

SatCom For Net-Centric Warfare January/February 2011

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***Image: AEHF
courtesy of Lockheed Martin
and Northrop Grumman***



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About the cover image

The U.S. Air Force’s Advanced Extremely High Frequency (AEHF) system is the nation’s nexgen military strategic and tactical relay system, which will deliver survivable, protected communications to U.S. forces and selected allies worldwide. When fully operational, the system will consist of four crosslinked satellites, a ground mission control center, and user terminals. The AEHF system provides joint, interoperable, assured connectivity for warfighters in operations in all levels of conflict — a capability not available through other planned military communication networks. AEHF provides greater capacity and more flexible coverage than its predecessor, Milstar, while assuring operational continuity through compatibility with the Milstar constellation.

Under contract to Lockheed Martin, the AEHF prime contractor and overall space system manager, Northrop Grumman, builds and integrates the AEHF payload that consists of processors, antennas, radio frequency subsystems and crosslinks. The payload delivers the new XDR (Extreme-Data Rate) communications services, providing data rates up to 8,192 Mbps per user, Milstar LDR (Low Data Rate) services (75-2,400 bits per second), and Milstar MDR (Medium Data Rate) services (4.8 Kbps-1.544 Mbps). AEHF delivers the flexible connectivity-on-demand needed to achieve 21st century objectives — swift, decisive outcomes based on information dominance. On-orbit processing provides the flexibility needed to rapidly establish and reconfigure networks to meet dynamic command and control requirements.

Electronically steerable antenna beams and flexible channel-to-beam mapping allow the delivery of capacity when it’s needed, where it’s needed. EHF frequencies, onboard digital processing, and highly directional antennas reduce the probability of jamming and intercept, assuring secure, reliable communications. Satellite crosslinks enable flexible global communications without the need for fixed site ground gateways.



MILITARY COMMUNICATIONS A KEY TARGET FOR SATELLITE SERVICES

AUTHOR: DUSTIN KAISER, SENIOR SPACE ANALYST, FUTRON

KEY MILITARY MARKETING TRENDS

The strongest trends impacting military demand for commercial satellite capacity over the next decade include growing use of satellite capacity to support new types of warfighting, which are increasingly dependent on broadband communications. Key among these are the expanded global troop

deployments, primarily by U.S. defense forces, as well as use of satellites to support *Intelligence, Surveillance and Reconnaissance (ISR)* activities, in particular those carried out using a variety of *Unmanned Aerial Vehicles (UAVs)* or *Remotely Piloted Aircraft (RPAs)*.



While commercial satellites have increasingly been used to meet these requirements, there is still a bias in the military for specialized, proprietary capabilities, using military satellites.

Given the range of uncertainty regarding development and deployment of new technologies, new regulations, and new market solutions, **Futron's** forecasting includes projection of a series of possible future states, not just a single demand scenario, with the key variables summarized below.

Futron's forecast includes a full alternate view representing conversion of demand into Mbps, with military demand in 2009 estimated at almost 16 Gbps, growing to over 28Gbps in 2019.

While the United States military and security forces represent the largest buyer, demand from international security forces is anticipated to grow in aggregate terms as well as an overall percentage of demand. Fast followers, such as NATO allies and Israel, will continue to require increased supply of commercial capacity.

Other governments in the Middle East, Japan, Australia, and India will also likely require international commercial capacity. The geographic

Trend	Impact on Demand
Continued deployment of U.S. forces within theaters with poor terrestrial communications infrastructure	
Increased reliance on sensor platforms such as crewed and remotely piloted aircraft	
Deployment of extensions to the U.S. DoD's Wideband Global SATCOM (WGS) constellation	

Futron's assessment of demand for commercial military satellite communications suggests that the market is significantly larger than generally perceived, due to sizable demand for classified operations and agencies, as well as a rapidly increasing international customer base.

Futron estimates the 2009 market size for the military segment at 390 TPEs for C-, Ku-, and Ka-bands, with a baseline forecast for the addition of almost 300 units through 2019, or 5.6 percent annual growth over ten years.

demand requirements will include in-theater operations as military communications are pushed lower into the warfighter ranks, as well as "home country" demand tied to training, backhaul, and redistribution of data.

ASSUMPTIONS/METHODOLOGY

While Futron's forecast covers global military demand for commercial satellite communications capacity, it is estimated that U.S. military demand accounts for approximately 90 percent of global military demand for commercial satellite services.

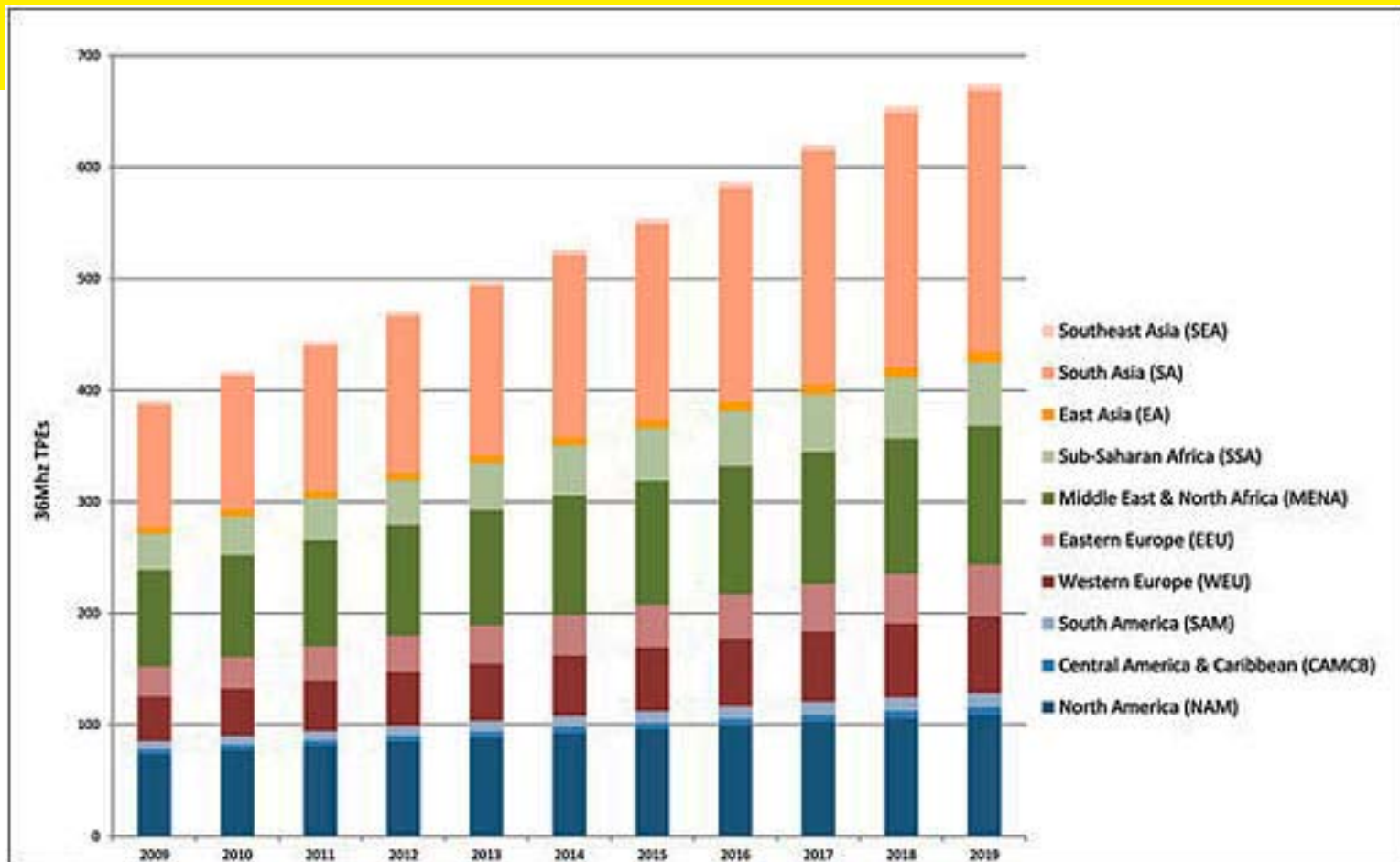
The rate of growth in demand for non-U.S. defense agencies is expected to grow at a rate similar to that of the U.S. military.

The 2010 Futron ten year forecast of military demand for commercial satellite communications is developed based on a bottom up terminal forecast model. Within the model, demand is analyzed separately amongst aerial, maritime, land mobile, and land fixed terminal programs.

Terminal demand is analyzed for growth in total number of terminals, terminal throughput, terminal spectrum usage, and overall terminal utilization levels within ten regions and the oceans. Demand is then

assessed across all frequency bands. The results of this analysis are shown in the regional break-out below.

While this year's military forecast does not model demand for secure military communications such as those provided by the Paradigm/Skynet system, the United States Advanced Extremely High Frequency (AEHF) spacecraft, or military demand for commercial narrowband satellite communications, Futron has developed extensive data on this market, and it will be included in future forecasts. This forecast does, however, include X-Band capacity provided on a commercial basis, in addition to C-, Ku-, and Ka-band.



Military Services Capacity: Baseline Demand Forecast by region

DRIVERS/TRENDS

—U.S. + Allied Deployments

The U.S. DoD's FY 2011 budget outlines key structural changes that will increase demand for satellite communications through increases in targeted personnel (e.g., Special Forces) as well the conversion of Army

Multi-functional and Functional Support (MFF)

brigades to a modular design with satellite capability driven down through the brigade to the company level. These are examples of strategic decisions driving military demand throughout the globe.

In addition to satellite communications providing the medium for tactical and strategic force projection, satellite communications supports troop morale. Access to the Internet and the ability to stay in touch with friends and family is a capability that helps retain professional

soldiers within the armed forces during repeated overseas deployments. Morale support will likely become increasingly important as the hyper connected millennial generation constitutes an increasingly larger percentage of the military. To help enable access to commercial bandwidth, the U.S. military is pushing for new military

broadband terminals to be compatible with commercial satellites.

Naval forces are deployed for long periods of time. The U.S. Navy in particular projects military force through the deployment of ships in locations around the globe. These ships currently have an average of 12 Mbps. U.S. Naval planners plan to increase through put to ship to 20–100 Mbps during the forecast period.

—ISR Platforms

Strong growth in UAV/RPA deployments, with associated growth in satellite communications demand, is projected worldwide based on increasing number of systems and exponential growth in their capacity requirements as more sophisticated sensor systems are deployed. New ISR

systems are under development in the majority of militaries around the globe.

In this connection, the U.S. military has indicated its intention to migrate from the current Ku-band to the use of Ka-band to support its fleet of **Global Hawk** vehicles, and plans to deploy an upgraded **Predator** drone, designated the **Gray Eagle**, with advanced communications capabilities that will require up to 50 Mbps satellite communications throughput.

—Wideband Global SATCOM Deployment

The **WGS** constellation is a fleet of military satellites, currently three of which are in operation, which is intended to provide the majority of U.S. military operated satellite communication. Each WGS satellite operates at Ka-and X-band, providing

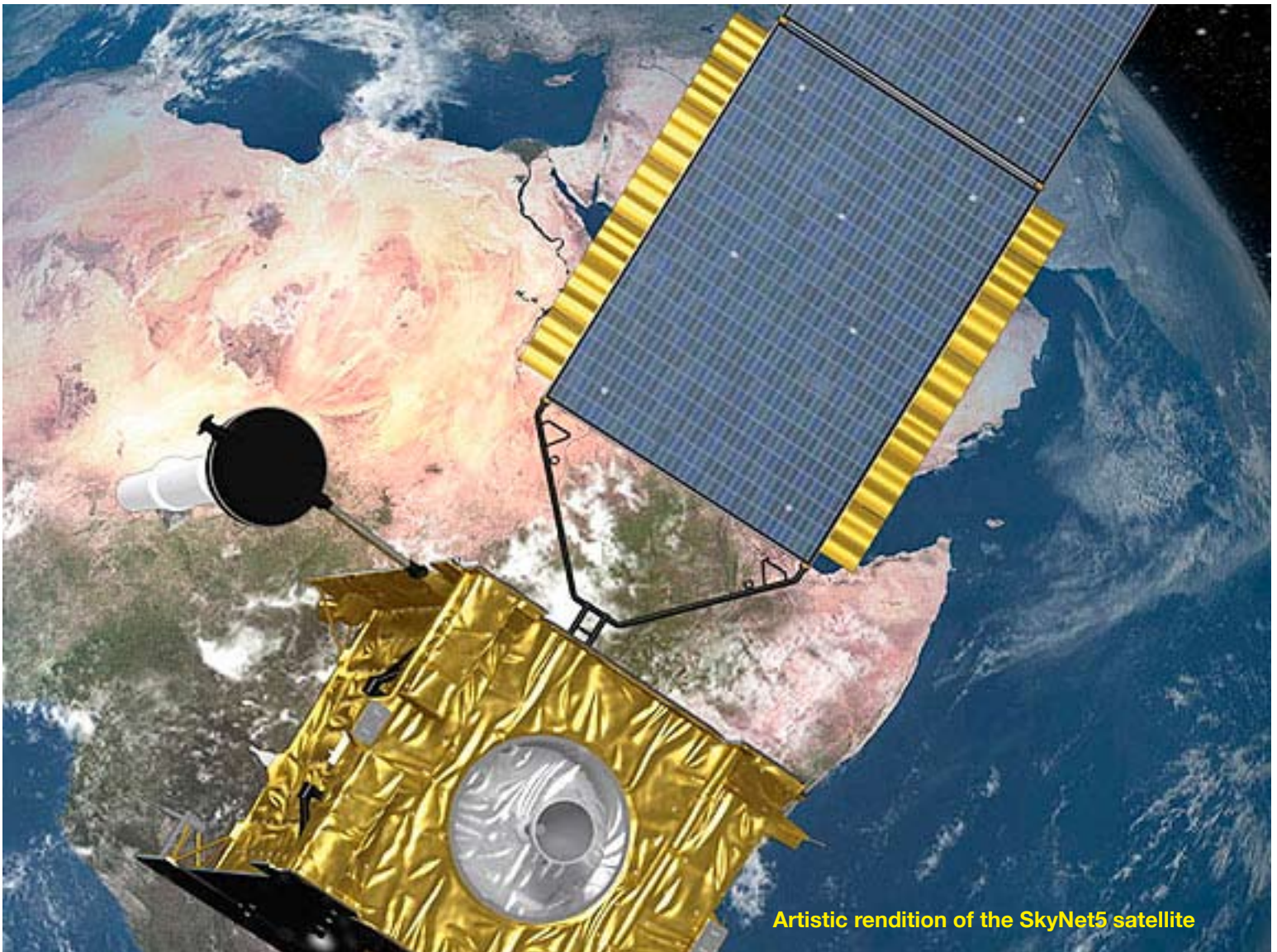


between 2.1 and 3.6 Gbps of data throughput. In addition to the three satellites on-orbit, three more are in production for launch over the next three years, with the last of these being jointly funded by the **Australian MoD**.

The U.S. government also recently authorized \$182 million to start work on a seventh satellite, and it is projected that as many as 12 WGS satellites may be built, some with other allied military funding. The number of WGS satellite procured will impact the level of U.S. military demand for commercial satellite communications.

—Use of Hosted Payloads or Public/Private Partnerships

One alternative increasingly being considered by a number of countries, including the U.S., is the use of commercial satellites to host military payloads either directly or through public/private partnerships. In some cases, such as the **Paradigm Secure** program operated by **Astrium Services** for the **U.K. Ministry of Defence**, the **Skynet** satellites are effectively military satellites operated by a private company.



Artistic rendition of the SkyNet5 satellite

Another variation is the agreement whereby the **Australian Ministry of Defense** has contracted with **Intelsat** for UHF capacity to be owned/operated by the AMoD on an Intelsat satellite, a venture in which the U.S. DoD is also participating. Similar arrangements are also being considered by other bands including Ka- and X-band, including the potential use of the **Inmarsat 5** satellites for military services. To the extent that these are payloads operating in military frequencies, they are not captured in this forecast. The growing interest in, and use of such payloads, may, however, support the deployment of more commercial satellites for both military and commercial services. This will be an important trend to follow in future forecasts.

NEW APPLICATIONS / TECHNOLOGY

Defense requirements for satellite communications include a range of commercial and military frequency bands. While militaries prefer to use their own frequencies, they have recognized the value of the flexibility offered by dual-use capabilities. Multiple military sources have noted the value of having more UHF capacity, particularly in the Pacific Ocean Region, given regional uncertainty/instability, the largely maritime nature of this region, and the lack of other capacity. Another region with specialized needs is Latin America, where the U.S. DoD has increasingly deployed both fixed and mobile satellite resources in support of multiple disaster response activities.

To help address various type of satellite communications demand, commercial providers are considering development of hybrid terminals that can access wideband and narrowband spectrum. Such a capability may allow troops that experience interference in higher frequencies such as Ka-band to gracefully degrade into an L-band link that would provide basic communications capabilities.

Similarly, a multi-band terminal that can access a broad spectrum of frequencies allows troops relying on the terminal to access the best space segment solution at the time of need and provide military planners greater flexibility to manage spectrum usage.

Commercial communications satellites are creating new methods for using satellites that allow for greater flexibility to direct high capacity beams to mobile platforms. Such concepts would allow for high throughputs to mobile platforms enabling greater transfer of data from sensor systems that are continuously increasing in capability.

The U.S. military indicates that it desires to improve its ability to create and manage hybrid networks both terrestrial and satellite based. It has also indicated that improvements are needed in the efficiency of spectrum usage from improved compression to interoperable and dynamic spectrum management.

A range of new applications are expected to drive growth in demand for satellite communications around



**Inmarsat 5
Image: Boeing**

the globe. The increasing availability of information access and the ability to fuse information from various data sets to create useful knowledge is becoming basic to successfully projecting military power, and is a constantly

evolving process.

BUSINESS ISSUES / GAME CHANGERS

While requirements continue to increase, two emerging issues are critical to future operations and military expansion plans.

The first issue is that changing priorities limit the funding/fielding of new military satellites. The second issue is that changing priorities and asynchronous program cycles make it difficult for DoD to match the availability of capacity on orbit with terminal deployments.

These mismatches of capacity, equipment, funding, and demand are driving greater interest in more responsive procurement models. The cancellation of the **Transformational Communications Satellite (TSAT)** has led to a gap in wideband satellite communications capacity for the U.S. military.

To fill this gap, the U.S. military is considering a number of traditional solutions including deployment of a greater number of military operated WGS satellites to other options such as hosted payloads, commercially operated military satellites, and other innovative procurement and operational concepts. In this connection, the U.S. Air Force is in the process of soliciting input from commercial satellite operators to help understand the range of solutions from which it might develop a new systems architecture.

All of these new and evolving circumstances mean that demand is certain to evolve as well. Futron has developed alternative high and low scenarios around the baseline to reflect potential changes in key variables. At the end of the day, however, all forecasts indicate that demand for commercial satellite capacity to serve military users worldwide will continue to expand.

About the author

Dustin Kaiser is a Senior Space Analyst at Futron, where he works with commercial and government clients addressing a range of international space markets from military communications to remote sensing and the commercial spaceflight industry, including spaceports, launch vehicles, and astronaut training. Mr. Kaiser has a B.S. in Aeronautics and is currently completing an M.S. in Space Studies from the University of North Dakota. In addition, he holds a commercial multi-engine pilots license and is an FAA certified flight instructor-instrument.



GEOINT + SATELLITE DATA TIMELY + ACTIONABLE

**AUTHOR: MARV GORDNER
PROGRAM MANAGER, INTELLIGENCE SOLUTIONS
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It is no secret that the Department of Defense (DoD) and the intelligence community (IC) are dealing with a new frontier of information collection and dissemination. Over the past five to seven years, technological advances

in the areas of satellite technologies, geospatial imagery, full-motion video, and other raw data have increased the volume of information available to decision makers and warfighters.



Joint Task Force North Intelligence Directorate Geospatial Intelligence Office provides the JTF North staff and law enforcement partners with imagery support, to include: multiple scale maps, line drawings, and custom geospatial intelligence analysis. [Photo courtesy of JTS North](#)

While the explosion in the development of innovative and forward-thinking data-gathering solutions has created a world of opportunity, it has also caused a tremendous amount of inefficiencies that can actually hinder our missions abroad. Simply put, geospatial intelligence (GEOINT) and satellite data must be timely and actionable in order to serve their purpose.

As a former military intelligence officer, I can say firsthand that getting the right intelligence at the right time is critical. However, the reality is that from a data retrieval standpoint, it takes weeks for the necessary information to get into the hands of warfighters and other decision makers.

A few weeks is an extremely long time to wait, especially when intelligence data must be received within days or hours in order to be effective.

As a result of this “data traffic jam,” our troops repeatedly engage in the same battles in the same locations, creating an endless loop of warfighting that does not advance the mission and, frankly, quells the morale of our troops.

A main driver of this issue is the proliferation of GEOINT and satellite data collection technologies over the past decade. Advancements in **Light Detection and Ranging (LIDAR)** as well as the surge in **unmanned aerial vehicles (UAVs)** have created an influx of data that is simply too overwhelming for analysts to handle. UAVs alone generated 24 years worth of video footage in 2009. In 2010, they were expected to generate

30 times that amount of data, and 2011 will most likely prove to be another year of UAV data overload.

