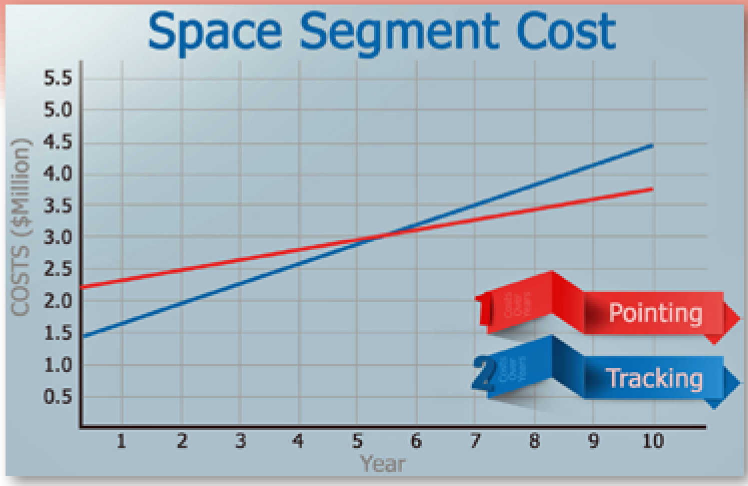

Figure 3. Space Segment Cost Analysis.

course, the generic transponder lease cost of $1k/Month is likely optimistic, meaning that the Total Cost of Ownership of a network employing Terminal 1 will usually happen much sooner than six years.

Antenna specific parameters including INS precision, operational mode, servo performance, and stiffness all directly impact the leased bandwidth cost billed to the end customer for terminals required to meet FCC VMES requirements. Similar analyses for SOTM terminals operating on different satellite operating bands or under different regulatory requirements have similar EIRP spectral density and pointing impacts—they simply happen at different relative power levels.

Examples illustrated in this article reveal the advantages of lower cost Track Mode terminals at the time of procurement as well as the accelerated cost implications over the life of the system. The discussion on servo and sensor selection illustrates the importance of system level requirements and sensor precision. The discussion on antenna stiffness as well as mechanical and structural considerations shows the impact effect on pointing error and thus cost. Although rarely specified by a customer, total cost-of-ownership for a communications network is a critical aspect in deciding which on-the-move or on-the-pause antenna terminal is best suited for the end user.

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Rohit Murthy is the Technical Director for General Dynamics Mission Systems' SATCOM On-the-Move (SOTM) and SATCOM On-the-Pause products group. He is responsible for product configuration and technical research, product business development, and technical lead for IRAD efforts.

Mr. Murthy has been involved in engineering and design of SATCOM, servo, and stabilization systems for over 11 years. His product expertise includes systems engineering, stabilization and control for SOTM pedestals as well as software development for stabilized platforms. Mr. Murthy was also involved in establishing General Dynamics Mission Systems' communications on-the-move product line and has led various iterations of the product line in creating the industry-leading line of ground SOTM systems. Mr. Murthy also plays key roles in business development including proposal development and guiding new solutions for new markets.

Mr. Murthy holds a BSEE and MSEE from the Georgia Institute of Technology in Electrical and Computer Engineering with a specialization in Controls, Stabilization, and Signal Processing.

David Svesko is the Deputy Program Manager of Engineering for General Dynamics Mission Systems' SATCOM On-the-Pause products group. In this role he is responsible for new product development, sustaining engineering product improvements, proposals, customer training and manages a team of design engineers.

Mr. Svesko has worked at General Dynamics Mission Systems for over 10 years and has held a number of roles including design engineer, test engineer, and systems engineer on various products spanning from small antennas (1.0m) to large fixed Earth stations (16.4m), developed and embedded antenna control systems into tactical fly-away antennas, and was a project engineer for the Atacama Large Millimeter/submillimeter Array (ALMA) in its first year of production.

Mr. Svesko holds a BSME degree from Rose-Hulman Institute of Technology with a concentration in Aerospace Engineering.

A Hiltron Communications Focus: Advancing Secure SATCOM Technology

By Jan Molter, Managing Director, Hiltron GmbH

The claim has been made that, in broadcasting, nobody dies if a device or system fails.

With military applications, the opposite is obviously true. In reality, broadcast infrastructure designers go to great lengths to ensure reliability by ensuring no single point of failure exists in the vital components of any system, encouraging news for those engaged in MILSATCOM, as well.

Naval Fleet Data & Voice Comms Systems

In the military communications sector, Hiltron recently announced the completion of data and voice communication systems for one of the largest naval fleets in the NATO Maritime Group. The project was carried out in partnership with a major European company which specializes in naval electronics.

This was the latest project in a series with this particular partner, which has been ongoing on a ship by ship basis since 2011. Each installation provides the codec facilities needed for secure satellite-based communication between vessel and land, including IP network access and vocal telephony. The previous systems have proven to be highly reliable and are based on Vocality codecs, which are among the most efficient of their kind currently available.

Ship to shore communication is a vital aspect of naval operations and far easier to achieve using satellite links than traditional radio technology. Vocality multiplexers provide the full range of user-facing connectivity, while managing the bandwidth used in multiplexing the services between locations.

Four variations are available: portable V25 and V50plus and rackmount V150 and V200. Each voice and data multiplex offers a different layout and density of ports such as voice, Ethernet, serial data or ISDN. As they all operate the same software, their management interface is nearly identical and they are all interoperable.

