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May 2013

MilsatMagazine

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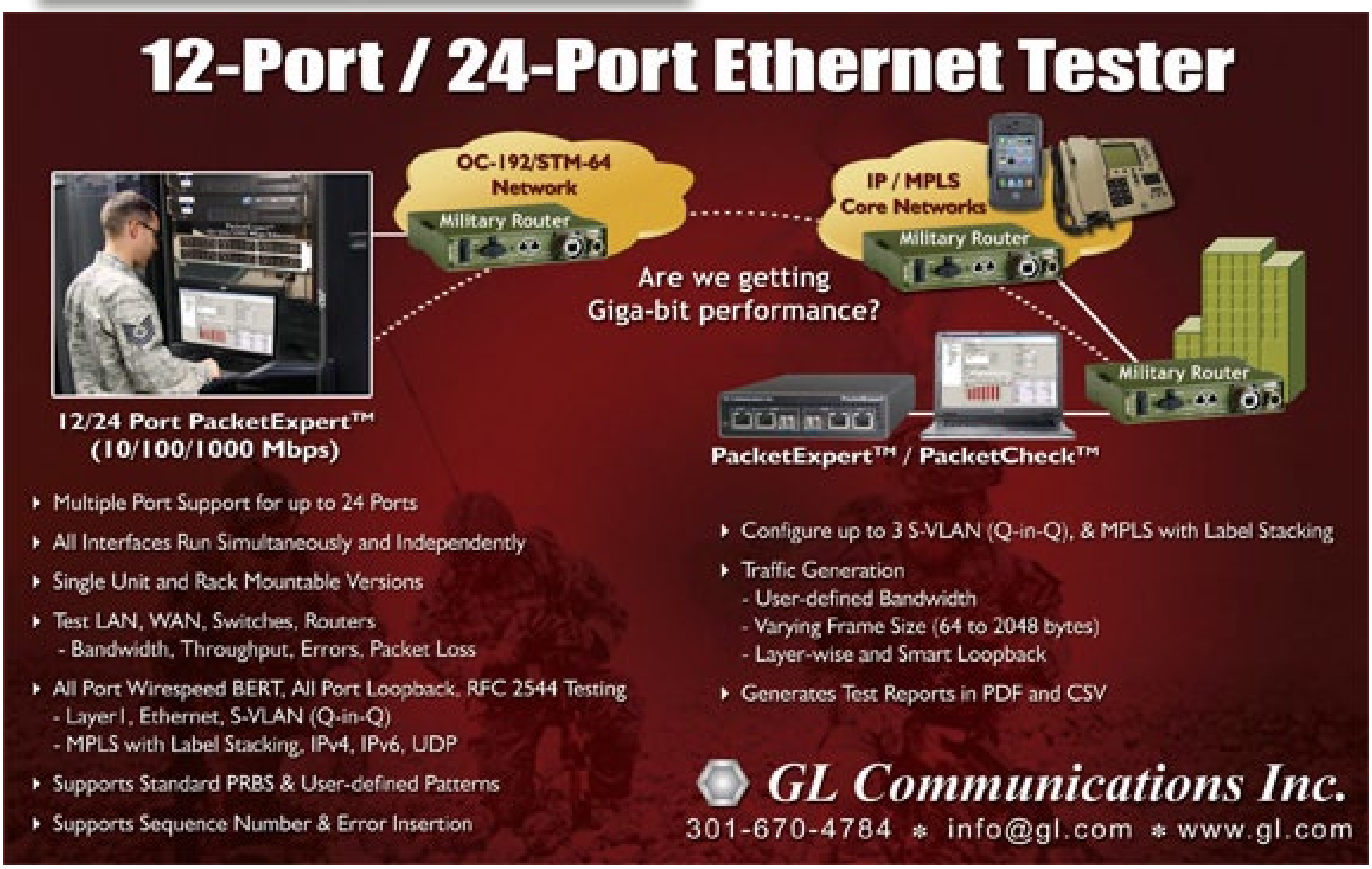

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Features (Continued)


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DISPATCHES

About MILSATCOM + COTS

Reportlinker.com has released a new market research report, now available in its catalogue: Global Military Communications & COTS Market 2013-2023.

Effective, efficient and reliable military communications remain one of the most integral components of any modern military force. Diverse yet highly connected, network centric theatres of operations demand robust, wide ranging and accurate communications equipment and services in order to share, process and distribute vital real-time situational data.

As a consequence, investment in military communications systems and services is set to continue throughout the next decade, despite significant budget cuts, economic limitations and potential technological challenges. Visiongain has therefore determined that the value of the global military communications & COTS market will reach $17.46B in 2013.

Greater focus within the market is expected in high technology SATCOM systems and services through increased public and commercial partnerships, COTS based equipment as an operational and cost saving mechanism and greater protection and security for communications data as part of overall cyber security investment.