Military leaders are also starting to come to terms with this issue. According to a recent article in *Defense Industry Daily*, Lt. Gen. **David A. Deptula**, the U.S. Air Force deputy chief of staff for intelligence, surveillance, and reconnaissance, said, “We are going to find ourselves in the not-too-distant future swimming in sensors and drowning in data.”

On top of that, it is estimated that intelligence analysts spend approximately 80 percent of their time conducting research (essentially sifting through incoming data) while just 20 percent of their time is focused on developing actionable solutions. Clearly this distribution of effort should be altered so that analysts are able to develop actionable and timely intelligence that moves the ball forward.

If we look at the history of using aerial and satellite imagery in war, we can actually trace this data explosion back to a few key moments.

During **World War I**, the U.S. military first used aerial photographs to provide accurate overviews of battlefields, troops on the move, and resources such as factories and bridges.

By **World War II**, specialized photoreconnaissance aircraft were introduced, bringing new challenges such as deciphering enemy countermeasures that involved fake



1914 camera photo reconnaissance cameras...the pilot held the huge camera over the side of the plane and acquired photos from approximately 12,000 feet in the air. [Photo courtesy of The History Blog.](#)

units that were deployed to cause faulty intelligence gathering.

Fast forward to 1995, when in an effort to end the conflict in Bosnia, President *Clinton* gathered key representatives from the warring factions to meet in Dayton, Ohio. In preparation for this meeting, the U.S. delegates relied on mapping and topographic data from the

Defense Mapping

Agency and the ***U.S. Army Topographic Engineer Center***, which ultimately led to the creation



of the ***National Imagery and Mapping Agency (NIMA)***.

By 2003, and living in the aftermath of the September 11th terrorist attacks on American soil, NIMA changed its name to the ***National Geospatial-Intelligence Agency (NGA)***, and the concept of *geospatial intelligence (GEOINT)* came to fruition.

The U.S. had just completed several years of massive technological innovations during the dot-com era. Coupled with the nation's new terror threats, the U.S. was poised for a boom in the development of GEOINT technologies.

During this era, the DoD and IC also relied on members of industry to develop key GEOINT innovations. This created major business opportunities for the larger defense contractors and spawned a world of smaller companies creating advancements in the areas of full-motion video, 3-D imagery, remote sensing LIDAR, GeoPDFs, and cloud-based solutions.

Looking toward the future, the next generation of satellite imagery and data retrieval will likely put the power directly into the hands of the end user. This vision was advocated by *Letitia Long*, the director of the NGA, at the recent ***GEOINT Symposium*** in New Orleans. She spoke primarily of providing online and on-demand access to GEOINT knowledge, ultimately granting access to the agency's content, services, and expertise through more open-sourced solutions.

This is a laudable vision for the future of the NGA, and living in today's world of user-generated content, it makes perfect sense. But the key to bringing this vision to life is ensuring that the open source data is relevant, real, and actionable. The real GEOINT revolution will be about finding solutions for data retrieval that allow for effective information sharing.

The recent disclosure of key classified documents by *WikiLeaks* may cause more barriers for successful information sharing. However, any changes that result from this disclosure will likely take place on the policy level, and may trickle down to impact the day-to-day use of intelligence data.

Despite the new information sharing challenges facing the *Office of the Director of National Intelligence (ODNI)*, there is still a need for tangible



During World War II, Germany used their Henschel Hs 126 for military reconnaissance.


retrieval innovations — and the ODNI is moving forward to address these issues. Prior to the WikiLeaks issue, the ODNI had already taken steps to deal with information sharing issues.

By appointing *Robert Cardillo* to serve as the deputy director for intelligence integration, the ODNI united the roles of analysis and collection to advance information sharing and collaboration between these two essential functions.

The U.S. Army is also making an effort to enhance information retrieval by expanding its intelligence databases. By adding regional analysis capabilities, data will essentially be stored in distributed data warehouses that allow analysts to access and share actionable intelligence to support forces in theater. The Army intelligence brigades will use these tools to store and study data before providing it to deployed forces.

From a technology innovation standpoint, the IC is also starting to tap into logic algorithms that overcome the human challenge of situational understanding by using dynamic planner tools to expedite combat and interagency decisions.

Other solutions include enterprise web-based portals to aid in collecting, analyzing, and ultimately converting vast amounts of raw intelligence and open source data into actionable intelligence — as well as keeping everyone in the enterprise informed and maintaining a flat organization.

Although steps have been taken to address the GEOINT and satellite data distribution issue, many inherent challenges remain. And as long as innovations continue to emerge in the collection department, we will be swimming in a sea of data. We will eventually reach a tipping point and there will be a shift toward making data actionable and usable. Hopefully 2011 will be the year that this happens. 

About the author

Marv Gordner serves as Program Manager in the Intelligence Solutions division at MorganFranklin. Mr. Gordner possesses 21 years of extensive leadership and management experience in the Department of Defense and intelligence fields. He is a retired Military Intelligence Officer and Lieutenant Colonel, with service including the 101st Airborne Division and Special Operations Forces, including 5th Special Forces, 3rd Special Forces, and the Joint Special Operations Command (JSOC).

For additional information regarding MorganFranklin, their website is located at...

<http://www.morganfranklin.com/>

JOSEPH W. TRENCH **V.P., NAVIGATION SYSTEMS** **LOCKHEED MARTIN** **SPACE SYSTEMS COMPANY**



Under Mr. Trench's leadership, the Navigation Systems mission area is responsive for the design, development, and production of the GPS IIR/IIR-M and GPS III programs. The mission area leverages technology, program management, and operating excellence gained through GPS program execution to drive growth and develop innovative, affordable Position, Navigation and Timing (PNT) solutions.

Mr. Trench joined GE Aerospace in April 1978 as a hardware design and development engineer. Between 1978 and 1994, he held a number of increasingly responsible positions associated with the design, development and testing of ground systems used for command and control of Department of Defense and NASA communications satellites. In 1994, Mr. Trench was appointed the director of engineering at Lockheed Martin's Missiles & Space Valley Forge, Pennsylvania facility. In 1996, he was named the Landsat 7 program director. Mr. Trench joined M&DS in January 1999 as the director of Delaware Valley Technical Operations and was soon promoted to vice president in August 2000. In June 2002, he was appointed vice president of the Department of Defense Systems line of business, responsible for ground systems supporting DoD and civil space customers.



MilsatMagazine (MSM)

Overseeing the next generation of GPS spacecraft, you must have as good of an idea as anyone...Just how critical has GPS become to the world?

Joseph Trench

Simply put, the importance of the Global Positioning System (GPS) cannot be overstated. No other satellite constellation in history has affected so many lives in so many ways. With nearly one billion users and counting, GPS has become indispensable to our world.

GPS allows the military to strike with precision when it matters most, and accurately navigate unfamiliar territory with confidence.

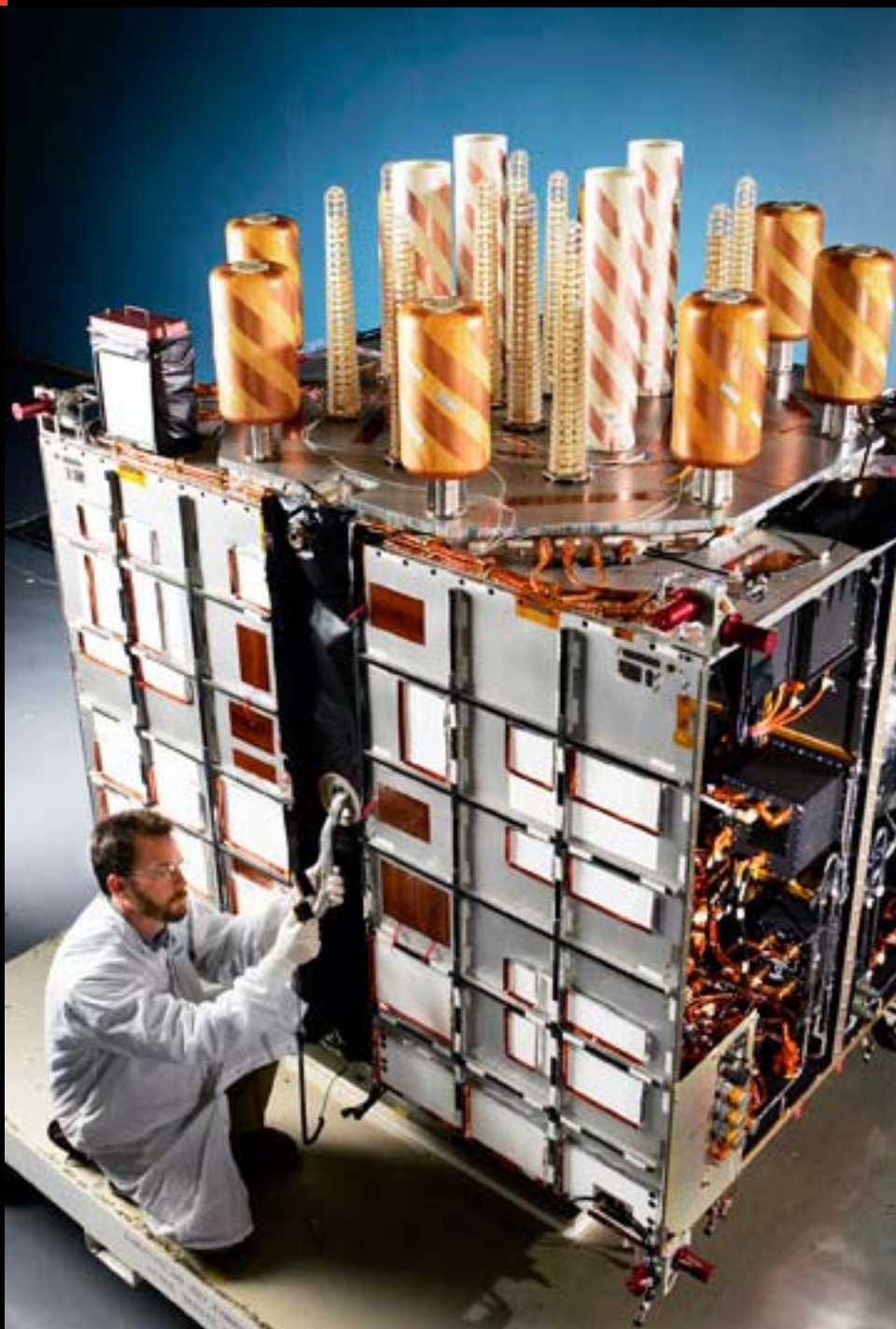
Providing the ability to know exactly where you stand, 24/7/365, GPS has essentially taken the “search” out of the Search and Rescue mission.

More than just a military application though, the use of GPS is now a mainstay of the global information infrastructure. Banking, mobile phone operations and power grid management all depend on the accurate timing provided by GPS. Disaster relief and emergency services use location and timing services to arrive on the scene faster. Farmers,

surveyors, geologists, miners and many other civil and commercial industries rely on GPS to perform their missions more safely, efficiently and affordably.

Our transportation system, in the air, on the ground and at sea, depends on GPS to navigate efficient routes

that reduce fuel use and ensure safety no matter the weather conditions. These are just the most visible industries; new GPS applications are being invented every day. The power to know exactly where you are and at what precise time is tremendously valuable. And now, thanks to GPS, it's easily available.



While not a distant memory, it's hard to imagine a world without GPS. The constellation has been so successful and reliable that the user now either takes the system for granted, or is demanding even more precision and availability. That's why we are building GPS III. As the current spacecraft on-orbit continue to age, but the user demand increasingly expands, GPS III will replenish and enhance the system to meet the needs of any GPS user around the world well into the future.

With the importance of this mission in mind, we are proud to be a partner with the U.S. Air Force and are laser focused on executing and delivering GPS III to provide the critical position, navigation and timing (PNT) signals that keep the world ticking.

MSM

While the GPS III contract was awarded in May of 2008, Lockheed Martin's experience in developing Position, Navigation and Timing solutions started long before that. Can you describe Lockheed Martin's heritage experience in the GPS arena?

Joseph Trench

GPS is not new to us; in fact, the Lockheed Martin-built GPS IIR and IIR-M spacecraft have been and will continue to serve as work horses for the constellation for many years to come. Our team designed and built 21 GPS IIR satellites for the Air Force and subsequently modernized eight of those spacecraft, designated GPS IIR-M, to enhance operations and navigation signal performance. The current fleet of Block IIR and IIR-M satellites has reached more than 120 cumulative operational years on-orbit with a reliability record of better than 99.9 percent.

We are also engaged in the operations and sustainment of the constellation, and work closely with Air Force Space Command to maintain and monitor the GPS IIR and IIRM satellites on orbit to ensure the very best service for the military and civilian end users.

While Lockheed Martin has played a large role in GPS, the system's success is a product of the hard work and dedication of countless government and industry organizations. All the credit in the world goes to the U.S. Air Force for successfully managing the largest, and one of the most critical military satellite constellations in the world.

MSM

Compared to current spacecraft, what enhancements will GPS III bring for the user?

Joseph Trench

GPS III will usher in a new era of vastly improved PNT capabilities, while also reducing the cost and labor needed to operate and sustain the satellites throughout their life cycle.

GPS III will improve position, navigation and timing services and provide advanced anti-jam capabilities yielding superior system security, accuracy and reliability. The first increment, in a planned three increments, GPS IIIA will deliver signals three times more accurate than current GPS spacecraft and provide three times more power for military users, while also enhancing the spacecraft's design life and adding a new civil signal designed to be interoperable with international global navigation satellite systems.

This will dramatically improve GPS Earth coverage for military users, providing them more reliable GPS service anywhere in the world, including canyons, mountains, at sea or in dense urban environments. GPS III's flexible payload also includes the capability to modify signals after launch, which allows the government to better accommodate future requirements without initiating a new space vehicle procurement. The design also has the flexibility to add improved clock capabilities to further enhance precision without major redesign.

To be concise, GPS III will last longer; deliver more capability; and leverage the power of international cooperation — all to meet the ever growing demand of global military and civil users, while also reducing the life cycle cost to the U.S. government.

MSM

You have mentioned the success and reliability of the current GPS constellation to date, so why do we need GPS III?



Joseph Trench

The current GPS constellation has performed extraordinarily well, and provided fantastic reliability to date. However, the various applications and infrastructures we have discussed that have come to rely on GPS, and maybe even some new applications that have not yet come to market, will require changes and capability enhancements that cannot be accommodated by the current Block II GPS spacecraft.

GPS III is a key portion of an overall GPS modernization effort that will allow the GPS architecture to affordably meet the growing and ever expanding military, civilian and commercial user needs now and well into the future.

These enhancements are driven both by technological advances and user demand. Efforts to modernize the second-generation of GPS satellites have been successful in addressing some improvement needs through retrofits to the original design, but these initiatives don't extend far enough and the heritage designs cannot accommodate the enhancements needed in the future.

The GPS III accuracy and availability specifications have been identified as incremental improvements beyond what can be achieved by further modernizing Block II and updating the control segment. A valuable lesson both the government and industry has learned, not just on GPS, but with respect to many space acquisitions, is that the process for changing, developing, testing and implementing

new designs into an operational system can create significant cost, schedule and technical challenges that often result in overrun.

GPS III, designed from the beginning with the future in mind, provides a low risk path to constellation sustainment and incremental capability insertion that can keep pace with the growth and increasingly rigorous demand of users.

MSM

Can you update us on the program's current status and future prospects?

Joseph Trench

The GPS III team successfully completed the program's Critical Design Review (CDR) in August 2010, two months ahead of the baseline schedule. The CDR represented the culmination of 64 lower-level CDRs, validated the detailed GPS III design to ensure it meets warfighter and civil requirements, and allowed the program to begin the manufacturing phase.

Building on the highly successful CDR, GPS III has now transitioned into the manufacturing phase and has completed over 50 percent of its Manufacturing Readiness Reviews (MRRs). Approximately 80 percent of all parts are on order and the program maintains 225 days of margin.

Working shoulder-to-shoulder with the U.S. Air Force and GPS user communities, the GPS III team is currently ahead of schedule and on track to deliver the much needed GPS III capabilities as planned in 2014.

MSM

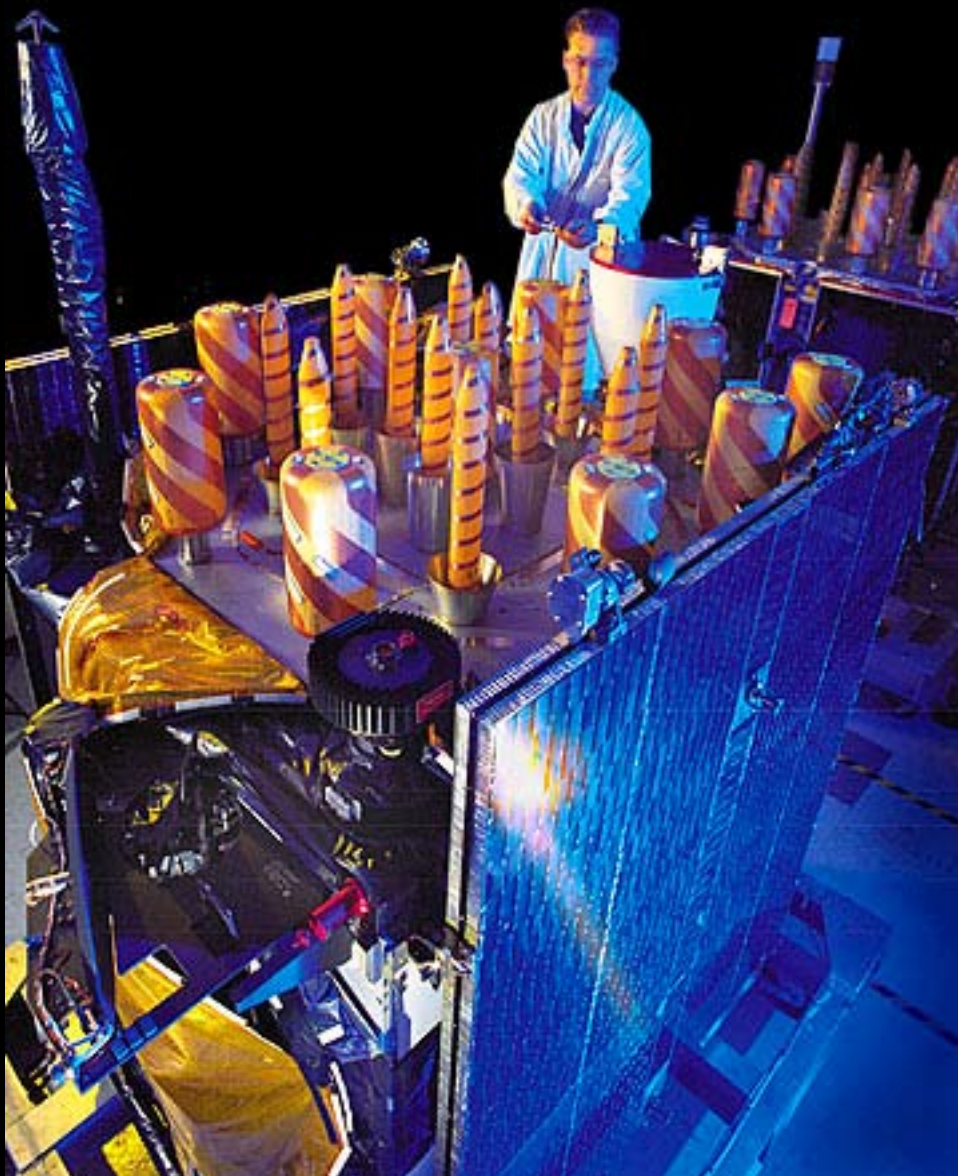
While we have noted that the GPS III team completed its critical design review two months ahead of schedule, large programs like GPS III typically run into its challenges later in manufacturing and testing — can you describe how you intend to meet these challenges while keeping the program on schedule and affordable?

Joseph Trench

Having managed GPS spacecraft development and numerous other space programs, we understand

the challenges that new programs often face. To mitigate risks, we have placed a heavy emphasis on reducing risk through an early and rigorous test program that identifies issues and solves problems before they become costly. With the use of flight-like engineering development units, we are succeeding thus far. Equivalent to flight units in form, fit, and function, these units are used as pathfinders for manufacturing and testing, which allows us to work out potential problems in advance of the flight hardware.

GPS III also procured a GPS Non-Flight Satellite Testbed (GNST) that will trailblaze a path for the first space vehicle. It provides space vehicle design level validation; early verification of ground, support, and test equipment; and early validation and rehearsal of transportation operations. The GNST will run through the same steps of the production flow as the flight vehicles, including environmental testing, through the Lockheed Martin facilities in Newtown, Pennsylvania, and Littleton, Colorado, followed by processing at Cape Canaveral Air Force Station, Florida.



Software development has also been a challenge on many space programs. The GPS III plan delivers qualified flight software prior to integration on the GNST, and well before the flight vehicle's need. A laboratory that provides hardware-in-the-loop testing with flight-like processors is further reducing risk, and ensuring an efficient and affordable software build.

While we recognize that we will face the same challenges that many space programs do, the GPS III team is well postured to meet these challenges, mitigate risk, continue through manufacturing and proceed into integration and test — and ultimately deliver the first GPS IIIA spacecraft in 2014, efficiently and affordably.