Aerospace Satellite Tracking System

Another recently completed project was the installation of a global satellite tracking system for one of the world's largest aerospace companies. The system included six Hiltron HMAM motorized satellite antenna mounts integrated with a Hiltron HACU antenna control unit and associated motor-control electronics.

HMAM is a high-precision motorized satellite antenna mount designed for two-way VSAT communication or receive-only downlink applications. This mount can be used for a wide range of applications that include broadcast and telecommunication downlinks.

An optional motorized feed changer allows the head to be moved quickly to a new position for switching between frequency bands. HMAM comes complete with professional-grade drives for azimuth and elevation plus a high-accuracy polarization drive.

The combined head and drive form a three-axis motorized mount with 180 degrees of azimuth adjustment, 90 degrees of elevation adjustment range and fully adjustable polarization.

Each of the six installations in the global satellite tracking system is configured to operate in main-plus-backup roles. Two are located at ground stations in the southern hemisphere, two in Europe and two in North America.

Each HMAM mount supports a 2.4 meter dish (*see Figure 1*) and is fitted with a wind sensor which activates a safety lock if wind speed exceeds 80 km per hour. The system is being used in a variety of modes to ensure continuity of the client's satellite network.

SORBAS

This global tracking system project is the latest in a long series of successful HMAM installations. HMAM forms the core element of Hiltron's SORBAS satcom product family (*see Figure 2 on the next page*) that is designed to form the heart of customized SATCOM systems. These also include Hiltron's HMCS monitoring and control software, HCS universal control unit, HSACU satellite antenna control unit and HDCU de-icing control unit.

Central to the SORBAS product family is the HCS-Core, which is used as a control element for tasks such as switching downconverters, integrated receiver/decoders, digital video broadcast encoders, high-power amplifiers and waveguides. The other products in the series are field-proven and in

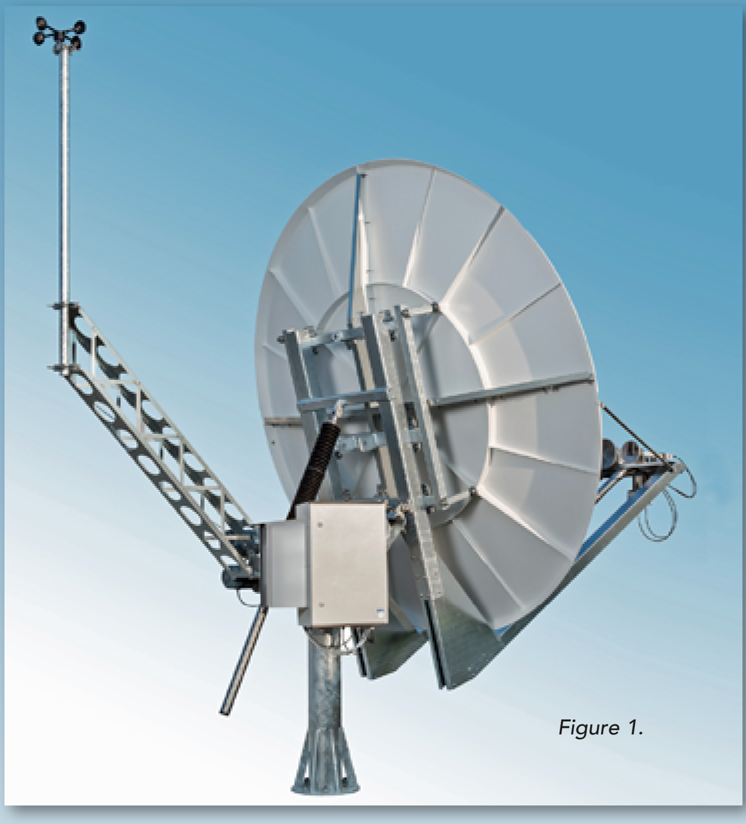


Figure 1.

successful operation at many locations around the world, forming elements of our own systems and those designed by systems integration partners in many countries.

The HCS-Core element of SORBAS is available in 2U high full-rack-width and half-rack-width versions. The full-rack-width model can accommodate up to 16 modules and is Hiltron's largest and most versatile satcom controller to date.

The current range of cards includes a monitor, control and power supply for fiber optic devices, a fiber-optic switch, LNB redundancy systems for C- and Ku-band, HPA redundancy control, redundancy for DVB MPEG encoders/ modulators/IRDs and a generic monitoring and control module.

The Hiltron HACU is designed to control three-axis motorized antennas. The antenna control unit and associated motor-control electronics are contained in an IP65-rated weatherproof outdoor housing with a hinged front access port secured by dual key screws.

The HACU can be operated from a PC running a graphic user interface compatible with standard web browsers. The control GUI displays all the information required to set and maintain azimuth, elevation and polarization, including current and target positions plus a database of potential accessible satellites.

The Hiltron HDCU-E is a combined ice-sensing and dish heating controller for use with large satellite antennas. It is capable of handling up to 450 kilowatts of power across multiple heating groups. Each group is divided into three independently-controlled heater arrays. Each array in turn feeds up to three antenna heater circuits.

A four-group configuration, for example, allows control of 12 arrays addressing a total of 36 heating circuits. This modular control approach permits easy configuration of parameters such as antenna size, number of heater pads and the power requirement of each pad.