MSM

GPS III is often noted for its “back to basics” acquisition approach — would you explain how this approach is being applied and how it is benefiting the program?

Joseph Trench

Yes, the government–industry team adopted a “Back to Basics” philosophy and applied it to the GPS III program. With an incremental approach and stable requirements, capabilities that have less technical maturity or have greater risks of being properly integrated now, are deferred to the later increments when risk is reduced. Next, we are applying government and industry lessons learned over the past decade and reinstated rigorous technical specifications and standards, a strong emphasis on systems engineering, and a robust mission assurance process.

These provide the basis for verifying the quality of the technical work and ensuring issues are surfaced

earlier in the program. Additionally, the Capability Insertion Program is a key element in maturing and integrating the deferred capabilities and assessing new requirements. This approach contributes to greater assurance for meeting schedule and cost commitments and delivering mission success for the end user.

The current GPS III contract includes a Capability Insertion Program (CIP) designed to mature technologies and perform rigorous systems engineering for the future IIIB and IIIC increments planned for follow-on procurements. Eight GPS IIIB and 16 GPS IIIC satellites are planned for later increments, with each increment including additional capabilities based on technical maturity.

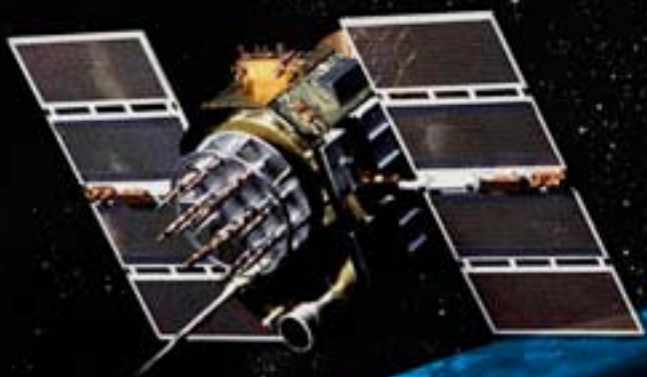
When fully deployed, these enhancements will contribute to improved accuracy and assured availability to meet the expanding needs of military and civilian users worldwide.

MSM

Who are the main GPS III team members, and where will different aspects of the program take place?

Joseph Trench

The GPS III team is led by the Global Positioning Systems Directorate at the U.S. Air Force Space and Missile Systems Center, based at Los Angeles Air Force Base, California. Air Force Space Command’s 2nd



GPS IIIA, image courtesy of U.S.A.F. Space & Missile Center, LAFB

Space Operations Squadron (2SOPS), based at Schriever Air Force Base, Colorado, manages and operates the GPS constellation for both civil and military users.

Lockheed Martin is the GPS III prime contractor, with teammates ITT of Clifton, New Jersey, and General Dynamics of Scottsdale, Arizona.

MSM

The Government Accountability Office (GAO) has released two reports now citing a possible gap in GPS coverage in the future. What is the health of the GPS constellation going forward, what are the chances of a gap in coverage, and what needs to be done to ensure a robust constellation?

Joseph Trench

Well, I'd like to first commend Air Force Space Command and the GPS Directorate at the Space and Missile Systems Center. Together, they have fielded and are operating the most robust GPS constellation in history. While the constellation is healthy, and a gap in coverage is not likely, the GAO report does underscore the importance of GPS and the underlying need to maintain a strong GPS architecture. Going forward, steady funding and meticulous management of GPS acquisitions will be critical to ensuring the GPS constellation meets all user requirements well into the future.

While there are many different players and aspects of the GPS sustainment and modernization effort, the Air Force has a tremendous GPS track record, one that I would bet on. To do our part, we are working shoulder-to-user communities to execute GPS III efficiently and affordably. We are on firm footing to deliver GPS III as planned in 2014.



Image credits

All artistic renditions and photographs are courtesy of Lockheed Martin, unless otherwise stated.



A SOFTWARE-BASED APPROACH TO AIRBORNE COTM NETWORKING

AUTHOR: PETER CARIDES, CEO + CTO, TACHYON NETWORKS

In April of 2008, the Department of Defense created a new Task Force empowered to significantly improve ISR capabilities in Iraq and Afghanistan.

The unconventional nature of the wars in both Iraq and Afghanistan demanded persistent and pervasive ISR capability. A key component of this ISR capability is airborne networks, which include sensors and communication systems capable of simultaneously delivering real-time *full-motion video* (FMV), *Signal Intelligence* (SIGINT) and *Communications Intelligence* (COMINT) to field and command personnel. These diverse sensor capabilities operating on airborne platforms are seen as critical to the success of counterinsurgency operations. They also demand high bandwidth communication links from ISR aircraft to users.

This article describes some of the challenges and solutions to delivering multi-megabit per second ISR sensor data from aircraft to *Beyond-Line-Of-Sight* (BLOS) locations. Specifically, this article will discuss the benefits of a software-based approach to end-to-end satellite *Comms-On-The-Move* (COTM) networking.

LIMITATIONS OF HISTORICAL COTM SOLUTIONS

L-band MSS (*Mobile Satellite Services*) providers have offered COTM solutions to commercial aviation and maritime markets for decades. These COTM offerings have been adapted to Government and Military markets from the commercial side. The challenges of using commercial MSS services for ISR platforms include:

- » *High cost of network services*
- » *Lower speeds (typically 200 to 400 Kbps) do not match the data volumes of ISR sensors*



Defense Communications

- » *Network congestion, which is a common occurrence with the shared nature of public networks*
- » *Network security concerns*

Since the licensing of Ku-band FSS (Fixed Satellite Services) for COTM services, however, there has been a growing interest in applying this broadband satellite technology to military applications. This is due to its capability of delivering higher data rates and greater network capacity at a much lower cost. Some of the challenges to widespread deployment of Airborne Ku-band FSS COTM solutions in military applications include:

- » *Systems adapted from the commercial side are aircraft download-centric and don't meet ISR requirements for increased upload speeds.*
- » *The availability of appropriate commercial satellite capacity covering hotspot locations to support the warfighter, especially in remote and rugged forward-deployed terrain is limited.*
- » *The ability to transmit and receive FMV in High Definition (HD) video formats, especially in critical ISR missions across the globe is limited by the capabilities of on-board equipment currently deployed.*

- » *The need for a network-centric system that is capable of delivering reliable and secure video, voice and data "on the move" to the battalion and company levels with reachback capabilities to the divisional level and Continental United States (CONUS) headquarters.*

UNDERSTANDING MILITARY AIRBORNE NETWORKING REQUIREMENTS

In working with the *Department of Defense (DoD)*, prime contractors and the United States military, **Tachyon** was able to better understand and address a broad set of Airborne networking requirements. A few such requirements are listed below:

- » *BLOS Communication systems must be able to handle multiple high data rate applications simultaneously, such as FMV in HD along with SIGINT and COMINT.*
- » *A global commercial satellite footprint is necessary to ensure worldwide coverage as required, especially in active hotspots, and specifically in the current war theater.*
- » *Airborne communications solutions should achieve commonality across multiple airborne platforms, wherever possible, in line with the DoD's broader Network Centric Warfare (NCW) goals and Information Assurance policies.*
- » *Airborne communications should achieve seamless interoperability with*

existing land mobile and maritime communications systems. Preferably, the Airborne COTM solution should be adaptable to the forthcoming Joint Aerial Layer Network (JALN) layer so as to provide required connectivity to air, maritime and ground users in permissive, contested and anti-access threat environments for sustained and surge requirements.

- » Link integrity, accuracy, resiliency and availability of Airborne COTM systems in accordance with FISMA/DIACAP guidelines are absolutely critical and of paramount importance to mission success.

- » Airborne COTM equipment performance, size, weight and power, integration with existing aircraft power and navigation systems, and remote manageability are of vital importance.
- » The implementation timeframe for an Airborne COTM solution must meet the needs of each DoD initiative/program, which in some cases, can be very near-term (months not years).

A COMPREHENSIVE MOBILE NETWORKING ARCHITECTURE

Tachyon has amassed extensive product integration capabilities with sophisticated networks and applications across multiple third party platforms,

as well as a track record of expertise in applicable COTM technology, including high-speed mobile satellite waveforms.

In response to the urgent requirements of the US military, Tachyon has designed and implemented the **aXiom 7300 Integrated Mobile Airborne Network**.



Figure 1: The aXiom Concept
A Comprehensive Mobile Networking Architecture

Figure 1 on the previous page illustrates the Company's mobile networking vision and how such fits into the US military's requirements listed above.

aXiom end-to-end (E2E) managed network solutions are designed for operation over air, land and sea and incorporate a VSAT mobility architecture that can be tailored to deliver a high-quality custom offering with the following elements:

- » *Total E2E solution that focuses on all or any component of each and every facet of the satellite network including integrating and managing remote terminal equipment mounted on board the requisite airborne platform*
- ◇ *Connection to the corresponding satellite hub/teleport, which in some cases is built from scratch*
- ◇ *NOC with customized Network Management System (NMS) tools as required that increase operational efficiency and customer visibility, enabling efficient and secure network management on a 24x7x365 basis*

- ◇ *Financially backed Service Level Agreements (SLA's) that deliver performance and availability guarantees of 99.9 percent*
- ◇ *Strong partnerships with trusted, world-class mobility system integrators*
- ◇ *Acquisition and deployment of satellite capacity as required by the COTM application; and,*
- ◇ *Technical support, training, and maintenance on the use of the E2E network or equipment as contracted*
- » *Truly technology-agnostic integration across every component of the E2E network solution*
- ◇ *A modular architecture that can be easily customized on a turnkey basis to deliver specific solutions in the most diverse and complex environments*
- ◇ *Field-swappable remote terminal modem equipment manufactured by various industry suppliers and waveform technology suppliers, each mounted on-board the requisite mobile platform with matching form factor*
- ◇ *Antenna and antenna control units*
- ◇ *Satellite hub/teleport interfaces on the ground, which correspond to any or all of the above-referenced remote terminal hardware and includes the aXiom Services Platform (ASP)*
- ◇ *Worldwide space segment used by the COTM terminal regardless of operating spectrum or frequency band, namely, Ku-, Ka- or X-band with significant availability in critical areas such as the AfPak Theater*
- » *Software-based ASP that provides seamless integration and operation of all the requisite equipment components on-board mobile platforms with E2E satellite network services...*
- ◇ *Web-based Graphical User Interfaces (GUI) for local and remote command, control and configuration of all Airborne networking components on-board the aircraft including modem, router, antenna, antenna control unit (ACU) and Inertial Reference Unit (IRU)*
- ◇ *An integrated virtual machine host in the aXiom terminal enabling customer-specific applications and services, including virtual network hosting with customer-specific routing, tunneling, quality of service (QoS), and so on*

THE FUNDAMENTAL PHILOSOPHY

Figure 2 on the next page illustrates the on-board components of the **aXiom 7300 Airborne Network** solution. The ASP is an extensible software platform — the embedded intelligence — at the heart of all aXiom network solutions and is used across all of Tachyon's remote COTM terminals and hubs. The ASP enables Tachyon to deliver managed services across the entire OSI layer stack, from the antenna and hardware beneath the physical and link layers, through to the application layer. The Linux-based ASP client resides within the remote COTM terminal on-board the Airborne

platform and interoperates seamlessly with ASP servers at the corresponding Earth stations and teleport gateways.

ASP FUNCTIONALITY

The aXiom 7300 Airborne Network solution integrates, operates and manages multiple vendors' antenna systems, navigational systems, terminal components and Earth station equipment through its software-based ASP. Specifically, the ASP performs all of the traditional functions that are required to support high-performance in satellite networking including HTTP acceleration, WAN & TCP/IP acceleration, MPLS, IP policy routing using DHCP, NAT, IPv6, DNS, ARP, etc.

More significantly, the ASP enables several distinctive capabilities:

- » *Fast network connectivity using high-fidelity link performance (<10⁻¹⁰ bit error rate) and patented pre-fetch technologies, for industry-leading IP acceleration.*
- » *Capabilities include remote field upgrade and net booting.*
- » *Advanced functions for monitoring, reporting and control, including both real-time reporting and capture and analysis of historical performance and trends, both at the NOC and locally by the customer.*

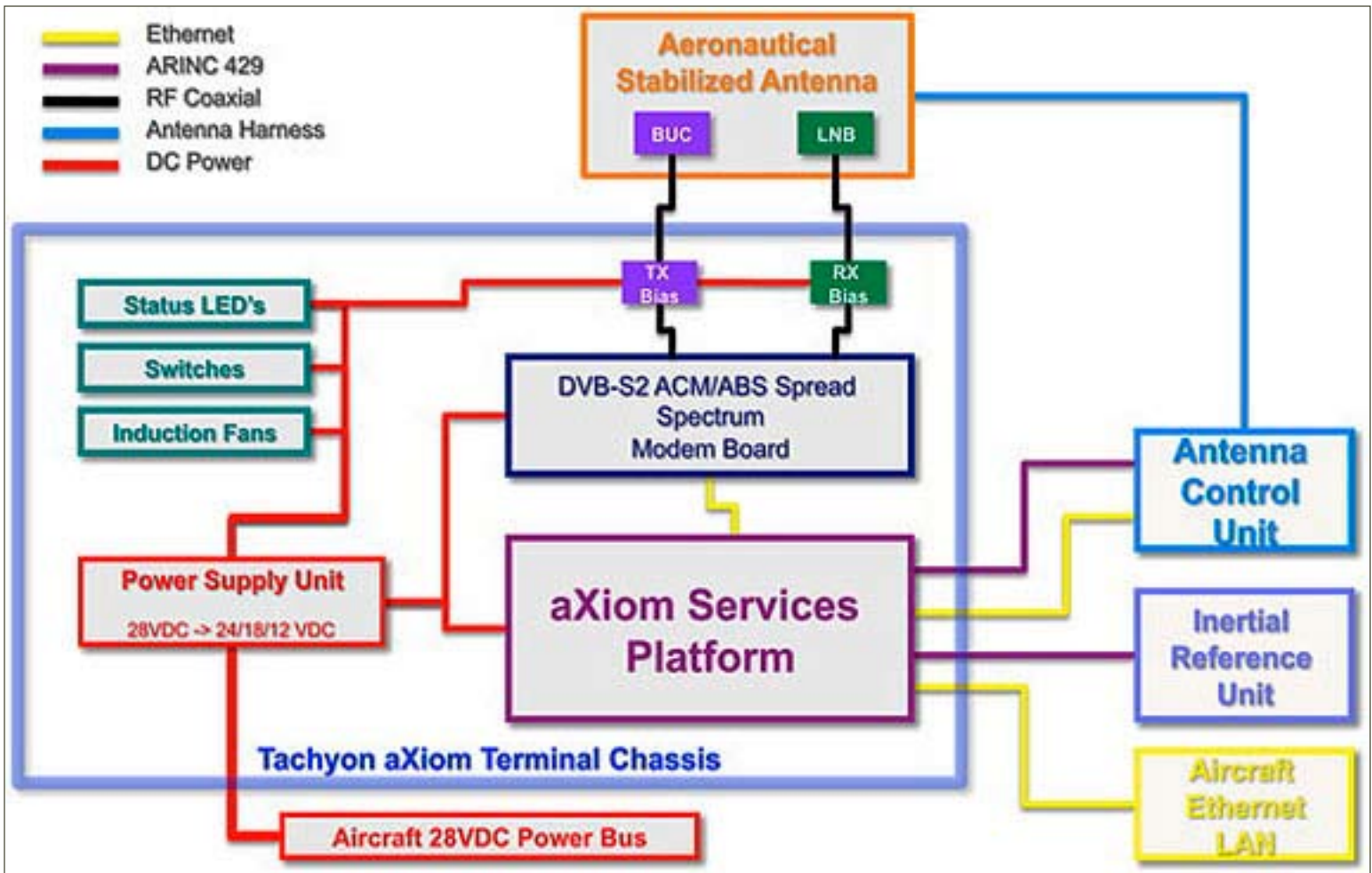


Figure 2: aXiom 7300 On-Board Equipment Diagram

In addition, the ASP image is engineered into all of Tachyon's COTM terminals via **VM Ware** installed on a Linux server. New releases of ASP software reside alongside the existing release on an adjacent Virtual Machine. This feature offers two critical benefits including, ensuring that the ASP is completely stable in a transition from one release to the next, and that the ASP is readily transportable to different hardware platforms. This ASP feature empowers the customer with seamless deployment of new capabilities and a very high degree of reliability and flexibility.

The ASP also enables another key feature in Tachyon's suite of E2E solutions — it provides for sophisticated management, monitoring and reporting with a range of analytical tools. This set of tools provides much greater visibility into the historic and current performance of the network than is currently available from most other service providers. This feature enables Tachyon to operate and manage remote networks more efficiently, and to provide customers with unprecedented visibility into their remotely deployed assets.

The use of VM Ware in the ASP maximizes the use of remote upgrades. Taking the needs of the forward deployed warfighter into account, the ASP comes with a web-based GUI for local and remote command, control and configuration of on-board modem, router, antenna, as well as, the ACU and IRU in the airborne domain.

The deployment of a successful Airborne COTM Network relies on an unwavering focus and dedication to executing each and every step of the total E2E solution, which includes the following:

- » *Remote CPE: Integration of field-swappable custom terminal equipment on various aircraft platforms, using multiple antennas, ACU's, IRU's, routers and modems.*
- » *Teleport: Designing, building, installing and testing completely redundant satellite gateways.*
- » *Network Operations Center (NOC): Performing seamless 24x7 monitoring of all aircraft and teleports from a US-based NOC by developing customized NMS tools to increase operational efficiency and customer visibility.*
- » *Technical Support: Providing a superior customer support helpdesk with professional support personnel*
- » *Space Segment: Enabling the acquisition and deployment of extremely scarce satellite capacity for COTM*
- » *Training: Educating military personnel in the field in the operation of airborne satellite systems*

The Company implemented its first Airborne networking platform based on an initial version of its aXiom mobile network architecture for the U.S. military in the **AfPak Theater** of operations. Tachyon was commissioned

to design, build and operate an Airborne network in Afghanistan, by integrating third party terminals aboard C-12 aircraft, to deliver video imagery to commanders on the ground. Tachyon's E2E solution met the U.S. military's short but demanding list of requirements:

- » *Need to deploy an E2E network incorporating the Airborne-networking platform on a turnkey basis.*
- » *Need for integrated infrastructure/hubs for air, land and sea operations.*

- » *Ability to support required commercial space segment capacity in-theater.*
- » *Need for a proven solution with a small form factor terminal that is light, low-power, fits in a compact space, and minimizes resource consumption.*
- » *Increased bandwidth throughput to support near real-time video feeds.*



AfPak Theater Coverage Map Ku-Band IS-24




AfPak Theater Coverage Map Ku-Band IS-26

Later, in April of 2010, Tachyon also successfully demonstrated its aXiom 9300 Airborne Terminal by streaming full motion video, with sustained return (upload) data rates of 2 Mbps, in flight. The outcome of this effort was the **aXiom 7300 Integrated Mobile Airborne Network** solution incorporating the aXiom 9300, and which, using stationary and inclined orbit spacecraft, streams live full-motion video at data rates of 2 Mbps for display in real time on HD monitoring terminals on the ground.



aXiom 9300 Terminal Router

Today's broader Government/ Military market has an urgent need for E2E managed network services and equipment that can deliver voice, data, high quality HD FMV, SIGINT and COMINT in real-time and while on the move — all of which are accomplished in the aXiom 7300 solution. 

About the author

Peter Carides possesses more than 28 years of experience with a proven track record in the international wireless telecommunications and satellite industries. At Tachyon Networks, Carides lead the company's turnaround, from a loss of \$12m to a profit of \$9m over the past six years. Overall, the company's revenues have quadrupled under his leadership and it has been profitable and self-funded since 2007.

Service coverage areas have also been increased, new products have been developed, and more than a dozen new Fortune 500 Enterprises and government agencies have become satisfied customers.



As CEO & CTO, Peter has personally spearheaded the integration of aeronautical, land mobile and maritime capabilities

into the company's solution matrix, resulting in the aXiom 7000 Series of Integrated Mobile Network Solutions and the aXiom 9000 Series of Aeronautical Communication Routers.

FIELD TRIALS OF MOUNTED BATTLE COMMAND KA-BAND SATCOM “ON-THE-MOVE”

**AUTHOR: PETER WOODHEAD
DIRECTOR OF BUSINESS DEVELOPMENT, EM SOLUTIONS**



Increasing broadband SATCOM *On-The-Move* (SOTM) is a strategic requirement for Network Centric Warfare. Operating at higher frequencies is intrinsically linked to achieving this objective. The *Wideband Global Satcom* (WGS) System offers U.S. DoD and Australia — through joint partnership — an opportunity to access significantly increased SHF and EHF spectrum. This spectrum access is essential in realizing broadband SOTM across a variety of military platforms including air, naval and the more challenging land mobile.

EM Solutions was awarded a contract to develop a *Mounted Battle Command Ka-band Satcom On-The-Move System* under the Australian Defence Force (ADF) *Capability and Technology Demonstrator* (CTD) Program. The objective was to develop a SOTM terminal that was suitable for WGS operation and would allow the ADF to investigate, demonstrate, and examine its potential as a key system supporting the ADF's *Network Centric Warfare* strategy.

The antenna terminal was designed by EM Solutions, with BAE Systems Australia Limited as a major subcontractor. This article offers a brief overview of the antenna terminal,

and then presents some results from field tests conducted with the antenna terminal mounted on a **Bushmaster Protected Mobility Vehicle (PMV)**.

ANTENNA TERMINAL OVERVIEW

— Design Aspects

The antenna terminal was designed to track the **Optus-C1** satellite while mounted on a moving **Bushmaster PMV1**. WGS operation was not required for the CTD, but was an important consideration at every stage of the design. *Figure 1* shows a picture of the antenna terminal with the radome removed as well as the antenna terminal mounted on the Bushmaster.

There were two main requirements driving the design. Firstly, the RF and antenna performance had to support the required uplink and downlink data rates of 4 Mbps and 1 Mbps under typical operating conditions. This is

discussed further in the **Field Trial Setup** section later in the article.

Secondly, the antenna had to track the satellite to within some allowed pointing error. Determination of the allowed pointing error was not trivial, as a number of factors had to be considered. These included: link budget effects of pointing-loss, existing regulations for stationary systems, and interference potential.

After consideration, a design target of 0.3 degree maximum pointing-error was selected.

Two of the earliest design challenges were the selection of the antenna type and tracking method, and until these had been decided upon, design of other subsystems could not progress. A novel implementation of the well proven parabolic reflector antenna was selected as such offered the



Figure 1: Views under the radome, and mounting to the Bushmaster PMV

best electromagnetic performance (i.e., sidelobe), defined tracking requirements, and acceptable dimensioned constraints. (*These were requirements of the CTD project.*)

Once the antenna type was selected, the tracking approach could be considered. There are two main types of tracking. One approach is **Inertial Navigation Unit (INU)** based tracking, where a high performance INU is used to determine the vehicle’s position and attitude — this information is used to steer the antenna to the satellite.

The other approach is closed-loop tracking, where the pointing error

is determined from the satellites beacon. A closed-loop approach was selected, which allowed the use of a less expensive INU, a lower precision mechanical design, and is more robust.

With the antenna and tracking approaches selected, the rest of the antenna terminal could be designed. Some of the main features of the antenna terminal include:

- » **Parabolic reflector in Cassegrain configuration**
- » **Closed-loop tracking using beacon**
- » **Proprietary beacon signal processing**

Tx Frequency Band	30.0 to 31.0 GHz
Rx Frequency Band	20.2 to 21.2 GHz
Reflector Size	480 mm
Tx Saturated Power	4 Watts
G/T	>12 dB/K
EIRP	46 dBW
Beamwidth, 3dB Tx and Rx	1.5 degree (Tx); 2.2 degree (Rx)
Sidelobes (Tx)	Mil-Std-188-164
Polarisation Tx and Rx	LHCP or RHCP (Not Simultaneous, Factory Set)
Axial Ratio	Tx: <1 dB Rx: < 1.5 dB
Azimuth Tracking	360 degree continuous
Elevation	± 90 degree
Tracking Limits Tx (Inhibit)	1 dB (Tx) Pointing Loss
Tracking Limits Rx (Closed-Loop)	3 dB (Rx) Pointing Loss
Tracking Acquisition	< 5 minute cold start-up and while moving < 5 sec due to blockage (<1 minute) after initial lock
Tracking Performance	100 km/hr Seal Road; 20 km/hr Off-road
IF Interface	1.0 to 2.0 GHz
Height	< 750 mm
Diameter	< 1000 mm
Weight	< 150 kg
Power Supply Voltage and Watts	28 VDC, < 500 W Peak

» **COTS motors, motor drivers, encoders, gyros**

» **Proprietary motion control system implemented in FPGA**

» **BUC and LNBS repackaged versions of standard EM Solutions product**

Specification for the antenna terminal are offered in *Figure 2* on this page.

Figure 2: Specifications for the antenna terminal.

Operating Modes

The antenna terminal has a select number of operating states that are visible to the operator. Ignoring the power-up mode, the operating modes are:

- ◇ *Searching*
- ◇ *Tracking*
- ◇ *Gyro Holding*

Searching

The searching mode is basically an open loop tracking mode. It is used for initial acquisition and for re-acquisition when the satellite has not been tracked for extended periods of time. In this mode, the INU is used to determine the vehicle position and attitude, and this information is used to point the antenna toward the satellite.

A limited scan is conducted around the pointing direction calculated from the INU data. If the vehicle is not in motion, the INU cannot accurately determine the vehicle

heading. (*The INU does have a built in compass. Unfortunately, its performance is degraded by the proximity of the antenna positioning motors.*)

In this case, the antenna terminal continuously uses INU attitude information to calculate the elevation

angle to the satellite, and then conducts an azimuth scan. Once the beacon has been detected, the control system switches over to the tracking mode.

Tracking

In this mode, the beacon is used to estimate the pointing-error, which is then used to continuously steer the antenna back to the satellite. If the estimated pointing error is too big, the control system commands the TX to mute. If the beacon strength suddenly drops (*i.e.*, due to obstruction by trees), the antenna terminal switches to gyro holding mode.

Gyro Holding

This mode is used to keep the antenna pointed to the same location in the sky during periods when the beacon is suddenly lost. This can happen when trees or overhead bridges obstruct the path to the satellite. Once the beacon is reacquired, the antenna terminal switches back to tracking mode. If the antenna terminal remains in gyro holding mode for use-set time, the antenna terminal returns to searching mode. (*Once again, the INU does have a built in compass. Unfortunately, its performance is degraded by the proximity of the antenna positioning motors.*)

— *Field Trial Setup*

Field trials were conducted in August 2010, with assistance from *Defence Science and Technology Organisation (DSTO)*, **BAE** and **8/9 RAR** based at **Gallipoli Barracks Enoggera**. During field trials, the SOTM antenna terminal was operated as the vehicle drove on main highways, suburban roads, dirt roads and off-road.

Integration With Bushmaster

Integration of the antenna terminal on the Bushmaster was performed by BAE. The terminal was fitted to the rear-hatch opening using a temporary mounting plate. A baseband system was installed inside the vehicle, and included an **MD-1366 EBEM** modem, an Ethernet router, a reference oscillator, and a PC for monitoring. Satellite services were provided by **DSTO**, which included: a digital TV video signal streamed to the vehicle; video from a forward looking IP camera streamed out of the vehicle; VoIP services allowing phone calls to be placed and received from inside the vehicle; and web-based management displays to assist with monitoring terminal performance.

Link Budgets

DSTO coordinated satellite and modem configurations to achieve various link rates for testing the SOTM antenna terminal. *Figure 3* on the next page gives the link budgets used for maximum data rate and for typical operation during testing. The *ADF Ka-band Defence Payload Segment* onboard **Optus C1** was used for the testing.

Typical Results

To verify correct operation of the antenna terminal relevant internal variables were logged, in conjunction with **Google Earth**, and correlated with location during test drives. This allowed visibility of variables such as operating mode, estimated pointing error, beacon C/N0, motor torques and GPS location.

Logging GPS information was very useful, as it allowed correlating events, such as switching out of tracking mode, with obstructions due to trees and bridges.

Highway + Suburban Roads

Good performance was observed during highway driving. Modem events, such as sync-loss and bit errors, were only observed when obstructions were present. In general, obstruction by trees was not a problem on major highways, as the trees were generally back from the road. On suburban roads, tree obstruction was common. *Figure 4* on the next page shows a typical highway used during field testing, and *Figure 5*, also on the next page, shows the distribution of pointing errors during a 2.5 minute period of highway driving. *Figure 6* plots six minutes worth of data gathered during highway driving.

This data illustrates some common obstructions such as trees, light poles and overpasses. Between obstructions the pointing error was generally less than about 0.06 degrees. During the obstruction, the pointing error in the plots should be ignored, as the error is based on the beacon signal and this is not present during a blockage.

Off Road

Figure 7 shows a typical off-road terrain. As can be seen by comparing histograms in *Figures 5* and *8*, pointing performance during off-road testing was not as good as during highway driving. The pointing error histogram, shown in *Figure 8* is correlated with the off-road data shown in *Figure 9*. Most pointing error recordings are less than 0.1 degree, however the maximum recorded pointing error recording was nearly 0.2 degrees.

Link Budget Parameter	PMV to Anchor	Anchor to PMV
Maximum Data Rate		
Data Rate (kbps)	2048	8000
Uplink EIRP (dBW)	46	70
Downlink EIRP (%)	0.5	88
G/T (dB/K)	32	12
Allocated BW (%)	6	23
EbNo (dB)	2	6
Typical Data Rate		
Data Rate (kbps)	1024	2048
Uplink EIRP (dBW)	46	64
Downlink EIRP (%)	<0.5	23
G/T (dB/K)	32	12
Allocated BW (%)	3	6
EbNo (dB)	5	6

Figure 3: Link budgets for maximum data rate and typical operation.



Figure 4: Typical highway used in testing.

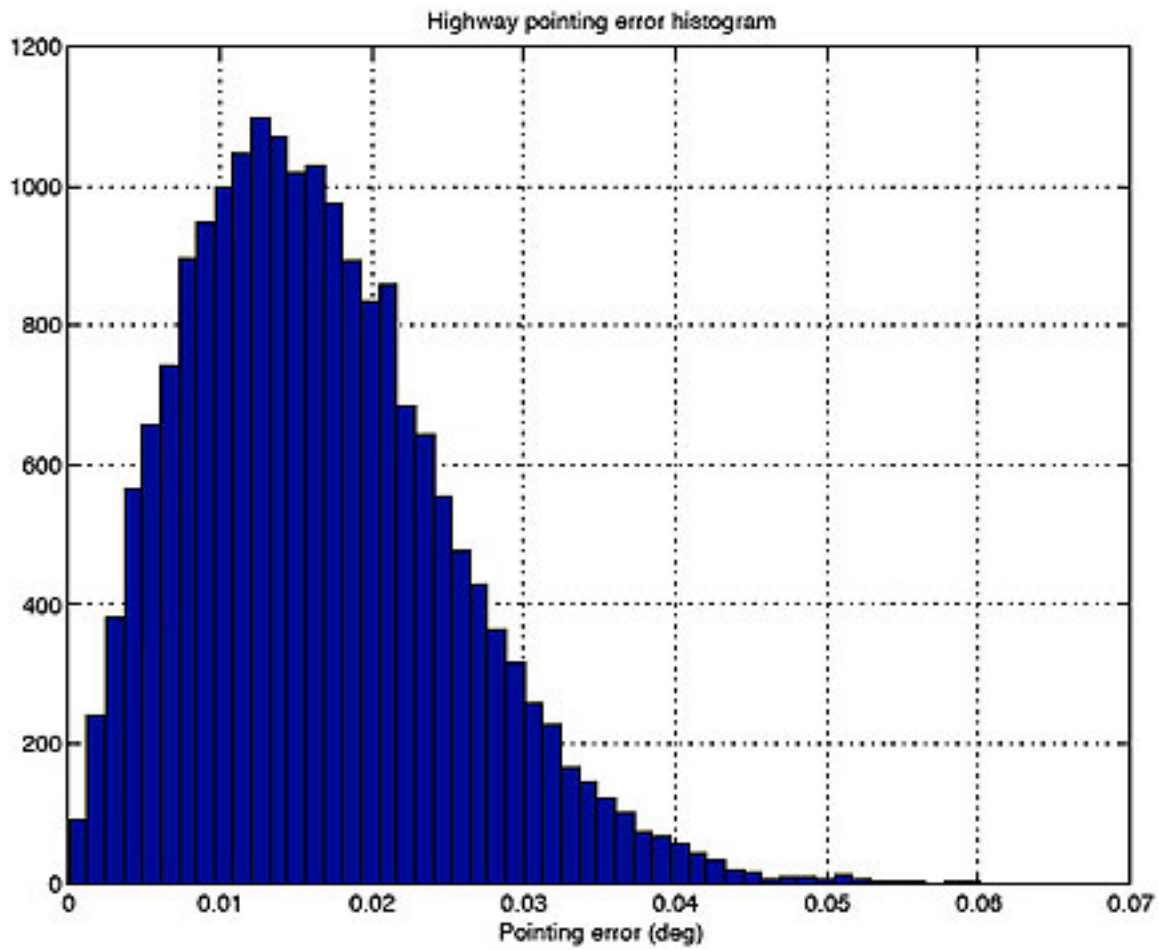


Figure 5: Histogram of highway pointing areas over a 2.5 minute period with no obstructions.

COMMON OBSTRUCTIONS

— Overpasses

Overpasses were encountered frequently during highway driving.

Figure 10 shows data gathered when passing under an overpass. Upon encountering the obstruction, the antenna terminal detects a rapid drop in beacon signal power and switches to

gyro holding mode (shown as light-blue in plots). Gyro holding keeps the antenna pointed at the satellite's position, so that after leaving the underpass the antenna terminal can quickly return to tracking mode.

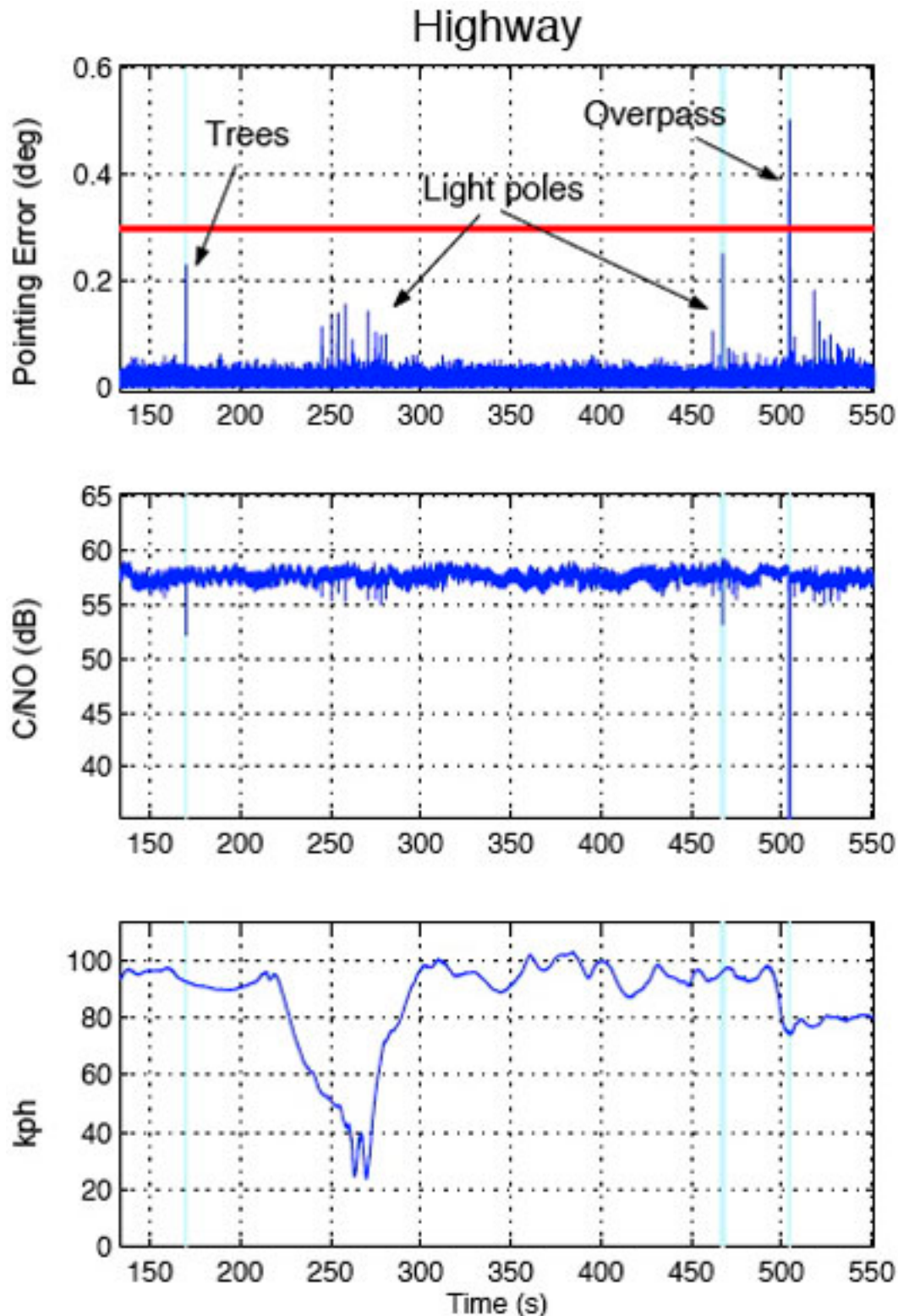


Figure 6: Highway performance.

The reacquisition time was typically much less than one second during the field trials, and in many cases this enabled the satellite modem in the PMV and the anchor station to maintain carrier lock through these blockages.

The view of the overpass is illustrated in Figure 11.

Trees and Light Poles

Figure 12 shows a typical highway scenario as seen from the Bushmaster PMV,



Figure 7. Off road terrain.

note the light poles in the view. Trees and light poles close to the road

edge can produce very short term obstructions. *Figure 13* shows the

effect of driving past a series of light poles. In this case, the light poles produced short term reduction in beacon C/N0 (*Note: Pointing errors should be ignored*). However, the EBEM modem still retains lock with these types of short-term transient interruptions.

Modem bit sync loss was a common occurrence, with a short interruption to data flow. Importantly, carrier lock loss was not common.

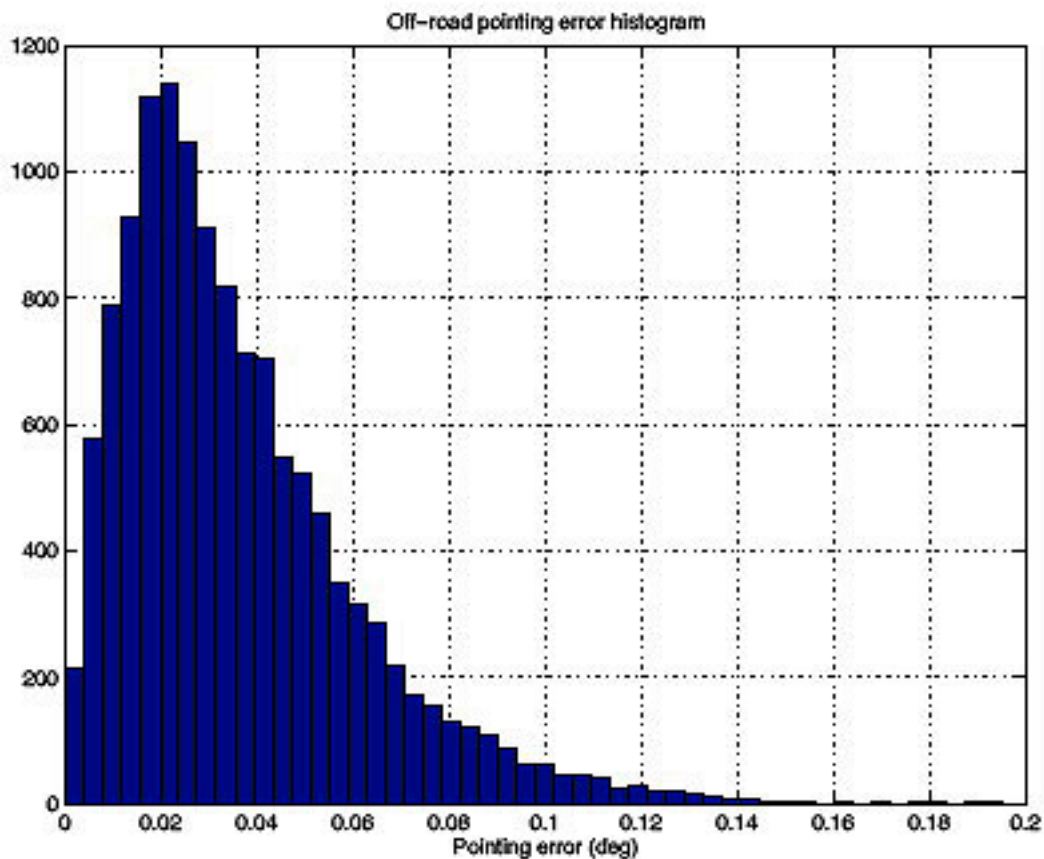


Figure 8: Histogram of pointing error for off road data shown in Figure 9.

Tunnels

Tunnels obviously produce an extended blockage to the satellite, and drift of the gyros can result in a significant antenna mis-pointing when the vehicle exits the tunnel. The actual pointing error can be so large that the satellite would not be reacquired. To handle this situation, the antenna terminal switches to search mode after an extended period of gyro holding.

The response to extended blockage during motion was tested by driving the Bushmaster PMV through a 6.8 km tunnel in Brisbane. The tunnel takes approximately four minutes to transit. This satellite blockage is long enough for the antenna terminal to revert to the search mode as the Gyro-hold timeout was set to one minute in field tests. In this particular test, it was observed that the antenna terminal acquired the satellite approximately

45 seconds after exiting the tunnel. It should be noted, however, the reacquisition process was made more difficult by the presence of a number of overpasses and large metal overhead street signs at the exit of the tunnel.