Snow detection is via a reflective sensor with a polarizing filter. Each heater circuit is individually supervised and controlled via user-adjustable minimum and maximum thresholds. Sequential switch-on is performed within the controller to prevent rapid changes in current load when the antenna heating process is activated or deactivated. Sequence timing is user-configurable.

Transatlantic Broadcast Link

Long-range links are, of course, a natural application of satellite communication technology, whether for defense or civil applications. Recently initiated is a satellite link that will be used to carry broadcast television content from South America to viewers in Europe. The new system will be located in one of the Baltic states and needed to be live by the end of June in time for the 2016 Summer Games in Rio de Janeiro.

The new link will be a complete turnkey solution with five active channels and is designed to operate as a complete backup system, which can be switched into action if the primary feed fails. Initial planning was completed in partnership with one of the world's largest satellite fleet operators. A site survey was conducted earlier this year.

Figure 2.

Assembly subsequently took place at Hiltron's headquarters in Backnang prior to factory acceptance tests, followed in turn by on-site integration, commissioning and acceptance.

hiltron.de/

After graduating with a university degree in economics, Jan Molter served for 14 years as an officer with the German Navy, latterly as Commanding Officer of the submarine U15. He joined FS Antennentechnik GmbH in 2006 as Head of Economics, progressing in 2008 to Schott AG where he served for over five years as Vice President. He was appointed Managing Director of Hiltron GmbH in September 1 2014.

Hiltron GmbH is Germany's leading integrator of satellite and wireless communication systems. They provide turnkey systems of any required scale for customers world-wide. They are part of the Danmon Group, one of Europe's leading suppliers of audio, video, transmission products and digital media solutions. Hiltron operates from modern purpose-built headquarters at Backnang near Stuttgart. On-site facilities include a large technical operations area with high access doors and ceiling, capable of accommodating satellite link vehicles and their roof-mounted antennas.

Although the majority of Hiltron's products and systems are designed for broadcast rather than military fields, they conform to the high standards of performance and reliability demanded in both areas of operation.

The technical solutions offered by Hiltron include compact point-to-point microwave links to ground stations with antennas of 11 meters or more. Also produced are truck-mounted satellite links for applications such as broadcast news gathering plus a range of fiber-optic systems delivering signals to and from SATCOM terminals.

Additional company experience also overlaps into asynchronous transfer mode networking for major broadcasters, such as Bayerischer Rundfunk and Südwestrundfunk. The network adapters are usually equipped with an interface card that enables transmission of the signal via terrestrial microwave links to the transmitter stations. The latter are mostly located as high as possible above neighboring terrain, ideally at the top of mountains.

BUILDING TO MEET CHANGING NEEDS FOR THE 21ST CENTURY

By Heather Bulk, Co-Founder and Chief Executive Officer, Special Aerospace Services (SAS)

Privately funded ventures have disrupted the way aerospace companies do business. Whether the customer is in the government or commercial sector, the competition is fierce.

Providers of spacecraft and launch vehicles must now focus on rapid development, going from concept to final product in a fraction of the time once required. This has put pressure on the entire aerospace supply chain.

Special Aerospace Services (SAS) has experienced these paradigm shifts first hand with the numerous tactical engineering projects. Client frustrations were observed when manufacturers couldn't keep up with the need to develop new parts and components with the speed and efficiency dictated by changing economics.

The SAS team examined aerospace manufacturing from an engineering perspective and concluded the entire approach to fabricating specialty parts—from equipment to processes and even shop culture—had to evolve along with the rest of the industry in an increasingly competitive landscape. State-of-the-art 3D printers and automated milling machines were part of the solution, but putting the aerospace client at the center of the manufacturing process was critical.

In spring 2016, unveiled was what the company dubbed a '21st Century' manufacturing facility in Englewood, Colorado, to meet the unique demands of space and aviation clients. The culture and basic approach to aerospace manufacturing, machining and milling was changed. The centerpiece of the new SAS Manufacturing shop is an online platform interface, now under development, that gives clients instant access to job status, product assurance, delivery and information at every step of the process.

THE STATE OF MANUFACTURING

SAS opened its doors a decade ago as an 8(a)-certified woman-owned small business focused on tactical engineering of components for aerospace and other high-tech industries. With a heavy emphasis on research and development, braces, brackets, avionics/control boxes, mechanisms and pump houses for spacecraft were developed, including propulsion system parts, as well as platforms and jigs for aircraft. Most products fell under the heading of 'specialty' components involving production runs of 50 or less. Clientele includes Boeing, United Launch Alliance, JHU Energetics Group, NASA, Orbital ATK, Sierra Nevada and DARPA.

As the competition in aerospace began heating up, the trend in the engineering of parts became clear—clients wanted products developed faster and less expensively. Spacecraft and launch system integrators who were previously satisfied reviewing a new design concept in CAD format now asked for a prototype in hand a few weeks after the initial meeting. The proliferation of 3D printers helped fuel this expectation.

In many cases, manufacturers were not able to meet the accelerating demands of aerospace, and this handicapped our engineering business at SAS as well, especially related to rapid prototyping. As a small firm with a client-centric approach to our work, the situation was studied to see what the company could do to such problems.