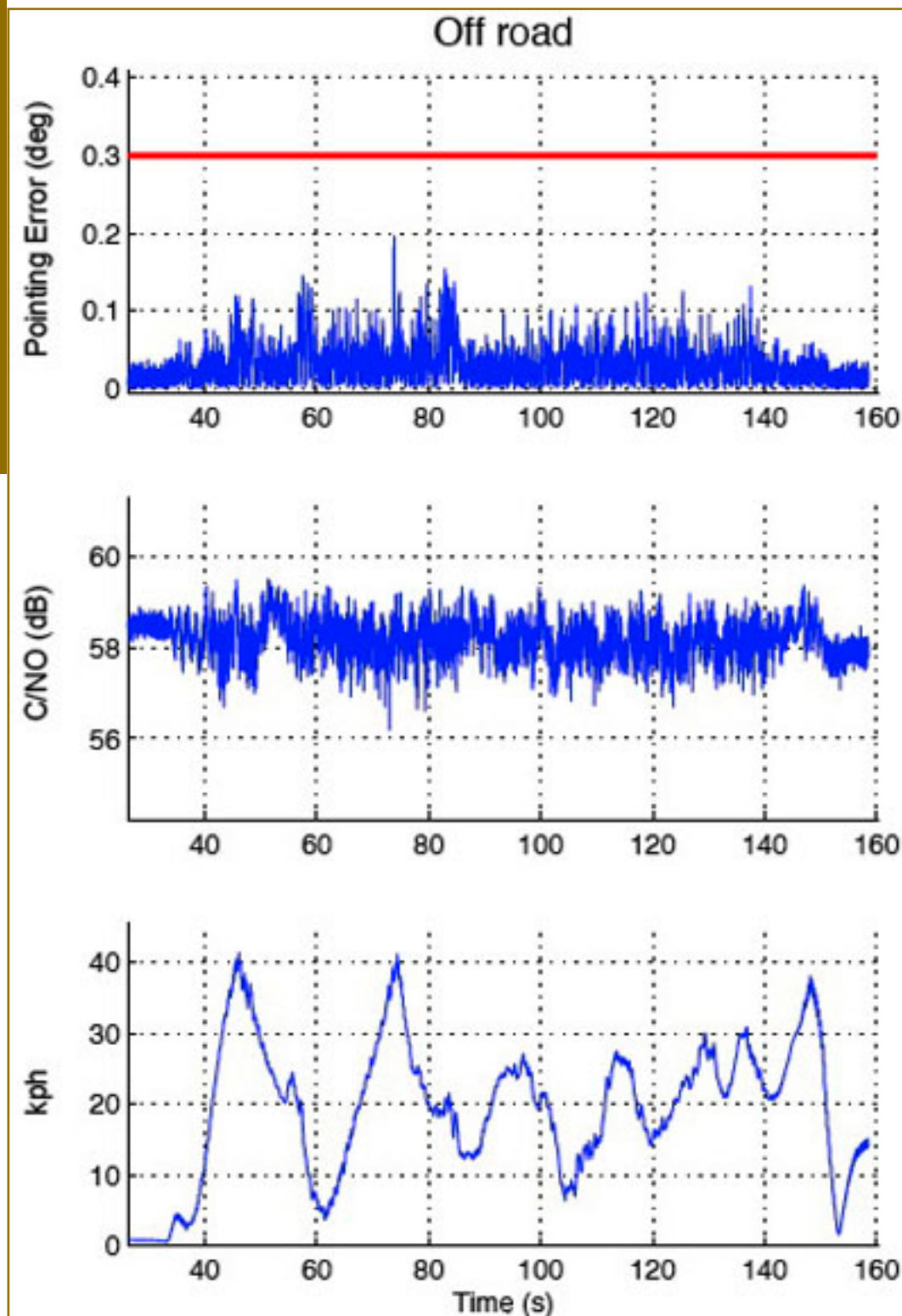


Figure 9. Off road results.

CONCLUSION

A Ka-band SOTM antenna terminal has been developed and demonstrated under the Australian CTD program. The antenna terminal has been field tested on a Bushmaster PMV on sealed roads, dirt roads and off road.

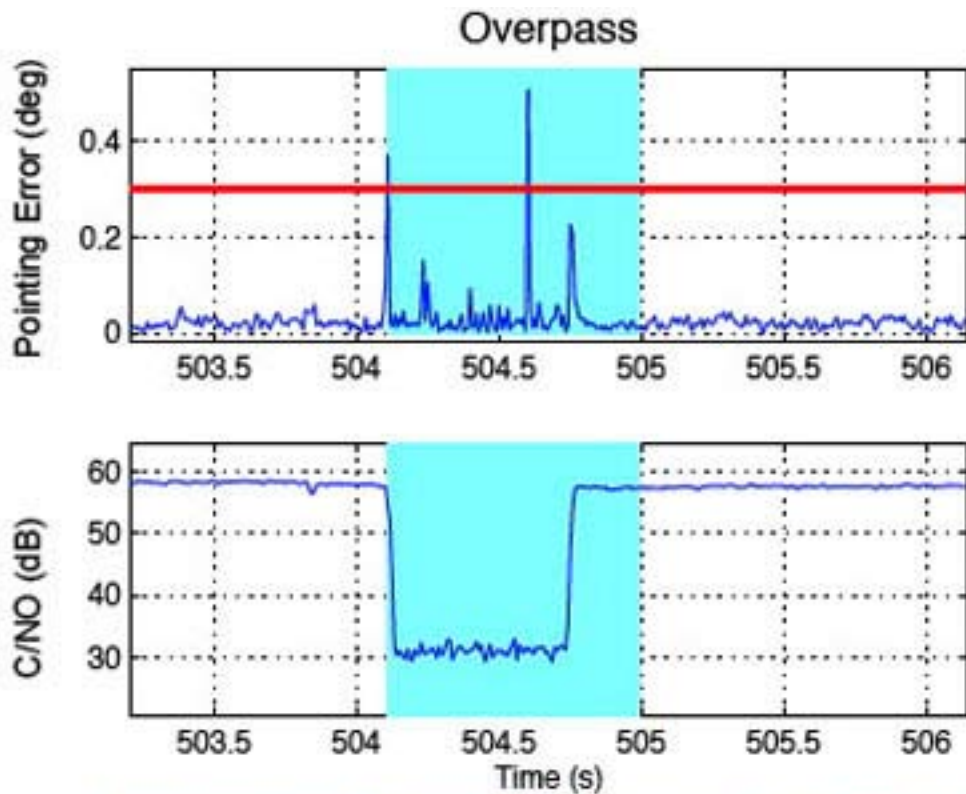
The antenna terminal demonstrated downlink data rates of 8Mbps and uplink data rates of 2Mbps on the Optus-C1 satellite.

A standard *Frequency Division Multiple Access (FDMA)* modem is not the most appropriate waveform for use in an environment that includes blockages. A more burst acquisition nature modem, with shared outbound (to vehicle) carrier, to improve satellite power efficiency, would be preferred.

About the author

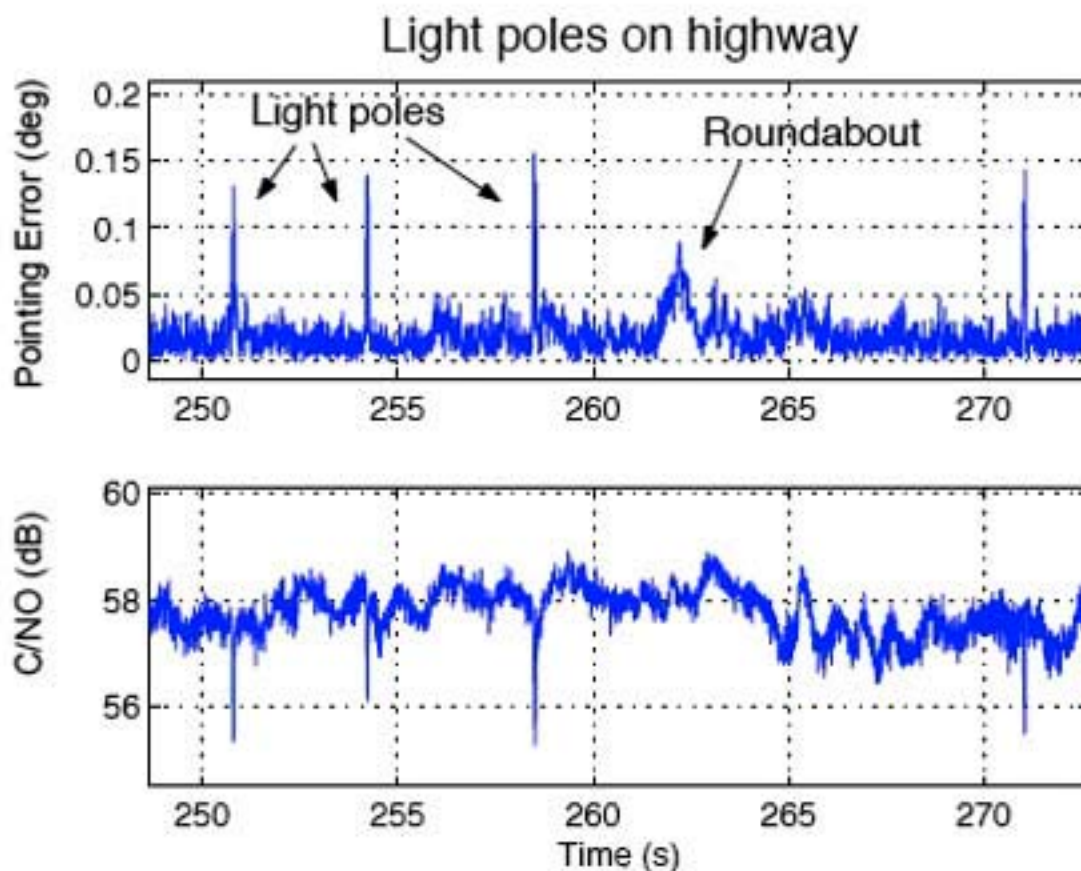
Peter Woodhead has been directing EM Solutions' business and product developments since its establishment in 1998. He has 30 years experience in design, manufacturing and service industries including over 20 years in the telecommunications sector, and holds an Engineering Degree and MBA in marketing.





Top—Figure 10: Effects of driving under an overpass. The light-blue background indicates gyro holding periods.

Bottom—Figure 11: Google Earth view of the overpass.



Top—Figure 12: Image showing the light poles from Figure 13. Taken from forward looking video camera mounting in the Bushmaster.

Bottom—Figure 13: Illustration of effects of light poles beside road.

THE ATLAS HERITAGE

AUTHOR: JOS HEYMAN, FBIS, TIROS SPACE INFORMATION

One of the main launch vehicles currently in use, the Atlas V, has a long heritage commencing in the late forties. This article summarizes the various developments that led to the current launch vehicle and, as the current Atlas V has little in common with the

original Atlas missile, other than the name, the Atlas development is considered as a good example of incremental technology development.

EARLY EXPERIMENTS

Although the development of the Atlas intercontinental ballistic missile did not commence until 1951, the “thin skin” tank, which had to be pressurized at all times, had been developed in the late forties for the **Convair MX-774** missile.

The MX-774 had a length of 9.93m and a diameter of 0.76m and was powered



An Atlas V launch, photos courtesy of United Launch Alliance



Convair MX-774 missile

by four **Thiokol** solid fueled motors. The first launch was on July 13, 1948, with further launches on September 27, 1948, and December 2, 1948.

Further studies were conducted as **MX-1593**, commencing in January 1951 and, later that year, the military designation **XB-65** was assigned to the project.

By 1953, the initial design studies had been completed and envisaged a vehicle with five engines. It was decided to develop a single engined test vehicle powered by a North American **XLR43-NA-5** rocket engine and designated as **X-11**. Some reference sources have suggested that the X11 program covered only one flight, *i.e.*, the prototype of the **Atlas A**, which was launched on June 11, 1957. The **Atlas A**, however, was equipped with three engines rather than the single engine that was specified for the X11.

X-11 AND X-12

The subsequent **X12** was a 1-1/2 stage rocket ballistic test vehicle for the **SM65**. The program was initiated in 1953 in parallel with the X11 and was a three engine version, with three North American **XLR43NA5** rocket engines.

Some reference sources have suggested the X-12 covered the second Atlas A flight, which was launched from **Cape Canaveral** on September 25, 1957, and was destroyed during the flight. The suggestion that this flight was the X-12 is certainly incorrect and neither the X-11 nor X-12 was ever flown.

The five engine XB-65 version never materialized as nuclear warheads had become lighter in weight. The initial prime contractor of the Atlas was **Convair**, which later became **General Dynamics**.

In 1994, the rights to the Atlas launch vehicle were sold to **Martin Marietta**, which merged with **Lockheed** in 1995 to become **Lockheed Martin**.

ATLAS

As a missile, the Atlas carried military designations **XSM-65A (Atlas A)**, **XSM-65B (Atlas B)**, **XSM-65C (Atlas C)**, **XSM-65D**, **SM-65D** and **USM-65D (Atlas D)**, **SM-65E** and **USM-65E (Atlas E)** and **SM-65F (Atlas F)**. On September 18, 1962, those missiles remaining in service were redesignated as **CIM-16D** (was SM65D0, **CTM-16D** (was USM-65D), **CGN-16E** (was SM-65E), **CTM-16E** (was USM-65E) and **HGM-16F** (was SM-65F).

As a military missile, substantial numbers of the Atlas were built, but due to their slow response time when under attack, they were gradually replaced by **Titan** and **Minuteman** missiles. The Atlas missiles which became available due to this changeover were then used as launch vehicles, either

Designation	Type
LV-3A	Atlas first stage for Agena upper stages
LV-3B	Atlas D (for Mercury program)
LV-3C	Atlas first stage for Centaur upper stage
SLV-3	Atlas first stage for Agena D upper stage
SLV-3A	Atlas first stage for Agena D upper stage but with upgraded engines and longer tank
SLV-3B	Atlas first stage for Agena D upper stage but with constant diameter tank
SLV-3C	Atlas first stage for Centaur D upper stage but with constant diameter tank
SLV-3D	Atlas first stage for Centaur D1AR upper stage but with constant diameter tank
SB-1	Atlas E
SB-2A	Atlas II
SB-2B	Atlas IIA, Atlas IIAS

Military Atlas launch vehicle designations

by themselves or in combination with an upper stage. Additionally, development of the missile as a dedicated launch vehicle continued.

In addition to the military missile designations, the basic Atlas first stage received military designations in the **LV/SLV** and **SB** series. *Table 1* lists these designations — as far as the cross references to the launch vehicle types are concerned, there remain discrepancies in this list. It is probable these designations were only used for flights carrying military satellites.

As a missile, the first launch of an **Atlas A** missile took place on June 11, 1957, as part of a series of eight test flights from Cape Canaveral — only four were successful. This was followed by 10 launches of the **Atlas B** missile, of which four were failures, and six **Atlas C** flights, of which two failed.

The **Atlas D** version was the initial production version. Known military serials indicate 121 Atlas D missiles were built. The missile test program lasted until January 23, 1961, and involved 49 launches, of which six failed, eight were partially successful and 35 were successful. The final flight was on November 7, 1967.

The use of the missile as a space launcher started on September 9, 1959, and of the 18 launches, four failed and two were sub-orbital. The last launch was on July 27, 1967.

These basic missiles were fitted with an additional upper stage and have also been referred to as **Atlas Satar**. Those Atlas D launch vehicles used in the **Mercury** program were also referred to as **Atlas-Mercury** and could place payloads of 1360 kg into a low orbit. The remainder of the Atlas D missiles were used as first stages in the Atlas configurations with the **Agna**, **Able** and **Centaur** upper stages, although the actual disposition is not known.

The **Atlas E** was launched successfully for the first time on January 24, 1961. Known serials indicate that 203 missiles were built.

In the '80s, surplus Atlas E missiles, which had a length of 28.10m, were used as space launch vehicles after having been fitted with an additional upper stage, allowing them to place a 820 kg payload into a low orbit.

Between December 18, 1981, and March 24, 1995, a total of 25 flights were made, of which two failed.



An Atlas D missile being trailored for its move from its above ground launcher.

The remainder of the Atlas E missiles were used as first stages in the Atlas configurations the Agena, Able and Centaur upper stages, although the actual disposition is not known.

For two sub-orbital flights, the basic Atlas E was also fitted with a **Trident** missile as an upper stage. The Trident missile was a three stage missile and it is not clear from references which stage (or all) was used for the Atlas E/Trident launch vehicle.

The **Atlas F** differed from the Atlas E by having a modified fuel system. The version was launched successfully for the first time on August 8, 1961. Known serials indicate 122 missiles were built.

Surplus military missiles were fitted with an additional upper stage and were used as space launch vehicles from April 6, 1968, to June 23, 1981. They had a payload capacity of 820 kg into a low orbit. A total of 20 flights were made, of which one was a failure.

The remainder of the Atlas F missiles were used as first stages for the **Agena**, **Able**, **Burner** and **Centaur** upper stages.

A number of Atlas F missiles were fitted with a Trident missile as upper stage and used in a sub-orbital

flight program. The Trident missile was a three stage missile and it is not clear from references which stage (or all) was used for the Atlas F/Trident launch vehicle.

The Atlas A, B, C, D, E and F were powered by two **Rocketdyne LR89-NA-5** and one **Rocketdyne LR-105-NA-5** rocket engines and, where appropriate, a second stage.

The **Atlas G** version was to be powered by the further improved **Rocketdyne LR89-NA-7** and one **Rocketdyne LR-105-NA-7** engines. The Atlas G was specifically developed as a first stage for the Atlas Centaur combination and was not flown as a launch vehicle without the upper stage.

The **Atlas H** version had engines similar to the Atlas G and was used five times between February 9, 1983, and May 15, 1987, as a space launch vehicle for payload of up to 3630 kg into a low orbit.

The **Atlas SLV-3** was a version of the basic Atlas (probably Atlas D) without an upper stage used to launch the **Prime SV5D** re-entry test vehicles into a sub-orbital flight trajectory. Three flights took place between December 21, 1966, and April 19, 1967.

ATLAS ABLE

To increase the launch capability, the Atlas D basic stage was combined

with the **Able IV** and **V** upper stages developed by Aerojet and **Allegheny Ballistic Laboratories** for the **Vanguard** launch vehicle. After three failed flights between November 26, 1959, and December 15, 1960 it became evident that the Atlas Able combination was not successful and further development was abandoned. The length of the vehicle was up to 35 m and it would have been capable to launch a payload of 170 kg into a low orbit.

ATLAS VEGA

The **Atlas Vega** was a proposed development of the Atlas Able. The

second stage was to have been propelled by a **General Electric GE 405H** liquid fueled engine (similar to the one used for the first stage of the Vanguard), while a third stage was to be propelled by a liquid fueled engine to be developed by the **Jet Propulsion Laboratory**. An orbiting capability of 2270 kg into a low orbit was envisaged.

At one stage it was intended to use the Atlas Vega for seven lunar fly-bys, a Mars fly-by in October of 1960, a Venus fly-by in January of 1961, a lunar hard lander in July 1961, a lunar satellite in September of 1961, a Venus lander and orbiter in August of 1962 and a Mars lander in November of 1962. It was also considered as the launch vehicle for the **Mercury Mk II**, later **Gemini**, crewed spacecraft.

Type	First flight	Sub-orbital	orbital	failed
Atlas A	11-Jun-57	4		4
Atlas B	9-Jul-58	5	1	4
Atlas C	23-Dec-58	4		2
Atlas D	14-Apr-59	98	12	24
Atlas E	11-Oct-60	24	21	11
Atlas E/Trident	6-Mar-68	2		
Atlas F	8-Aug-61	48	19	10
Atlas F/Trident	9-Jun-67	16		
Atlas G	not built			
Atlas H	9-Feb-83		5	
Atlas SLV-3	21-Dec-66	3		

Basic Atlas launch summary

The first flight was envisaged in August 1960 but development was cancelled on December 11, 1959, in favor of the **Atlas Agena B** vehicle. The cause of the failure was the delay in development, by which time the development of the Centaur upper stage was proceeding successfully.

ATLAS AGENA

The Atlas D first stage was also mated with the **Lockheed Agena** upper stage, which had been developed for the US military reconnaissance satellite programs.

The **Atlas Agena A** combination was capable of placing a 490 kg payload into orbit and four were launched

between February 26, 1960, and January 31, 1961, of which two failed. It had a maximum length of 31.10 m.

The **Atlas Agena B** introduced an improved and longer Agena engine. Between July 12, 1961, and June 7, 1966, 28 were launched, of which five failed. The combination, which had a length of up to 33m, was capable of placing a payload of 2627 kg into low orbit. Commencing with the Atlas Agena B, **NASA** procured launch vehicles directly from the contractor and not through the U.S. Air Force.

The **Atlas Agena D** combination, with a length of up to 35m, was capable of orbiting payloads of up to 2718

kg. The first flight was on July 12, 1963, and until the last flight on April 8, 1978, 76 were launched, of which five failed. Many of these launches placed multiple satellites into orbit.

ATLAS ANTARES II

The Atlas launch vehicle was also combined with an **Antares-II** solid fueled sounding rocket as upper stage. It was used on May 22, 1965, for a sub-orbital flight designated as **Fire-2**.

ATLAS BURNER II

The **Atlas F** was matched with the **Burner II** upper stage. The vehicle had an orbiting capacity of 215 kg into low orbit and between August 16, 1968, and February 24, 1979, three flights were conducted, of which one failed.

ATLAS CENTAUR

The **Centaur** upper stage was initially developed by General Dynamics to place military communications satellites into orbit. This upper stage was fitted with two **Pratt & Whitney RL-10A-3**



An Atlas E missile at its launch facility. The square ventilators in the photo's foreground indicate the location of the underground launch control and command.

rocket engines. When the program was cancelled, the launcher was handed over for civilian use by NASA.

The first stage was based on surplus military Atlas D, E and F missiles. The Atlas G was also used as a first stage after all Atlas D, E, and F first stages had been depleted. These first stages only differed in minor detail and no information is known to match the missile's originated first stage with the Atlas Centaur launch vehicle, the latter being identified by an AC number only.

The Centaur upper stage allowed the combination, which had a length of up to 38m, depending on the size of the payload bay, to have an initial orbiting capability of 4670 kg into low orbit but this has been improved over time. In two instances (viz. the *Pioneer-10* and *-11* launches) a further **Thiokol TE-M-364** upper stage was carried.

The **Atlas Centaur A** version was the prototype of which one was launched on May 8, 1962. The launch failed.

The next prototype was the **Atlas Centaur B**. Only one was flown on November 27, 1963. Three **Atlas Centaur C** launch vehicles were flown between June 30, 1964, and March 2, 1965, but only one was successful. The **Atlas Centaur D** was the first production version of which 24 were flown between August 11, 1965, and August 21, 1972. Two of these were failures. Six examples of the **Atlas Centaur D1A** were flown between April 6, 1973, and May 22, 1975. One of these failed.

The next version was the **Atlas Centaur D1AR**, which flew for the first time on September 26, 1975. Thirty-three were launched up to September 25, 1989, including two failures. Since then, the Atlas Centaur has been referred to as simply **Atlas I** or **Atlas II**. The reason for the name change — other than for marketing purposes — is not known.

The Atlas I was similar to the earlier Atlas Centaur and had a length of up

Type	First flight	Sub-orbital	orbital	failed
Atlas Able	26-Nov-59			3
Atlas Vega	not built			
Atlas Agena A	26-Feb-60		2	2
Atlas Agena B	12-Jul-61		23	5
Atlas Agena D	12-Jul-63		69	5
Atlas Antares II	22-May-65	1		
Atlas Burner II	16-Aug-68		2	1

Atlas + upper stage launch summary

to 43.90m, depending on the payload bay employed. It had a capability to place 3,630 kg into a low orbit. The first stage engines were comprised of two **Rocketdyne LR89-NA-7** and one **Rocketdyne LR-105-NA-7**. The first flight designated as such was on July 25, 1990, and 11 were launched until April 25, 1997. Two of these were failures. Some sources use the number '1' to indicate this version, but formal sources (*i.e.*, Lockheed Martin) use the Roman numeral. The basic Atlas II had an improved engines (two **Rocketdyne RS-56-OBA** and one **Rocketdyne RS-56-OSA**) as well as a larger tankage. With a length of up to 47.40m, the orbiting capability was up to 6580

kg into low orbit. Thirteen were launched between December 7, 1991, and October 9, 1998.

The **Atlas IIA** introduced an improved engine on the Centaur stage (two **Pratt & Whitney RL-10A-4**), thereby increasing the orbiting capability to 7280 kg into low orbit. It had a length of 47.40m.

Another major change was the deletion of the two small **Rocketdyne LR101** vernier engines, which had been used on previous versions to provide directional control during the launch. Instead a hydrazine roll control system

Type	First flight	orbital	failed
Atlas Centaur A	8-May-62		1
Atlas Centaur B	27-Nov-63	1	
Atlas Centaur C	30-Jun-64	1	2
Atlas Centaur D	11-Aug-65	22	2
Atlas Centaur D1A	6-Apr-73	5	1
Atlas Centaur D1AR	26-Sep-75	31	2
Atlas I	25-Jul-90	9	2
Atlas II	7-Dec-91	13	
Atlas IIA	3-Aug-94	20	
Atlas IIAS	16-Dec-93	30	

Atlas Centaur launch summary

was fitted. The first flight was on August 3, 1994 and 20 flights were conducted until December 5, 2002.

The **Atlas IIAS** incorporated two **Thiokol Castor** solid fueled boosters, which were attached to the first stage. This enhanced the orbiting capability to as much as 8610 kg into low orbit. The length was 47.40m. The first flight was on December 16, 1993 and 30 were launched until August 31, 2004.

ATLAS IIIA

Initially known as **Atlas IIAR**, the **Atlas III** differed from the traditional Atlas II launch vehicle in that the first stage was propelled by a single **Energomash RD-180** engine. The RD-180 was expected to be more reliable than the traditional Atlas. Matched with the Centaur upper stage. it was capable to deliver 8640 kg into a low orbit.

For the Atlas IIIA version. the Centaur stage was fitted with a single engine. The length of the launch vehicle was 51.88m. The first flight of an Atlas IIIA was on May 24, 2000 and only two were launched.



An Atlas III launch

The **Atlas IIIIB** was similar to the Atlas IIIA, except that the Centaur stage had two engines. The launch vehicle had a length of 53.10m and the first flight was on February 21, 2002, and to the close of 2008, four were launched.

Stage	Length	Diam.	Engine	Fuel	Thrust
0	---	---	Aerojet SRM strap-ons as required	solid	1,274,910 N each
1	32.37 m	3.81 m	Energomash RD-180	Lox/kerosene	4,142,520 N
2	11.68 m	3.05 m	1 Pr & Wh. RL10A-4-2	Lox/LH2	99,158 N

Atlas V basic specifications

ATLAS V

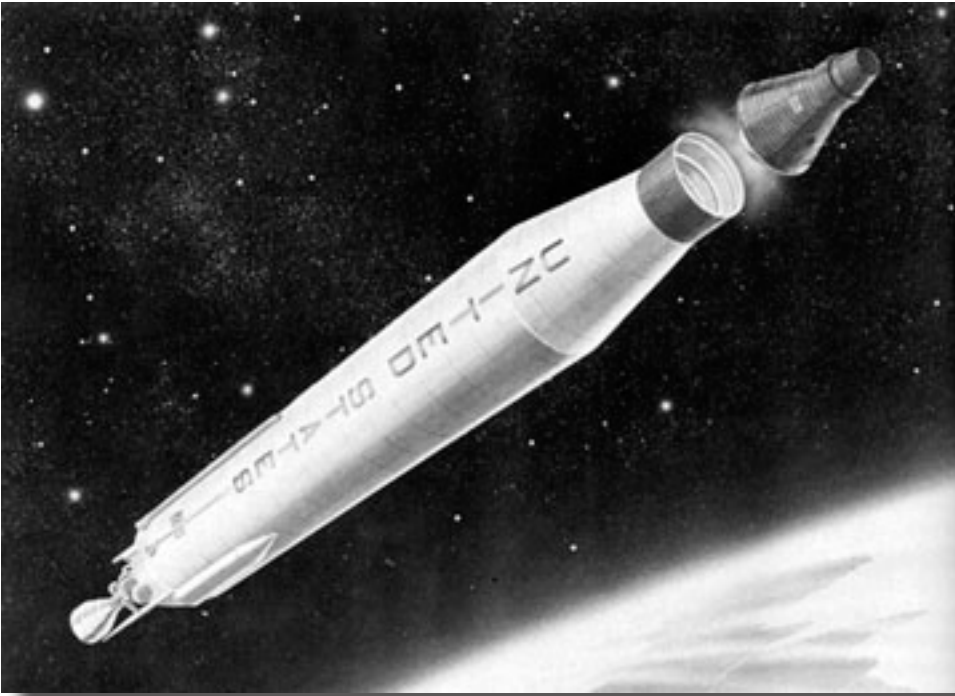
The latest development of the Atlas vehicle is the **Atlas V** (there was no Atlas IV) to meet the U.S. Air Force's **Evolved Expendable Launch Vehicle (EELV)** program requirements.

The feature that sets the Atlas V apart is the new rigid body *Common Core Booster (CCB)* that serves as the rocket's first stage. The CCB replaces the "balloon" pressure-stabilized stage used by previous Atlas vehicles. The

stage is common and will be used in all the various configurations of the Atlas V family. The stretched Centaur also will be common across the Atlas V fleet. The total length of the launch vehicle is 58.28m with the type 4 payload fairing, and 62.18m with the type 5 payload fairing. The different configurations are achieved via different sizes of payload bays as well as the number of solid-fueled rockets strapped to the

Type	Payl Shr	Strap-ons	CCB	Centaur	Kg load GTO
401	4 m	0	1 RD 180	1 RL 10A-4-2	4975
402	4 m	1 Aerojet	1 RD 180	2 RL 10A-4-2	
411	4 m	1 Aerojet	1 RD 180	1 RL 10A-4-2	5980
421	4 m	2 Aerojet	1 RD 180	1 RL 10A-4-2	6865
431	4 m	3 Aerojet	1 RD 180	1 RL 10A-4-2	7680
501	5 m	0	1 RD 180	1 RL 10A-4-2	3990
502	5 m	0	1 RD 180	2 RL 10A-4-2	
511	5 m	1 Aerojet	1 RD 180	1 RL 10A-4-2	5298
512	5 m	1 Aerojet	1 RD 180	2 RL 10A-4-2	
521	5 m	2 Aerojet	1 RD 180	1 RL 10A-4-2	6318
532	5 m	2 Aerojet	1 RD 180	2 RL 10A-4-2	
531	5 m	3 Aerojet	1 RD 180	1 RL 10A-4-2	7238
532	5 m	3 Aerojet	1 RD 180	2 RL 10A-4-2	
541	5 m	4 Aerojet	1 RD 180	1 RL 10A-4-2	8022
542	5 m	4 Aerojet	1 RD 180	2 RL 10A-4-2	
551	5 m	5 Aerojet	1 RD 180	1 RL 10A-4-2	8715
552	5 m	5 Aerojet	1 RD 180	2 RL 10A-4-2	
Heavy			3 RD 180		

Atlas V versions




Mercury Atlas after booster separation.

ATLAS V VERSIONS

The first Atlas V flight was on August 21, 2002, and to mid July of 2010, a total of 21 flights of the various versions have been conducted. Not all the listed versions have flown as of this writing.

FUTURE DEVELOPMENTS

The future of the Atlas V launch vehicle as one of the two mainstays of the U.S. space effort (the other being the **Delta IV**) is fairly well assured. The new launch vehicles currently under development (such

as **Falcon 9**) may make a small impact on the market share enjoyed by the Atlas V, but are unlikely to jeopardize the on-going use of the Atlas V. 

first stage. In addition, the number of Centaur engines can be varied.

There are three distinct versions of Atlas V rockets — the **400** series, **500** series and **Heavy** — each dedicated to launching a certain class of satellite cargo into orbit. In this designation, the first digit indicates the payload bay (4m or 5m), the second digit the number of strap-ons, and the third digit the number of engines on the Centaur upper stage.

About the author

Jos Heyman is the Managing Director of Tiros Space Information, a Western Australian consultancy specializing in the dissemination of information on the scientific exploration and commercial application of space for use by educational as well as commercial organisations. An accountant by profession, Jos is the editor of the [TSI News Bulletin](#).



LONG DISTANCE FORCE PROTECTION

AUTHOR: RODGER VON KRIES, VICE PRESIDENT, TECHNOMAD

The military has long relied on satellites for long-distance communications. The success of the early satellite trial phases in the mid 20th century led to increasing reliance of the satellite infrastructure to dependably deliver information to distant military bases over free space.

Today, military communications, or MILSATCOM systems, are still in place to inform and protect military personnel. MILSATCOM systems are aligned with various bands of electromagnetic spectrum to deliver provide such information. This includes the X-band, a microwave radio band that lives in the 7.0 to 11.2 GHz frequency range; and the Ka-band,



which falls into the 26.5 to 40 GHz range.

There is also the UHF, or ultra-high frequency band, more popularly known for its role in terrestrial (over-the-air) television delivery but sometimes used for military satellite communications. The U.S. military reserves the right to use the 1452–1492 MHz chunk of the UHF spectrum. The common aspect of these different bands of spectrum is that they are all reliable for the delivery of voice and data over free space, from point to point or one point to many.

IP ENTERS THE MIX

It is established that plenty of bandwidth exists in a typical long-distance satellite connection to deliver voice and data. Increasingly, these systems are interfacing with Ethernet and fiber links to provide both redundant and/or first-mile and last-mile connections.

Audio over IP is ideal for streaming live audio from a source to a target, both separately and in combination with satellite links. IP-based technologies have matured to the point where



it is simple to reliably “hand off” a communications signal from an IP-based system or network to a MILSATCOM system. The combination provides a powerful solution for multipoint communications and/or extending the reach of a point-to-point connection.

The challenge is in maintaining a consistent live, working connection for streaming data and audio over IP. Whether for everyday operations or emergency situations, the remote connection suffers if plagued by occasional dropouts and temporary outages. This becomes a potential safety hazard if a live or recorded voice message streamed in real-time goes silent due to a poor connection.

An alternative solution for remote satellite communications is to use the same technology for distributing commands. These CGI-based commands are useful for triggering tones, alarms, announcements and other audio as single events or repeated messages. This strategy temporarily opens the connection to trigger an event at the remote base(s)



Military PA System in use in Afghanistan. Photo courtesy of Technomad

instead of requiring a continuous, open IP connection to stream live audio.

CENTRAL CONTROL

Military bases using audio playback systems such as the **Technomad SuperConductor** have the option of informing base personnel of the day's events through a series of announcements, either triggered manually or on a scheduled basis. The option to repeat the message any number of times exists for important but non-critical announcements as well as for emergency situations.

The latter is an ideal example of how such technology can benefit warfighters and distant military bases receiving information from U.S.-based unit control centers over a MILSATCOM system. The ability to advise patrol teams and even local citizens of hostile movements, MOPP conditions, and other dangerous situations, is critical to force protection and mass notification — essentially, for saving lives.

The ability to trigger these announcements, tones and other warning signals locally from distant unit control centers ensures reliability of playback. The use of the CGI command as a data stream instead of streaming live audio also preserves bandwidth, making more efficient use of the existing space in the larger MILSATCOM system.



MilPA system installed on a Humvee, photo: Technomad

REMOTE BASE SYSTEMS

The momentary IP connection required to send a CGI command is enabled from the unit command center. If the remote playback system allows scheduling (such as the SuperConductor), military personnel at the command center can use the same command to set up an events in advance.

Once the connection is made, the operator would access a web interface, enter the appropriate passwords, schedule the event and quickly disconnect. The playback system would trigger the event at the schedule time, allowing for a very efficient use of satellite resources.

This can be achieved for multiple locations with the appropriate playback systems, with few human and time-related resources required. But what happens when the command is recognized and the audio event is triggered? It's at this point that the quality of the audio becomes relevant. Bases

with harsh sounding horn systems will produce tinny and distorted audio that is difficult to comprehend. Horn designs frequently have narrow coverage angles, behaving like an acoustic "spotlight." Those directly in line with the horn are blasted with sound while those to either side of the horn cannot hear the message clearly.

High-clarity PA systems with the appropriate end point (loudspeakers) and infrastructure components (amplifiers, mixers) will ensure that the message sent from the unit control center is loud and clear. Most remote bases will simply require turnkey systems with several loudspeakers to

cover something in the area of one square mile, although networked **Giant Voice** PA systems may be designed to cover much larger spaces. The latter can also double as a public safety system for local citizens.

CONNECTING THE DOTS

Setting up such a system at the remote base should be relatively simple. In most cases, the playback system would exist as 1RU component and live in a signal processing rack with additional infrastructure and networking equipment. Local military personnel would also have access to the system to manually trigger warnings in critical situations.

The delivery of the warning tone or message to the loudspeaker points can be handled over cabled infrastructure using Ethernet, twisted pair, or optical fiber lines; or wirelessly using RF transmission. In larger systems, Ethernet connections add the benefit of zone-control to stream audio to specific areas in a facility.

Announcements and warnings can be fanned out further by tying in a land-mobile radio system. This allows patrol units at the base to connect to the central PA using handheld radio, adding another local element of force protection to the mix. The brains of the system can live inside the same signal processing rack as the audio playback and infrastructure systems to create a clean, centralized and fully realized local PA system.



The TechnoMad SuperConductor unit

Protection from the elements is a final but important consideration. Military technology is nearly worthless without ruggedness and durability. Weatherproof loudspeakers are ideal for outdoor installations to cope with rain, snow, sleet, and water ingress. Likewise, outdoor loudspeakers should be able to withstand the blowing dust and dirt of a desert environment. Equipment that cannot survive the rigors of wind, impact and other abuse will not last long in the military or in other challenging installations.

The goal of military satellite communications is to supply information to military units that lack a reliable means of terrestrial communication. The proliferation of IP-based technologies can now provide more power and diversity to MILSATCOM systems to further enhance protection for military personnel serving at remote bases around the world.

PHILIP HARLOW PRESIDENT & COO XTAR, LLC



Philip Harlow was appointed President and Chief Operating Officer of XTAR, LLC, on June 1, 2010. He is responsible for the growth and strategic direction of XTAR's Government business, overseeing the management, marketing and technical aspects of the company. Previously, Mr. Harlow worked as Chief Technology Officer for CapRock Communications (since acquired by Harris Corp). In that role, Mr. Harlow was responsible for all aspects of engineering, IT, infrastructure development, new product management and strategic planning.

Prior to CapRock, Mr. Harlow was Vice President of Engineering and Technology at DRS Technical Services, provider of satellite, terrestrial and enterprise-wide network communications services. He joined DRS in 2006 from Intelsat General where he served as Vice President of Engineering following the acquisition of PanAmSat.

Before joining PanAmSat/G2, Mr. Harlow was instrumental in the PanAmSat acquisition and integration of Esatel Communications, where he served as Vice President for Business Development. Mr. Harlow also worked at Loral Orion as Director for Sales Engineering supporting the North America Sales Group.

Mr. Harlow graduated from the Royal Military Academy, Sandhurst, United Kingdom, and holds an honors degree in Electronic Systems Engineering from the Royal Military College of Science. He also has a Masters degree in Systems Engineering from The George Washington University.

MILSATMAGAZINE (MSM)

What history and experience do you have with commercial sales of X-band, for example with CapRock, and how will that benefit the government users?

PHILIP HARLOW

I have been helping to develop solutions for Iraq and Afghanistan since the first troops entered the region in 2001. Even then, Afghanistan was an underserved region in terms of deployed Ku-band capacity, and it quickly became clear that the rate of take-up of commercial Ku-band would result in a shortage of capacity in the region. This was recognized by all the major satellite operators, including the fledgling partnership that became XTAR, and plans were laid to augment the capacity in the region.

XTAR, of course, focused on X-band frequencies, with the aim of supporting those X-band terminals that were already in operation on DSCS, and the expected lead times for WGS and TSAT programs. The Company saw a gap in available capacity until those programs came online, and deployed our two spacecraft specifically to support the Iraq and Afghanistan theaters — because that's where the need was.

The XTAR team worked very hard to get their capacity on the right contract vehicles. I was at DRS when DSTS-G finally added X-band to the contract in 2007. The first task order for X-band on that contract was TO 350, awarded to my team at DRS, supported by multiple vendors who together played a crucial part in crafting that winning solution.

During my time at CapRock, CapRock Government Solutions identified a need for X-band to serve its government customers. CapRock gained a strong foothold in the marketplace, winning a number of subsequent task orders and gaining a great deal of experience with X-band and the customer base that understood how to leverage the unique advantages of these frequencies.

Looking back over the past few years, I'm proud to have been at the forefront of the use of X-band (from my time in the British Military) and in the deployment of commercially available X-band. The platforms that I have helped establish will continue to feed the expanding needs of multiple customer sets, to foster growth, and to lay the foundation for continued XTAR expansion.

MSM

What role do you see for commercially available X-band and how do you see that evolving over the next 1-3 years?

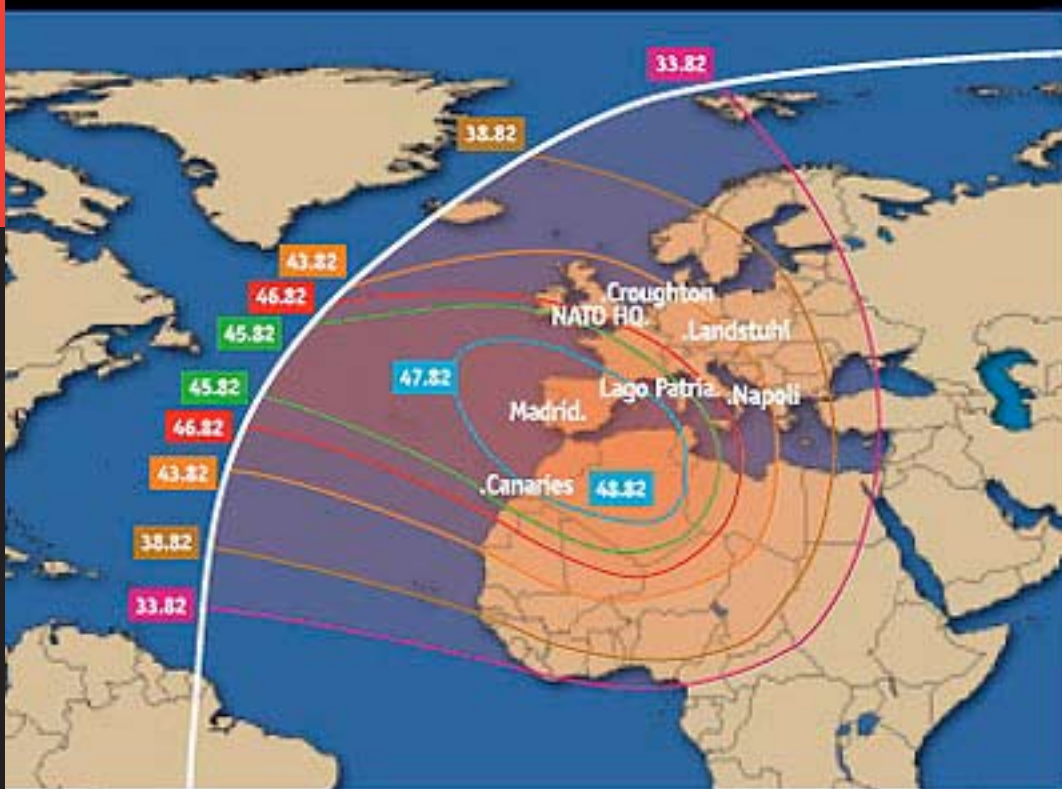
PHILIP HARLOW

I am very bullish about this marketplace, and believe that the Company has a critical role to play in developing the market for commercially available X-band, and for helping users make the most of this valuable mission enabler. I see a natural preference and a compelling reason for using X-band in a large number of cases, compared to almost any other satellite frequency. More and more people are becoming aware of X-band's strengths and advantages as a resource.