A number of drawbacks to traditional manufacturing processes became quickly apparent. The first was a classic Catch-22. The manufacturing facilities with the equipment, processes and certifications in place to handle the exacting standards of aerospace were the large ones. However, they were also the least agile, which meant they couldn't turn around prototypes quickly or focus on short-run production. The more responsive smaller plants could do those runs in theory, but often lacked the required technical and quality-control capabilities dictated by aerospace.

Another issue was one that faces US manufacturing in general. There wasn't (and isn't) much growth in that sector and the opening of new facilities was rare. As a result, the workforce is aging without a steady influx of young talent who are eager to challenge the status quo and alter the way manufacturing business was done. The prospect for changing the traditional culture found in manufacturing was dim, especially in the company's home state of Colorado.

The third factor identified as a road block to streamlining production and development in aerospace was a 'black box' approach to manufacturing. Traditionally, an aerospace client placed their order for new parts to be produced and then waited for the arrival of the delivery date. They seldom had any idea what happened in between the order and the delivery, which was fine if the production schedule happened to be maintained. But if materials were late reaching the plant and machining was delayed, a launch itself could well be jeopardized at enormous potential cost to the spacecraft or launch system integrator.

Of the hundreds of hours SAS spent interviewing aerospace clients on how they felt the prototyping and production process could be improved, communications with the manufacturer was the overwhelming priority. They wanted insight into the manufacturing process as part of their own quality assurance. If a part was going to be delayed or not meet their specifications, they wanted to know sooner rather than later so that necessary alternate steps could be taken to reach the launch pad on time.

RE-INVENTING MANUFACTURING

The conclusion was derived that the timing was perfect for a reinvention of the manufacturing process to meet the evolving needs of aerospace and other high-tech industries. In 2015, SAS purchased an existing machining facility in the Denver suburb of Englewood, Colorado, with which business had been successfully completed in the past. The 12,500 square-foot shop was considered small, but there were skilled personnel and a diverse client list. Most importantly, that business had the potential to become a state-of-the-art 21st Century manufacturing facility.

Established as a wholly owned subsidiary, SAS Manufacturing shared a vision of enhancing the plant processes and culture and achieved enthusiastic buy-in from the existing team. First on the list of changes was implementation of a quality management program similar to who was already employed on the engineering side of the SAS group. Not only was this key to streamlining efficiencies and increasing capabilities at the facility, strict quality management principles are a necessity for winning contracts from many US government and defense organizations.

In less than a year, AS9100C and ISO 9001:2008 certifications were received, verifying that the SAS machining facility was committed to the highest standards at every step of the fabrication process. AS9100C certification specifically demonstrates adherence to quality management principles relating to aviation, defense and space.

3D Printing & Automated Milling

Another important initial focus area was ensuring the facility contained the most advanced equipment needed for the manufacture of aerospace products. Fortunately, several 3D printing devices had been installed by the previous owner. Additional additive printers were purchased that possessed an emphasis on plastics, composites and alloys. This equipment has the ability to fabricate 3D parts as strong as traditionally milled products but weighing 30 to 50 percent less, a critical capability in space and aviation.

Although popular, especially in rapid prototyping, 3D printing is not the answer to every manufacturing challenge. In the production of metal components that fly in space or aboard aircraft, traceability remains a major concern. Aerospace companies want to know from where source materials are derived—if there is a problem, that part can be traced back to its origin so other parts fabricated from the same material can be inspected or replaced.

Unfortunately, the metal powders used in additive 3D printing processes cannot yet be traced with the same degree of certainty that solid metal pieces can be traced. For this reason, traditional subtractive metal-on-metal lathing and machining are still required for creating many parts. Although the SAS shop already operated some of these machines, the purchase of a 21st Century, 5-axis, computerized numerical control (CNC) milling machine from DMG MORI was necessary—this is an automated device that is capable of producing extremely complex metal parts and is typically found only in the largest of manufacturing plants.

Building A 21st Century Workforce

The next step for SAS was to simultaneously change the culture of the machine shop and to breathe new life into the Colorado manufacturing industry. An enthusiastic partner was found in the state's Office of Economic Development and International Trade, which awarded SAS Manufacturing an Advanced Industry Infrastructure Funding Grant to upgrade the workforce.

The money was used to attract younger workers, some with and without college degrees, to participate in an apprenticeship program where they would be mentored by veteran personnel, many of whom are eager to pass on their trade to the next generation. Departing from manufacturing tradition once again, this program rotates workers throughout the shop—they learn how to use automated and manual equipment in every phase of the fabrication and assembly process.

In just its first year, the apprenticeship program has had a dozen participants. Those who have completed the program and moved on have the skills to fill numerous positions at other manufacturing facilities in Colorado and elsewhere in the nation.

Putting The Client In The Process

Finally, but most importantly, SAS has smashed the black box approach to manufacturing as the move has been made from a product- to process-centric paradigm. The SAS team is developing an online interface to provide clients with a two-way communication portal into the status of their jobs. The platform will send regular updates to the client at key manufacturing milestones and will also allow them to check on the job directly, whenever they wish.

More than just notifications of when source materials arrive or milling begins, the platform will allow clients to query where the materials came from and to then examine the certifications of the involved vendors. The client will know which machinist and which piece of equipment are involved in their projects. Job status, certifications, material tracing and delivery deadlines will be transparent to the client.