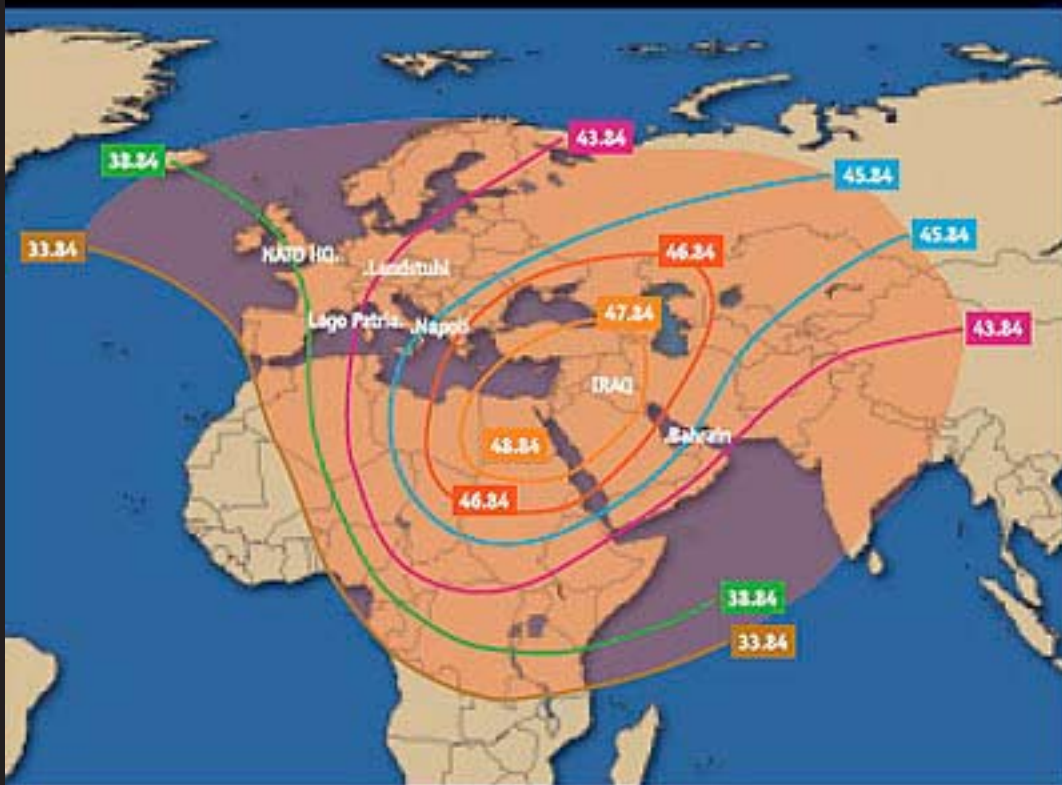
It is probably more useful to think in longer terms than 1–3 years when talking about the future impact of commercially available X-band.

Remember that this is a resource that has only recently become available, and already there is a significant uptake of capacity. Certainly, there are gaps

in the global coverage on the commercial side, but typically they can be fulfilled by using WGS capabilities. The Company has expansion plans to help fill those holes, but we are not here to compete with integral military assets. We're here to augment and provide support when those assets cannot meet those requirements.



XTAR-EUR Fixed Beam



XTAR-EUR Steerable Beam

Of course as we plan future expansion, discussions with military planners will be key. XTAR is eager to engage military planners and policy makers in dialogue, both directly and through industry forums such as the Satellite Industry Association. We want to be

ready to support the next conflict, wherever and whenever that might be. I think commercially available X-band has an important role to play in this strategic planning.

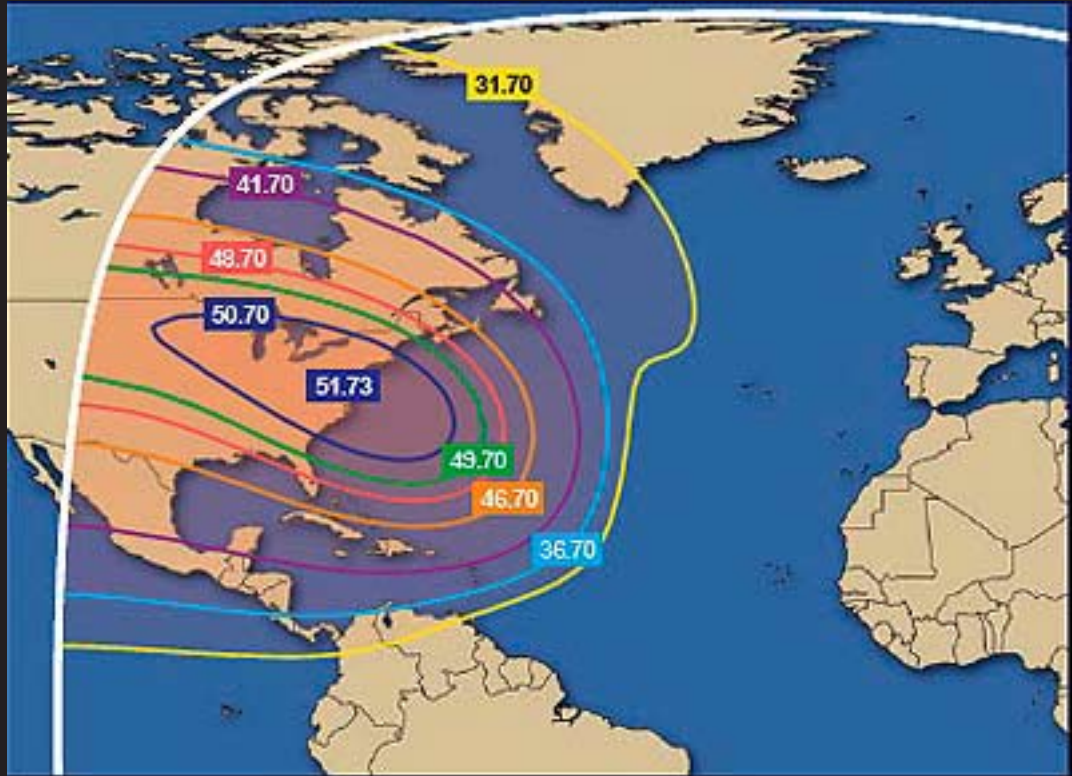
We have another obstacle to overcome — the military perception that commercial means C-band or Ku-band only, and that X-band is a military-only asset. Users do not recognize

MSM

What is the relationship between military users and commercial X-band providers, and how would you like to improve on this to better meet the mission requirements of the user?

PHILIP HARLOW

Providers of commercially available X-band have delivered strong performance to military users in Iraq and Afghanistan. Despite this positive record, users do not have strong awareness of commercially available X-band and its capabilities.



XTAR-LANT Fixed Beam

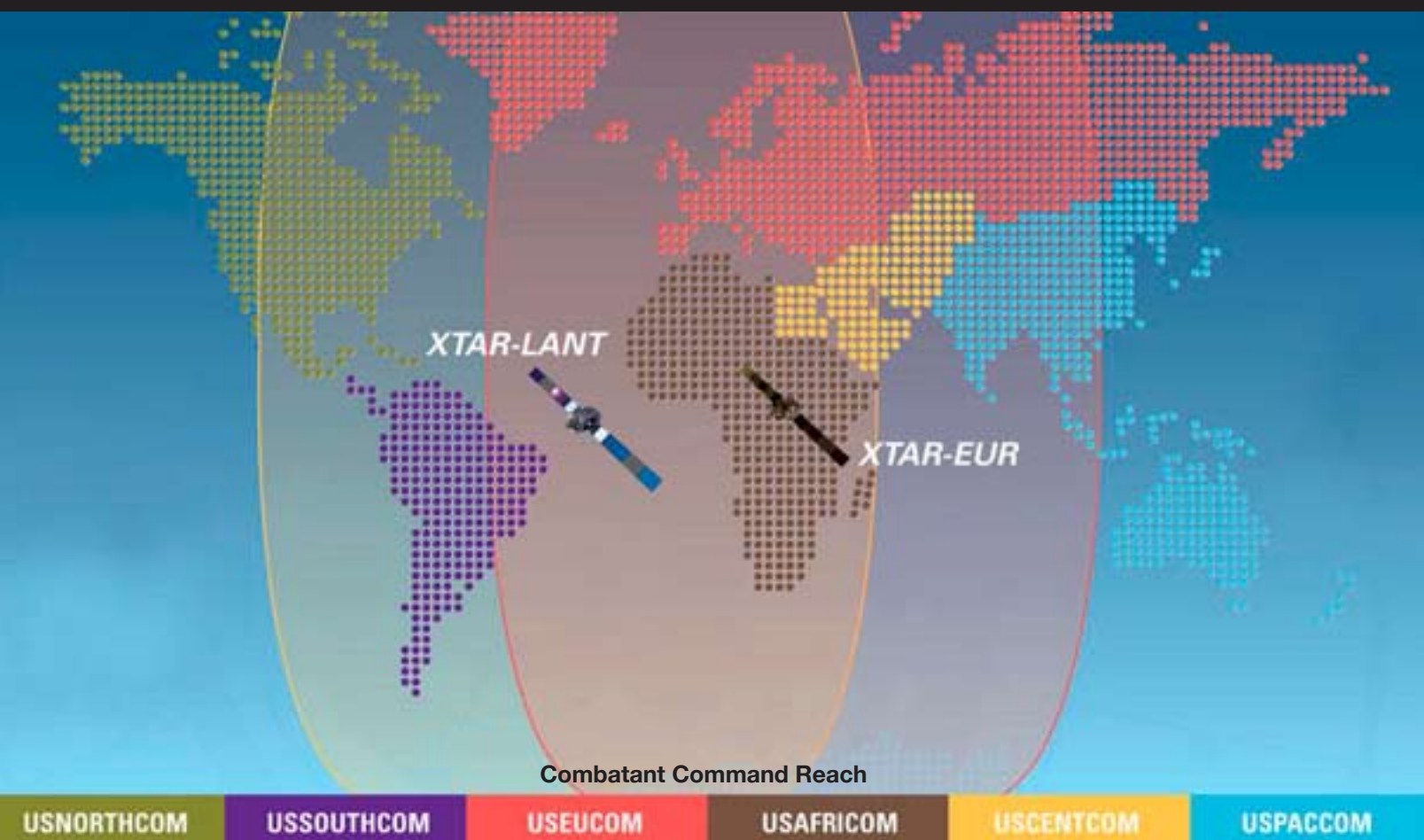


XTAR-LANT Steerable Beam

that industry has several sources for commercially available X-band, all of which bring a unique, commercial and government-oriented capability to the table. The mission of the providers is focused on fulfilling requirements for the U.S. military first and foremost. The bottom line is that we cannot sell a transponder to the next broadcaster that comes along — we don't have that outlet.

Understanding and supporting the military's and government's mission success is key to our future and gives us a very strong connection to the military. We cannot afford to deviate from that. We must enhance this very strong connection, and show the user that we have a vested interest in the success of their missions.

Since the DoD continually rotates decision makers in and out of key posts as promotions and Permanent Changes of Station (PCSs) take place, the relationship with X-band providers can be very challenging. The diffusion of knowledge about commercially available X-band is not and cannot be as thorough as we would like. Satellite, although an important mission enabler, is really a fairly small part of the overall military communications picture. This means that we are constantly engaged in an education and reeducation program, to ensure that this valuable mission resource is employed to the fullest extent.



MSM

Can you explain how XTAR's highly responsive and reliable service supports the users with whom you work directly and those who receive service through integrators?

PHILIP HARLOW

XTAR will distinguish itself in the market in various ways. Providing service on a unique part of the frequency spectrum is one way in which we do that. Just as important, is how we support the user's mission by understanding where we fit into the value chain and providing a highly efficient service. The Company is working hard to give customers easy access to our space segment. That means working with the government and integrators to establish as many teleports/access points as possible. It also means establishing contracting options which are efficient and flexible. Commercial X-band is very often used to support surge requirements for testing, demos and to support short-notice or short-term operations. For that reason, XTAR's objective is to make it as easy as possible for customers to get onto our bandwidth with little delay.

We measure our success by the success of those with whom we do business. In the case of those who wrap our services into a broader solution, integrators, that is, we go out of our way to support their business by doing what we do well — operating satellites and providing easy access to quality space segment — and helping them to do what they do well — assembling solutions targeted at specific requirements. In the end,

the big winners are the government users who get more for their money and can count on strong support on their way to mission success.

MSM

Please explain what benefits users have seen from XTAR's relationship with HISDESAT of Spain, and what new developments are on the horizon through this partnership?

PHILIP HARLOW

HISDESAT's stake in XTAR is an important aspect to the continued growth of the company. They are a source of operational support in that they host and maintain some key TT&C uplink sites. They are also an important reseller of the Company's capacity, and if taken collectively, they are one of our largest customers, growing their use of XTAR capacity significantly every year. This clearly demonstrates that they are fully behind the Company and the business model we have, are committed to our success, and have a wide-reaching capability to bring our capacity to a growing number of customers across the globe. Perhaps most importantly, they see XTAR as a long-term venture. This means both the initial investment, but also the time and effort they put into the continued growth of the Company, working with their customer base to grow capacity sales through a number of channels not directly available to XTAR. They are a strong partner, and fully vested in our continuing growth and success — they truly see our success as their success, and they are consequently great partners to have.

MSM

XTAR has two satellites which cover a very large and important portion of the globe. Please tell us about your plans to expand that coverage so you can provide service to more users in other regions.

PHILIP HARLOW

Growth is a key factor for XTAR in the future. We have already seen a large spread of the mission support being requested by customers. It is becoming more geographically diverse. We're also being asked to support smaller remote VSATs with higher data rates, on moving platforms on HUMVEEs, on airborne assets and even on fast moving, rigid raider-type assault boats. What this means is we need more capacity, more powerful beams to support the smaller antenna sizes we're being asked about, and a greater geographic reach than we have today.

We're working with our customers and partners to determine the market opportunity and to develop the business plans that will enable us to pursue the next stage of the Company's growth. This includes additional coverage of SWA, Africa and the Asia-Pacific region. This could mean a new spacecraft, or a hosted payload on someone else's spacecraft. Both are still under consideration. We are also considering whether we remain a wholly X-band provider, or bring military Ka-band frequencies or UHF frequencies into operation. If we do decide to go that route, we must decide in which region(s) we will bring those payloads to bear?

There's a lot to think about as we plan our future, but certainly we're bullish about the market, and feel we're well positioned for growth. The partnership is fully supportive of our ambitions, and is bringing their considerable influence to the market. All in all, the future looks bright for XTAR, and we're optimistic about our prospects.



XTAR satellite, image courtesy of SS/L

The Little — But Powerful — X-band BUC

The new Comtech Xicom XTS-50X-B1 block upconverter (BUC) packs the most punch into a 10.5 lb box that's ever been seen at X-band. This compact and highly capable unit provides 50 watts of 1-dB compressed power in a 5.7" x 4.4" x 10.6" box that can be antenna mounted. The BUC is designed to handle tough environments and meet the stringent RF requirements of X-band systems.

With the advent of new commercial and military X-band systems, significantly more bandwidth is available at X-band. This new capacity is being used to alleviate the severe overcrowding seen on Ku-band systems from Southwest Asia to Europe to North America. The XTS-50X-B1 enables integrators to offer highly compact transportable SATCOM terminals that take advantage of Xstar and WGS to provide much higher data rates than in the past.

The XTS-50X-B1 provides more than 32 watts of linear output power as defined for the WGS system in a 10.5 lb self-cooled feedmount outdoor package that operates in tough environments up to 60°C. This high linear output power level is achieved for both single carrier and multi-carrier performance.

This unit accepts a 950-1450 MHz L-band input, upconverts it to 7.9 – 8.4 GHz X-band, and amplifies the signal to achieve the full output power. Its rich feature set includes temperature compensation, gain control, harmonic filtering, tight gain variation and stability, serial RS-232/422/485 digital monitor and control interface, and options for operating from either 20-32 VDC or 35-52 VDC prime power.

With this new BUC capability, SATCOM integrators will be able to offer their customers the highest X-band data rates possible in the smallest packages. Now that's powerful!

Comtech Xicom Technology, Inc. was established in 1991 in the heart of Silicon Valley. Xicom provides rugged, efficient and reliable Traveling Wave Tube Amplifiers (TWTAs), Klystron Power Amplifiers (KPA's), Solid State Power Amplifiers (SSPA's), and Block Upconverters (BUC's) for commercial and military applications around the world. A broad array of products are available for fixed locations and mobile platforms.

— Heidi Thelander

Website: www.xicomtech.com

Phone: +1 408 213 3000

ViaSat Receives Green (\$13.8 Million) To Provide A Blue Force

ViaSat Inc. has received delivery orders from PM Force XXI Battle Command Brigade and Below totaling \$13.8 million under its Blue Force Tracking 2 (BFT-2) IDIQ contract. These contracts include the installation and test of production satellite ground station and satellite network control center equipment as well as L-band bandwidth leasing, network ground equipment, and thousands of additional production vehicular transceivers. These next generation BFT-2 systems are designed to enable much faster situational awareness updates and higher transmission speeds.



Selected to upgrade the US Army and Marine Corps Blue Force Tracking network, ViaSat brings real-time situational awareness and better networking capabilities to the warfighter with BFT-2. ViaSat's next-generation Blue Force Tracking transceivers provide dramatic improvements in situational awareness through faster Position Location Information (PLI) refresh rates and greater information throughput features. This BFT-2 system delivers improved network efficiency

and reduces the Department of Defense's total operational expenditure for the specified capability.

With BFT-2, network users can achieve real-time position accuracy by operating through a Ground Vehicular Transceiver or Aviation Transceiver to one of up to ten satellite channels back to a Satellite Ground Station (SGS). The average round-trip message latency through the network has been demonstrated and proven to be less than 2 seconds.

The ViaSat BFT-2 network offers situational awareness updates and increased data throughput. The next generation BFT-2 network is expected to improve situational awareness latency from minutes to just seconds.

The new BFT-2 system is derived from ViaSat mobile satellite communication technology, which enables fast, efficient network access using very small antennas. These systems provide communications-on-the-move (COTM) service to both military and commercial customers.

Website: <http://www.viasat.com>

PA-Based Protection

Technomad is now shipping its new **SuperConductor v2.0** mp3 playback and recording system for military applications. **SuperConductor v2.0** adds new features that include the ability to record field audio and immediately schedule the files for playback from a front-knob position — without the need for a computer or web browser. (See the “*Long Distance Force Protection*” article in this issue of *MilsatMagazine*.)

The original **SuperConductor** is used in fixed and mobile applications around the world, including combat simulation, mass notification, emergency messaging, and general military training exercises. Potential applications include playing Reveille daily at 0600, hourly safety announcements, local-language messages, sirens and alerts, combat simulation, training, and ceremonial music for command changes.

SuperConductor v2.0 builds on the original playback and scheduling features, adding the ability to schedule recorded field audio for immediate or future playback from the internal sound library. Another key new design feature is Local Configuration Mode, which allows the user front-panel access to all functions, eliminates the need to use a computer for managing sound files, and offers password protection. The unit also integrates an IP-based timeserver that automatically synchronizes the unit’s clock with the timesaver once a day.

Achieving FAT RAIDRS

Integral Systems, Inc.’s Military and Intelligence Group (MIG) has achieved an important program milestone. They successfully completed Factory Acceptance Testing (FAT) of the Rapid Attack Identification, Detection and Reporting System (RAIDRS) Block 10 (RB-10) program. The successful testing paves the way for the system’s deployment and activation.

Integral Systems is the RAIDRS RB-10 program prime contractor. RAIDRS is a ground-based defensive counterspace program. The system will provide near real-time event detection, characterization, geolocation and *Electromagnetic Interference (EMI)* reporting for critical satellite communications systems, directly supporting combatant commanders. The **United States Air Force’s 16th Space Control Squadron (SPCS)** operates RAIDRS from **Peterson Air Force Base, Colorado**, and is assigned to the **21st Space Wing**.