This information will pass seamlessly to the client without taking time away from work inside the plant. In addition, vendors will also have access to parts of the system for their own quality control purposes. They will see how their performance rates against other vendors in terms of on-time delivery and quality ratings, holding them to a higher level of accountability.

Ushering In A New Era

The benefits of integrating the streamlined manufacturing operations with existing engineering projects and passing the advantages onto clients is being experienced. A new part for a long-time aerospace client was recently developed and was taken from concept to 3D printed prototype in just one day, a process that once required three months when a traditional third-party manufacturer was involved.

The online client platform and multi-functional 5-axis milling machine should both operational by the fall of 2016—the SAS 21St Century manufacturing plant should be at full strength by year's end. SAS has started the process of introducing engineering clients to SAS Manufacturing with the expectations they will become customers of the new facility.

In addition to space and aviation organizations, the anticipation is that the concept and capabilities of a 21st Century shop will appeal to many industries that require rapid prototyping and specialty production of parts that meet exacting specifications and standards, including biotechnology, energy and semi-conductor businesses.

www.sasprecisionmfg.com
www.specialaerospaceservices.com

Heather L. Bulk is the Chief Executive Officer and Co-Founder of Special Aerospace Services, LLC. Ms. Bulk is responsible for providing direction for the company's business strategy, as well as oversight of SAS' legal affairs and financial performance. Throughout her tenure at SAS, Ms. Bulk has managed the Company's numerous partnerships and expanded the Company's footprint through new business ventures and industry networks.

A Spectra Group Focus: SlingShot & The Changing Focus Of Conflict

By Simon Davies, Chief Executive Officer, Spectra Group (UK) Ltd.

During my 35 year career as a communications specialist, much of which had been spent in a tactical arena, I began to realize that tactical systems in the military crucially needed new enhancements to provide better and more extensive coverage—these improvements required MILSATCOM to enable viable analysis of rapidly developing scenarios without having to secure land real estate to provide communications as situation evolved.

During this time, the nature and tempo of conflict had changed, significantly transforming the information needs of all personnel, from the commander to the front line soldier.

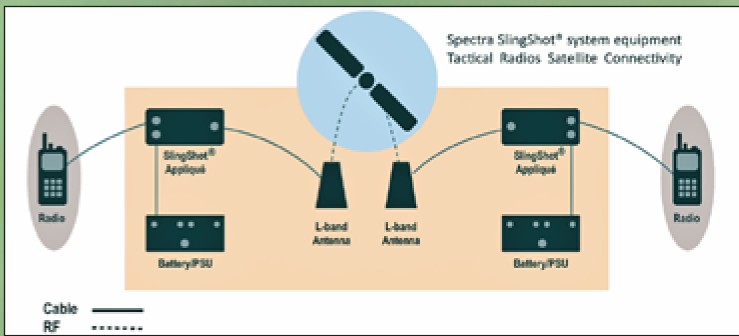
Spectra Group (UK) Ltd. was launched with the clear mission to provide reliable and resilient voice and data communications at a tactical level. A number of employees possess a military background and are only too aware of the true value in having such services available—and also realizing what the catastrophic effects could be of failure.

SlingShot®, Spectra Group's best known product, was developed three years ago and as of this writing, around 2,000 units have been sold to key users that have included Special Forces and more than 15 armies, ranging from the Americas to Europe, Africa and the Middle East.

The requirement was to deliver the benefits of UHF TacSat at a much more competitive price and without the restrictions that existed on the number of available channels. SlingShot offers this service by attaching a small and lightweight appliqué by coax to the radio's antenna connection. The appliqué converts the radio frequency to L-band SATCOM frequency for voice and data. SlingShot is presently being evaluated by the UK MoD to enhance their existing Bowman system and progress the technology to the level necessitated by the new Morpheus Requirement.

This small, external adapter for military radios permits low-latency voice and data regional communications, with the additional option of connecting to an out-of-theater rear-base command node. Using Inmarsat's SATCOM network, SlingShot offers a unique capability to access single-hop L-band relay from an existing global constellation of geostationary satellites.

The SlingShot capability can be bolted on to existing tactical radios without compromising the crypto system and delivers a tactical command and control Comms-On-The-Move (COTM) system. Conceived and designed in direct response to military requirements, SlingShot offers clear benefits to those engaged in high-tempo operations, which require reliable and robust COTM.



The SlingShot system extends in-service tactical radios to BLOS, COTM devices using commercial satellites.

Units using SlingShot can maintain secure BLOS PTT COTM.

SlingShot uses Inmarsat's L-TAC™, which provides a flexible service to cater to such high tempo, operational requirements. The nature of the coverage offered by L-TAC allows beams to be booked on a monthly basis with the capability of having large, narrow beams, or more specific multi-headed beams.

Such flexibility greatly adds to the ability to move quickly and respond to adapting situations. Inmarsat's global L-TAC service delivers dedicated bandwidth or, in other words, is not contended. This guarantees quality of service and, combined with the SlingShot system, means that even on the edges of the beam, voice and data communication is not compromised—recent tests proved this at 82 degrees latitude.

Already in place by Spectra Group are manpack, vehicle and maritime systems, while the recently introduced aviation capability offers Command and Control Communications of all units, no matter where they are located, to airborne platforms without the necessity for any land or air-based radio re-repeaters. Unlike other BLOS systems, SlingShot delivers robust voice and data COTM and now, with the aviation development, can provide the same capability on fixed wing aircraft and helicopters.

Another beauty of SlingShot is that the appliqué unit, which weighs close to 500 grams, is only a conduit for the radio communications and can be encrypted or unencrypted as required by the user. This allows for full security to be maintained as messages are conveyed between users or bases in locations around the globe.

Unlike conventional military manpack satellite communications that require the operator to halt and assemble a bulky antenna and then locate the position of the satellite in the sky, the SlingShot omnidirectional antenna allow instant COTM.

(GD) UK tested the system at their Edge facility, where the unit passed with flying colors. Slingshot was also trialed with great success on a recent 3 Royal Marine Commando demo at Plymouth, England, in association with the Defence Science and Technology Laboratory (DSTL).

www.spectra-group.co.uk

Simon Davies is the CEO of Spectra Group (UK) Ltd. Spectra is a leading provider of Voice and Data services into remote and hostile areas world-wide for Defence, Governmental and Non-Governmental sectors.

Upon leaving the Military in 2004, Simon established Spectra, which has achieved steady growth over the past 12 years through some difficult economic times and is fast becoming a leading service provider of reliable, robust, reployable communications. Spectra's services are deployed world-wide in some of the world's harshest environments and support the UK Military, European Union and Stabilization Unit, to name but a few.

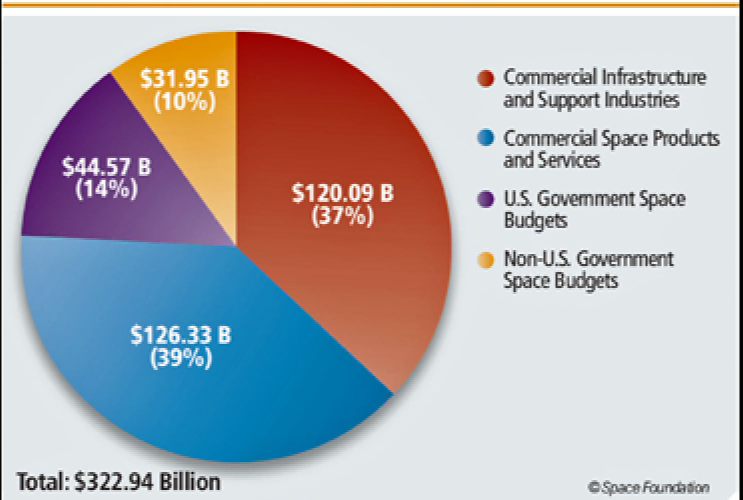
SPACE FOUNDATION: THE SPACE REPORT, AN EXECUTIVE SUMMARY

The global space industry appears to be going through a period of reinvention, as evidenced by a variety of changes in the way it conducts operations.

Efforts to reuse launch vehicles are beginning to bear fruit, and more efficient launch vehicles are being designed and developed, all of which may help to bring launch costs down. The satellite industry is seeing rapid growth in the number of small satellites, as vast constellations consisting of hundreds of satellites for Earth observation and telecommunications are being ordered and built.

Large satellites are taking advantage of more efficient propulsion systems that may help increase their usable lifespan. These are but a few examples of how the industry is making space more affordable and consequently more accessible to a broad swath of public agencies, industries, and individuals.

EXHIBIT 1. Global Space Activity, 2015



SPACE PRODUCTS & SERVICES

Space technology, combined with communication networks, is displacing traditional ways of monitoring infrastructure and providing services.

The Flanders region of Belgium is using geo-fencing and communications to replace underground sensors on its tram networks. In other parts of the world where buildings do not always have an address, or road networks are confusing, smartphones with positioning, navigation, and timing (PNT) chips are facilitating delivery services for mail and packages. In war zones, drones equipped with PNT guidance systems are being used to supply refugees with life-saving supplies.