Master Sgt. Eric Gemmell adjusts the support system of a Transportable Antenna System while Capt. Joseph Fixemer directs the leveling of the system. The antenna is a component of the Rapid Attack Identification Detection Reporting System, or RAIDRS, at Peterson Air Force Base, Colo. RAIDRS is the new defensive counterspace weapon system for 2010.

Emergency Enterprise

Lubbock County Texas is using Spacenet's high-performance satellite communications services and equipment to support critical communications across the state.

Spacenet's transportable antennas and *Connexstar S2* satellite services, based on the *SkyEdge II* VSAT platform, are being used to provide emergency communications as part of the county's instant command post. Lubbock County integrated Spacenet's satellite equipment and services into its mobile command vehicle that is used across the state to maintain data, voice and video communications during emergency situations. The vehicle is one of two primary mobile communications platforms within the region and it can be used as an alternate dispatch point for its jurisdiction in the case of an outage, helping to enable the county to operate normally. The system supports VoIP through telephone systems that connect back to Lubbock County's telephone numbers. The vehicle was recently used to support a community in Texas that lost its connection to the 911 system due to a cut in the fiber optic lines. The mobile command vehicle rolled into the community and within an hour was able to provide 911 access through its VoIP phones.

Earthy Radar

Harris Corporation has been awarded a 30-month, \$42 million contract by Sierra Nevada Corporation to supply antenna and radar electronics for a satellite that will provide military commanders in the field with timely, high-resolution radar imagery of the Earth's surface — regardless of weather conditions or time of day.

Harris will design, build, and integrate the *synthetic aperture radar* (SAR) satellite payload for **Sierra Nevada** as part of **NASA's Rapid Response Space Works and Modular Space Vehicles** program for the **U.S. Department of Defense's Operationally Responsive Space (ORS) Office**. ORS is a joint NASA/DoD initiative with the charter to field modular payloads rapidly and inexpensively. The payload architecture, designed to support a new family of modular military satellites, offers flexibility to support multiple missions with minimal changes in the basic design. SAR is the second payload to be developed by the ORS Office and will produce high-resolution radar imagery of the Earth's surface, even during darkness or inclement weather.

(Pictured below: TacSat-2 in orbit, the first ORS satellite)



CutterComms

The SATCOM Solutions division of Integral Systems, Inc. has been awarded a \$10 million, five-year, Indefinite Delivery/Indefinite Quantity (IDIQ) contract to modernize the United States Coast Guard's (USCG) satellite communications (SATCOM) network for the service's large cutters.

Integral Systems' SATCOM Solutions division will act as the prime contractor on the program, transitioning the USCG from

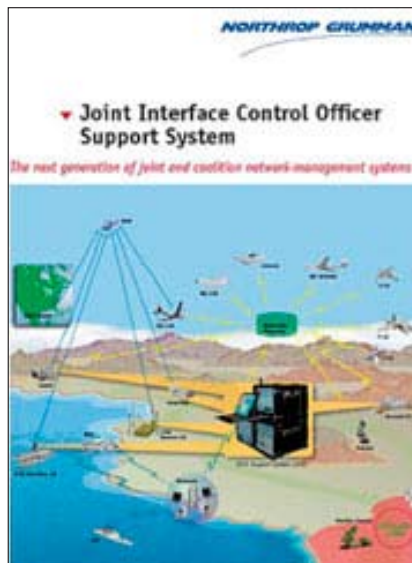
its legacy SATCOM network to a commercial-based, advanced Ku-band system, significantly enhancing network reliability, flexibility and scalability. Under the terms of the contract, Integral Systems' SATCOM Solutions division will provide an advanced **117MT Ku-band Maritime Antenna System** that includes its innovative, *electromagnetic compatible (EMC)* and *electromagnetic interference (EMI)* management system. The 117MT fully supports primary "off-the-cutter" connection to the **Coast Guard One Network (CGONE)**, and provides the ideal ocean-going platform for single channel per carrier or on-demand networks supporting video teleconferencing, virtual private networks, voice over IP and large file data transfers.

JICO JSS Passes Milestones

Northrop Grumman received a salute for having met two major milestones. Northrop Grumman Corporation's (NYSE:NOC) Joint Interface Control Officer (JICO) Support System (JSS) received Milestone C approval from the U.S. Air Force November 19. After integration with other air and space operations center systems, JSS will be deployed to as many as 26 Air Force and joint military sites worldwide.

In October 2010, JSS achieved two significant milestones needed for final fielding approval. JSS received the Air Force's *Certification to Interoperate* with U.S. and allied data link networks and was granted an *Authority to Operate*, permitting JSS to connect with U.S. classified networks. **JICOs** are officers responsible for planning and managing the critical joint tactical data link networks that aircraft and ground troops use to communicate in combat. JSS allows the JICO to optimally plan, configure, operate, monitor and exchange information among multi-tactical data link networks, using an integrated system of hardware and software. Northrop Grumman is delivering

42 JSS systems, 160 workstations, spares, training and support for fielding and logistics.



Flying With Ravens

AeroVironment, Inc. has received an order valued at \$46,226,984 under an existing contract with the U.S. Army. The order comprises 123 new digital Raven® small unmanned aircraft systems (UAS) and initial spares packages, as well as 186 digital retrofit kits for the U.S. Marine Corps. The order also includes 339 digital retrofit kits for the U.S. Army.

The Raven system and retrofit order represents the remainder of the funds appropriated for **RQ-11B Raven** system procurement in the *2010 Department of Defense Appropriations Act*, which was signed into law in December 2009. The orders were released under the existing U.S. Army joint small UAS program of record for AV's Raven. This program has included



contract additions from the Army, Marine Corps and Special Operations Command.

The items and services provided under these awards on this multi-year contract are fully funded. Work is scheduled to be performed within a period of 12 months.

The Raven unmanned aircraft is a 4.2-pound, backpackable, hand-launched sensor platform that provides day and night, real-time video imagery for “over the hill” and “around the corner” reconnaissance, surveillance and target acquisition in support of tactical units

Acquiring The 4th AEHF

The MILSATCOM Systems Directorate has awarded a cost-plus-incentive-fee contract modification valued at approximately \$1.4 billion to Lockheed Martin Space Systems, Sunnyvale, California, for production of the fourth Advanced Extremely High Frequency satellite.

The production contract includes manufacturing, integration and test of the fourth **AEHF** space vehicle. The satellite is contracted to be available for launch in 2017. **AEHF-1** was launched on Aug. 14, 2010, out of Cape Canaveral Air Force Station, Florida, and is currently in an orbit-raising phase. **AEHF-2** has completed production and is in storage until its scheduled launch in 2012. **AEHF-3** is undergoing Thermal-Vacuum Testing and is on track to complete production in 2011.

AEHF is the successor to the five-satellite Milstar constellation and will provide ten times greater global, highly secure, protected, survivable communications capability for warfighters operating on ground, sea and air platforms. The MILSATCOM Systems Directorate executes an annual budget of over \$2.4 billion as it plans for, acquires and sustains space-based global communications.



The JIST Of The Matter

ARINC Engineering Services, LLC has retained its key role as **Technical Support provider to USSTRATCOM** for the joint planning and management of **Satellite Communications (SATCOM)** resources of the **U.S. Department of Defense**.

Under a follow-on Air Force contract recently awarded, **ARINC** will continue support and development work on the *Joint Satellite Communications Management and Planning System (JSMPS)* and the related *Joint Integrated SATCOM Tool (JIST)*. The follow-on award is for a one-year base, four one-year options, and one additional option period. JSMPS is the hub of a net-centric suite of DoD databases and applications, providing global mission management of SATCOM resources. The JIST tool is intended to manage satellite access for DoD stakeholders through a request and authorization process. JSMPS/JIST is being matured into a web-enabled database and application suite for use by

all DoD SATCOM stakeholders. It will also provide a robust and secure environment for collaborative *Electro-magnetic and Radio Frequency Interference (EMI/RFI)* detection, tracking, analysis and mitigation.

Serious Surveillance System

Soon to come to Afghanistan is a revolutionary airborne surveillance system called **Gorgon Stare**, duly named after the **Gorgon**, a mythical Greek creature whose unblinking eyes turned to stone anyone who looked at him. Now the **Air Force** has a new drone that can see **everything**, and will transmit **live video images of physical movement across an entire town**.

Gorgon Stare is a nine video camera system mounted on an aircraft that is remotely operated and is capable of transmitting live video images of physical movement across any town. The system can transmit live video images to soldiers on the ground or to analysts tracking enemy movements, and sends as many as 65 various images to different users. This in comparison to today's UAV single camera that provides video from a single camera over a "soda straw" area the size of a building or two.

Contrarians question whether the military will be able to sort through enormous amounts of imagery in time to actually be helpful to troops in the field. Officials also agree that **Gorgon Stare** is of limited value unless they can match it with improved human intelligence — eyewitness reports of who is doing what... on the ground.



Radioing In More Awards

Harris Corporation has been awarded an Indefinite Delivery, Indefinite Quantity (IDIQ) contract with a potential total value of \$475 million to supply military and land mobile radio systems to international partners of the U.S. State Department and U.S. Department of Defense.

The five-year contract, awarded by the U.S. Army's *Communications Electronics Command (CECOM)*, certifies Harris as a provider of radios, accessories, communication systems and services to assist U.S. partners with their tactical communication needs. The contract is part of the U.S. government's *Foreign Military Sales* program, which support coalition building and interoperability through sales of defense equipment, training and services. The contract covers the Harris RF *Falcon II*® and *Falcon III*® radio portfolio, such as the *RF-7800M Multiband Networking*, and *RF-7800S Secure Personal* radios, as well as public safety and professional communications land mobile radios.



Fire Flies

Fire-X, a vertical unmanned air system (VUAS) developed by Northrop Grumman Corporation (NYSE:NOC) and Bell Helicopter, a Textron company (NYSE:TXT), completed its first fully autonomous flight Dec. 10 at Yuma Proving Ground, Ariz., less than one year after development began.

First flight involved a short-duration hover to validate safe and reliable autonomous flight. Additional flight tests and reliability data gathering will be conducted in the coming weeks. Integration of ISR sensor payloads and cargo carrying capability test flights is set to occur early next year. First flight was accomplished in 11 months after development began. It was achieved by integrating *Fire Scout*'s proven autonomous systems developed for the U.S. Navy with the highly successful *Bell 407* helicopter, a FAA-certified helicopter that's been in commercial service worldwide since 1996. The 407 system can carry ISR sensors and a useful load of more than 3,200 pounds – for fuel, payloads and/or enhanced cargo hauling capabilities – internally or externally. *Fire-X* will also be able to conduct ISR missions up to 16 hours in endurance and various cargo missions in support of U.S. Army and Marine Corps requirements.



Networking Backbone For Soldiers

The Joint Tactical Radio System, or JTRS, is transitioning from research and development, to production and delivery to Soldiers in the field. Providing cyber-hardened Internet Protocol networking on fluid, rough terrain battlefields, JTRS radios seamlessly interconnect air, ground, maritime and space platforms and networks in a multi-band, multi-mode capability to the individual Soldier.

The Soldier's personal C2-on-the-move communications network capability, located in a single box that acts like a mobile cell tower and router, operates in a deployable, mission-programmable, worldwide spectrum. Without **JTRS**, net-centric warfare, quite literally, stops at the command center.



JTRS GMR enables commanders to view and understand the battle space, communicate their intent, lead their forces and disseminate real-time information. It puts the full power of the Global Information Grid into the hands of the warfighter. Photo: Boeing

With JTRS products, every warfighter is connected to every other warfighter.

Today's Soldier can look forward to a personal communication support package that is lighter, self-contained, and cannot be hacked; has longer lasting batteries, and is able to transmit and receive at distances previously unimagined in a net-centric capability, at battlefield locations previously unreachable by legacy technologies. JTRS software-defined architecture increases network security as threats evolve, while providing position location information to the Soldier as real-time situational awareness is passed to the company level and below. Soldiers are safer, smarter and always in touch.

The convoy does not lose contact with battalion headquarters. JTRS products immediately go to work establishing a communications system and link throughout the entire convoy.

For the first time, the network now moves with the individual Soldier, rather than the Soldier having to move with the network. All operational and tactical data are at the Soldier's disposal, not pre-empted or interrupted by traditional communication limitations. With JTRS, the battlefield is truly networked and every Soldier is connected in a safe, secure communications nerve system where they need it most: at the tactical edge.

-Al Clayton and Mike Daily/Joint PEO JTRS

WIN-T Increment 2 Delivers OTM Comm

For the first time, Warfighter Information Network-Tactical Increment 2 will bring mobility to the Army's tactical network down to the company level. It will eliminate the need to stop to communicate, increasing maneuver speed on the battlefield and allowing Soldiers and commanders to stay connected at all times.

WIN-T Increment 2 is the early introduction of mature on-the-move technology. Its mission is to successfully deliver a self-forming, self-healing mobile communication infrastructure to Army combat units down to the company level, giving commanders the ability to communicate seamlessly on the move, and providing a solid foundation of program management and systems engineering for the increments that follow.

A key strength of WIN-T is its ability to adapt to changing battlefield conditions in real time, without the pre-planning and configuration required of traditional enterprise networking infrastructure. It enables network mobility by employing military or commercial satellite connectivity



WIN-T Increment 2 field test

and line-of-sight radios and antennas, to achieve end-to-end connectivity and dynamic networking operations.

Increment 2 maintains a constantly viable self-healing network by providing instant alternate connections in the event its connection is broken. As the vehicles that carry the mobile network move in and out of areas of blockage or beyond normal range of connectivity, the network will automatically adapt, allowing for continuous communications between Soldiers. From division down to battalion, Increment 2 will provide an OTM line-of-sight radio known as the **Highband Networking Radio**. This new radio will greatly increase line-of-sight capacity and ease of use. With the help of smart multi-beam antenna technology, the HNR can automatically detect all other HNR radios within range and allow users to pass video, voice or Internet Protocol data traffic to and from each other.

The *Program Manager WIN-T* has started equipment production for its initial operational test in the first quarter of fiscal year 2012. The first unit equipped is expected by the second quarter of fiscal year 2012. **WIN-T Increment 3**, which is still in development, will provide the air tier, using an advancement of the HNR radio, known as the **Joint Command Control Communications and Computers Intelligence, Surveillance and Reconnaissance Radio**, or **JC4ISR**, mounted on unmanned aircraft. The warfighter will possess a three-tiered communication network providing connectivity for the full spectrum of operations.

-Amy Walker/PEO Command Control Communications-Tactical

ADAPTING & UNDERSTANDING THE FUTURE OF WAR

**AUTHOR: COLONEL BRUCE SMITH, DIRECTOR
DIRECTORATE OF COMBAT DEVELOPMENT
FUTURE WARFARE CENTER**

In late December of last year, the Army published the Army Capstone Concept. The concept is subtitled “Operational Adaptability: Operating under conditions of Uncertainty and Complexity in an Era of Persistent Conflict.” The new concept is a guide to how the Army will apply available, yet dwindling, resources to overcome adaptive enemies, while concurrently articulating how to think about future armed conflict. This concept will serve as the foundation to drive development and modernization efforts. It provides the common framework for thinking about the conduct of future joint land operations under the conditions of uncertainty and complexity. The Army Capstone Concept helps place modernization decisions within the conceptual foundation of our DOTMLPF (doctrine, organization, training, materiel, leader development, personnel and facilities) requirements and development.

During the last two decades, many believed that the United States’ competitive advantages in communications, information,



and precision strike technologies produced a “*revolution in military affairs*” (RMA).

Advocates of RMA believed that the technology offered the Army a new way to fight a war that provided revolutionary abilities to find, identify, and target enemy forces with increased speed, precision and

lethality. RMA promised to provide unparalleled situational awareness that would enable commanders to see through the fog and friction of war, giving them unprecedented levels of certainty and assurance.

Unfortunately, proponents of RMA frequently failed to recognize the limitations of these new technologies and emerging threat military capabilities. Military concepts that relied on long range targeting and robust networks often divorced war from its human context; political, cultural, and psychological. RMA and defense transformation —

related thinking influenced Army doctrine, organization, manning, and modernization plans in ways that did not always reflect the reality of our forces’ experiences on the ground in Afghanistan or Iraq.



“The Army will remain dependent upon space-based capabilities such as satellite communications and position, navigation and timing to execute operations in uncertain and complex environments.”

Almost a decade of land combat operations has reinforced the fact that land warfare is fought in complex and uncertain environments. Political, cultural and psychological factors impact operations and cloud a commander’s situational awareness in ways technology alone cannot overcome. Army forces will continue to fight under these conditions of uncertainty and complexity. The Army Capstone Concept recognizes this fact, as well as the need for the Army to prepare to modernize and operate in this evolving and ambiguous environment. Rather than relying on perfect situational awareness, provided by technology, future forces and leaders must strive to reduce uncertainty through a mindset of operational adaptability. Soldiers must understand the situation in depth, develop the situation through action, fight for information, and continually reassess — adapting as the situation demands.

Leaders must be comfortable using their best judgement, and be willing to take prudent risks with the understanding that they will not have all the information and facts they would like, or might, need. Uncertainty and ambiguity cannot be completely overcome, but operational adaptability can help mitigate their effects.

Operational adaptability is essential to developing situational understanding and seizing, retaining and exploiting

the initiative. It is impossible to foresee the future, but developing leaders confident in operational adaptability will give the Army the ability to recover from surprise and exploit unforeseen opportunities. Operational adaptability requires the Soldiers master the operational art, or the ability to link the tactical employment of forces to policy goals and strategic objectives. It also demands Army forces that are proficient in tactical warfighting fundamentals and who possess common understanding of how to combine joint, Army, interagency, and multinational capabilities.

The Army Capstone Concept identifies a group of new, critical, and different capabilities that its Soldiers and forces require to fight and win in a complex and uncertain operating environment. Although the capabilities are listed in five broad categories: Battle Command, Movement and Maneuver, Fires, Protection, and Sustainment, the underlying theme or link is greater adaptability or versatility across the force in order to cope with future environment.

Although not all inclusive, key Army required tenants or capabilities include “mission command, train as we fight, command forward from mobile platforms, fight degraded, operate decentralized, defend networks, fight for information, and conduct reconnaissance to develop the situational.” What is

immediately obvious is that there are no space specific capabilities listed. In fact, the Army Capstone Concept does not discuss space at all.

Does the exclusion of space from the concept mean that the Army is changing its view on the importance of space and space-based capabilities? Is the Army throwing out space as it de-emphasizes RMA and technology and promotes the concept of operational adaptability?

The short answer to both questions is no. Although space-based capabilities are not specifically addressed in the new Capstone Concept, it is easy to see the linkages and dependencies that space-based capabilities provide to the Army and to the concept of operational adaptability. Space is no less important to the Army in this new concept. The Army will remain dependent upon space-based capabilities such as satellite communications and position, navigation and timing to execute operations in uncertain and complex environments.

Satellite communications and PNT provide the means to command forward from mobile platforms as well as operate in a decentralized manner. Space-based capabilities enable a unit to fight for information, as well as to conduct reconnaissance in order to develop the situation. Space-based capabilities and systems continue to enable Army operational capabilities within an uncertain and complex operating environment.

The findings from a variety of forums over the past several years, including the Allard Commission and the Space Posture Review, recognize that space-based capabilities are increasingly vulnerable. The Capstone Concept — while not specifically calling out this growing vulnerability to the Army — does point out that Army forces must be able to fight degraded, which includes space-based capabilities as well as degraded communications and command and control networks. The new concept also emphasizes the need for Soldiers to actively fight for information, rather than making the assumption that it will always be provided and present when they need it. At the same time, the concept recognizes the increasing need and importance that the Army defend its own networks in order to generate and preserve combat power.

U.S. space-based capabilities are an increasingly attractive target to our adversaries; all leaders — not just Army space leaders — must understand that there will be periods of time when space-based capabilities and systems are actively denied or degraded. Despite the recognition of our vulnerability, Army leaders have been reluctant to train in a degraded space environment.

Usually the loss of SATCOM or position, navigation and timing is simulated, accompanied by the rationale that training time is too valuable to waste and that we cannot afford to deny or degrade space-based capabilities, as it would detract from the main training objective. Consequently, leaders and Soldiers are not trained to operate in a degraded space environment.

The Army Capstone Concept provides the opportunity and rationale for rethinking this necessary training. In order to operate in a degraded environment, Army forces and leaders need to develop mitigation plans and strategies beforehand in order to successfully fight through these inevitable degradations. Army training, to include rotations at the Combat Training Centers, needs to routinely include denied or degrade space-based capabilities. Soldiers and forces should be practicing operations without satellite communications or GPS signals. They need to learn how to rapidly recognize degraded capabilities and take action to mitigate their loss, in order to preserve operational adaptability in an uncertain and complex environment.

In conclusion, the new Army Capstone Concept emphasizes operational adaptability. Leaders at all levels must have a mindset that is flexible, and they must be comfortable with collaborative planning and decentralized execution.

At the same time, our Soldiers must be able to tolerate and operate within ambiguous situations, and possess the ability and willingness to make rapid adjustments according to the situation. Space-based capabilities and systems enables the concepts, training and systems that make operational adaptability possible.

The new concept, rather than constraining space operations, provides U.S. Army Space and Missile Defense Command and Space Operation Officers a new opportunity and foundation challenging us to further emphasize, provide, and develop space-based capabilities within the Army. Operational adaptability is dependent upon space.

Editor's note

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