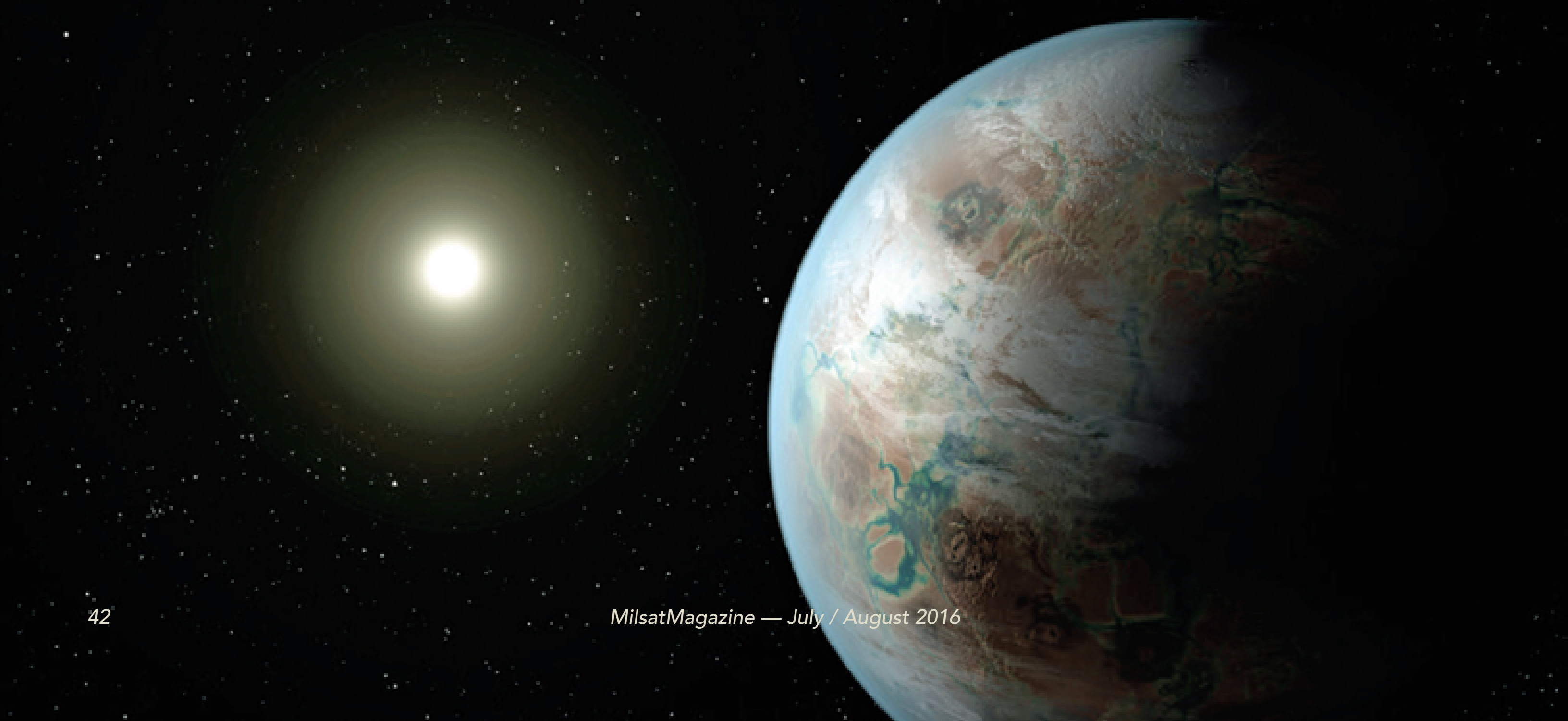
On the consumer side, there are space-enabled systems to assist with finding prime locations for sport fishing and to help coaches improve the performance of soccer players.

With the ongoing globalization of food production, space systems are helping the shipping industry better monitor the condition of food in transit across the ocean to ensure that freshness is maintained all the way to the grocery store. The abundance of satellite imagery has led to increasing numbers of space data analysis companies that help people understand their surroundings, whether for business or recreational purposes. The global demand for space data and applications is driving many of the recent investments in space.

THE SPACE ECONOMY

The global space industry grew in 2015, although currency fluctuations caused the appearance of a decline from $329 billion in 2014 to $323 billion in 2015. Due to the strong US dollar and the ever-increasing levels of activity outside the United States, these fluctuations have a more noticeable impact than would have been the case in previous decades when the US share of the commercial space industry was larger.

In 2015, revenues from commercial sectors continued to represent slightly more than three-quarters of all global economic activity in space. Commercial space products and services—including telecommunications,



broadcasting, and Earth observation—constituted the largest sector, growing by 3.7 percent to reach $126.33 billion in 2015.

Commercial infrastructure and support industries—including the manufacture of spacecraft, in-space platforms, and ground equipment, as well as launch services, independent research and development, and insurance—totaled $120.88 billion in 2015, a 5.2 percent decrease. The majority of this decline is attributable to global navigation satellite system (GNSS) receivers whose revenues are benchmarked in euros and were subject to the change in currency exchange rates.

SPACE INFRASTRUCTURE

Governments and companies around the world continue to invest in new space infrastructure. At least 19 countries have, are developing, or are planning to host spaceports for orbital or suborbital launches.

In spite of several launch failures and delays due to subsequent investigations in Russia and the United States, 86 orbital launches were attempted around the world in 2015—the third highest number of launches in two decades.

China conducted the maiden flights of two new space launch vehicles in 2015, the Long March 6 and Long March 11. There are plans to launch a third new vehicle in 2016, the Long March 5.

The United States saw the unsuccessful launch of a new small-satellite launch vehicle, the Super Strypi. In perhaps the most significant development for the launch industry, two US companies successfully landed rockets that returned from space. Blue Origin's launch vehicle landed after a suborbital flight and subsequently flew to space and back on two occasions (as of May 2016). SpaceX returned the first stage of its Falcon 9 launch vehicle after an orbital launch, initially to a launch pad at Cape Canaveral. In later launches, the first stage landed on an oceangoing platform.

Although none of the returned hardware has yet been flown again, the company hopes to reduce its operational costs by reusing the rockets. Reusability has long been discussed as a way to lower the cost of launching payloads to space, but it remains to be seen how much of an impact these developments will have on pricing and reliability.

Even at current prices, the number of large spacecraft being sent to orbit each year remains steady, and interest in small satellites continues to grow unabated.

With a mass of 10 kilograms (22 pounds) or less, nanosatellites constituted 48 percent of the 262 spacecraft launched in 2015. Looking at the past decade, the sudden rise of nanosatellites in 2013 means that the average number of spacecraft launched during the past three years is approximately double the average rate for the previous seven years.

Despite their numbers, nanosatellites constituted less than 1 percent of the total mass sent to orbit in 2015. At the other end of the scale, telecommunications satellites launched to geosynchronous orbit made up 41 percent of the total mass, with an average mass of approximately 4,500 kilograms (9,920 pounds) per satellite. These satellites form the backbone for satellite communications and broadcasting services that generate more than $100 billion each year.

THE WORKFORCE

The space industry operates at the cutting edge and requires a highly skilled, highly trained workforce to build, launch, and utilize space assets. Trends in the size and composition of this workforce provide insight into ongoing dynamics and future health of the sector.

In 2014, the US civil and commercial space workforce remained one of the largest in the world, with 221,585 workers, but continued to contract, while employment in Europe and Japan grew.

In the United States, the outlook for industry is mixed, with growth projected for scientific disciplines such as astronomy, but declining demand for aerospace engineers. However, the ongoing process of integrating space technology into all aspects of life means that other jobs are being created that do not fall into the traditional aerospace categories.

Programmers, computer scientists, and "big data" wranglers are all likely to find increasing demand for their skills as companies seek to monetize the growing torrent of information flowing from and through space systems.

Since the first edition of The Space Report was published in 2006, the Space Foundation research team has gathered an everexpanding collection of information about the space industry, government policies and priorities, and the evolving trends that influence space activity. Each year, we present the highlights in The Space Report, focusing on the points that we believe are of greatest interest to a broad audience.

To further address our readers' research needs, we introduced a new format in 2015—an online service that provides subscribers with access to all the research conducted for The Space Report throughout its existence, as well as new data sets that have never appeared in the report.

*Space Foundation appreciates the positive response to this valuable resource, and the organization is expanding the types of data offered in response to requests from their readers. To view more information about this new service, please visit **www.TheSpaceReport.org**.*

PERSPECTIVE: HOW TO IMPROVE ENTERPRISE GROUND SERVICES FOR SPACE

By Eric Moltzau, Manager, Space Services Development, Intelsat General Corporation

Air Force Space Command's Enterprise Ground Services (EGS) is not a new kind of ground system or acquisition program—this is a new approach to satellite ground infrastructure that is critical to support General John Hyten's overall concept for the future Space Enterprise Vision.

Space has been called this country's Achilles' heel when in regard to national security. The current space architecture has become inflexible and is a tempting target for potential adversaries.

I recently returned from a space technology conference where I presented the key benefits of, and considerations for, exactly how the US Government can acquire commercial services within EGS and future satellite program acquisitions.

Currently, every space system is highly stove-piped and has limited interoperability with other mission ground systems. The system is highly inefficient and creates too many single points of failure in the case of conflict. What's needed is a set of standards and common core pieces that would allow systems to interoperate and serve as backup for greater resiliency. This would also optimize resources across space missions.

There are two opportunities for Air Force Space Command (AFSPC) to implement EGS and optimize overall buying power.

The first is through commercializing routine satellite operations. The Air Force is leaning toward commercializing Wideband Global SATCOM (WGS) operations this year, with other satellite missions to follow.

Routine satellite command and control can be serviced by a commercial operator, which will allow the Air Force to focus personnel on battlefield management tasks and payload mission operations.

The second opportunity is implementing EGS to focus on reorganizing existing ground systems to support a common infrastructure and a multi-mission environment. This would allow for interoperability and a more resilient dispersal or virtualization of space fighting capabilities.

The Air Force can no longer allow every space program to be stove-piped, which is incredibly inefficient, is vulnerable to disruption and provides no holistic situational awareness in space.

To date, there has been a great deal of discussion around common data standards for EGS, which is a positive step towards a more resilient space architecture. Standards for data fusion are very good, but EGS needs to be about defined services as well. A focus on standards alone could quickly evolve to more government requirements, which could be used to promote proprietary, non-COTS solutions.

However, beyond that, focusing on standards eludes a major shift that must occur for EGS efforts to succeed. Where it makes sense, the US Government needs to shift their buying practices and begin purchasing services from commercial space operators. Trying to do otherwise in today's threat environment ensures that systems will be obsolete before they ever make it into space.

The way to ensure EGS considers commercial space services is to make it part of the due diligence process for developing future Air Force satellite mission acquisition strategies.

The current procurement process for a new space system requires review and approval through the Joint Requirements Oversight Council and Congress, through the Joint Capabilities Integration and Development System (JCIDs) and the congressional budget process.

That's a process that takes years, and makes rapid technological innovation impossible. In contrast, buying space services from commercial operators "bakes in" innovation, as the commercial sector is constantly innovating to stay competitive.

The process around purchasing space services greatly increases efficiencies as well as innovation. Military needs would be clearly scoped and the DoD could take advantage of rigorous Service Level Agreements guaranteeing availability and reporting. Government customers would be leveraging decades of commercial operational expertise, and the services can be delivered and operational in a period of weeks and months. The current procurement structure requires years or decades.

Procuring services from commercial space operators is a critical piece for EGS to succeed and keeps the DoD ahead of potential space adversaries, increases flexibility and resiliency and is the only way to innovate rapidly.

Commercial space is an incredibly competitive market, with operators constantly investing in technology to manage their own operations most affordably and to stay ahead of the competition.

If the USG can make the procurement shift from making systems to purchasing commercial services, they, too, will stay ahead of their competitors. This will increase resiliency and allow DoD to innovate rapidly in and through the Space domain.

intelsatgeneral.com/