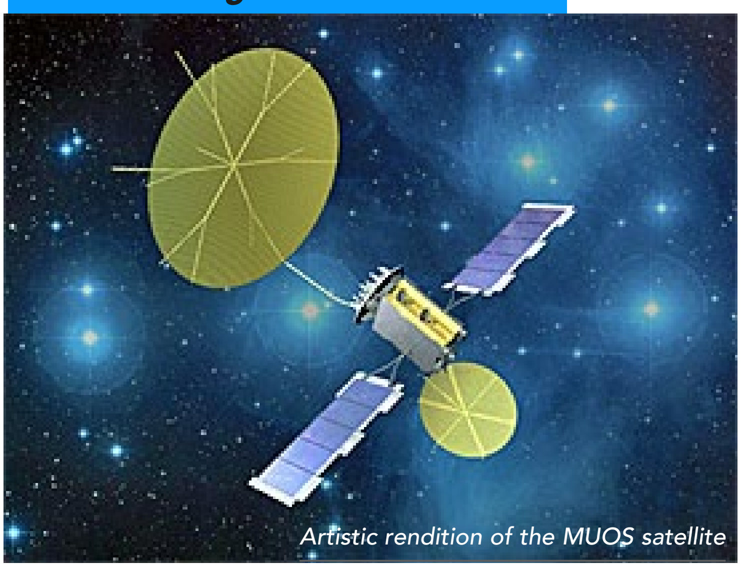
What makes this report unique is that Visiongain consulted widely with industry experts and full transcripts from exclusive interviews with Gilat Satellite Networks, Pentek Inc. and SkyWave Communications are included within the report.

The reports therefore have a unique blend of primary and secondary sources providing informed analysis. This methodology allows insight into the key drivers and restraints behind market dynamics and competitive developments, as well as identifying the technological issues.

The report also presents an ideal balance of qualitative analysis combined with extensive quantitative data including global, submarket and regional markets forecasts from 2013-2023—all identifying strategic business opportunities.

The report comprises 265 pages. Discover market forecasts, technological trends, predictions and expert opinion providing you with independent analysis derived from Visiongain's extensive primary and secondary research.

MUOS Moving Forward



Artistic rendition of the MUOS satellite

Lockheed Martin has integrated two of the most important components onto its fourth Mobile User Objective System (MUOS) satellite for the U.S. Navy.

Recently engineers mated the multi-beam assembly, which hosts 16 ultra-high frequency (UHF) antennas for distributed, global communications coverage. Earlier this year, the team delivered and integrated the vehicle's communications system module.

With bus and payload now together, the satellite is entering its first system check-outs before progressing to environmental test. Supporting UHF satellite communications, MUOS will provide mobile warfighters with assured communications, including the new capability of simultaneous voice, video and data for mobile users.

Designed and built by Lockheed Martin in Newtown, Pennsylvania, and delivered to the company's facilities in Sunnyvale, California, the antenna and system module enable communications coverage using the wideband code division multiple access standard. This provides a 16-fold increase over legacy UHF communications in the number and capacity of satellite links. The first MUOS satellite and associated ground system already provide legacy UHF communications capability.

The second MUOS satellite recently completed system testing and is undergoing final preparations for shipping, then launch in July. The third spacecraft is progressing through environmental testing. The five-satellite, global constellation is planned to achieve full operational capability in 2016.

Lockheed Martin is under contract to deliver four MUOS satellites plus a spare and the associated ground system to the U.S. Navy. Lockheed Martin Space Systems in Sunnyvale is the MUOS prime contractor and system integrator. The Navy's Program Executive Office for Space Systems, Chantilly, Virginia, and its Communications Satellite Program Office, San Diego, California, are responsible for the MUOS program.

Iris Bombelyn, vice president of Lockheed Martin's Narrowband Communications mission area. "We continue to focus on reducing risk, maintaining efficient operations and delivering a flawless vehicle to our customer."

WGS-5 Flight Clearance Obtained

United Launch Alliance (ULA) has cleared the launch of the WGS-5 mission, after thorough flight clearance process that was executed following a flight data anomaly that occurred on the Global Positioning System (GPS) IIF-3 launch on October 4, 2012.

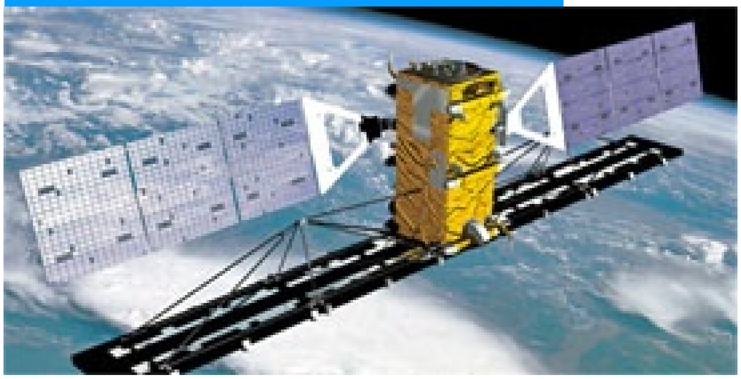
"This will be the first Delta IV launch following the low engine performance that was identified on the successful Global Positioning System (GPS) IIF-3 launch last October," said Jim Sponnick, ULA vice president, Mission Operations. "Although the GPS IIF-3 spacecraft was accurately placed into the required orbit, ULA, Pratt & Whitney Rocketdyne (PWR) and our U.S. Air Force teammates embarked on an investigation to determine why the upper stage engine performance was lower than expected. ULA completed a flight clearance assessment recently for the WGS-5 mission and our Air Force customer also assessed and

The ULA/PWR investigation concluded that a fuel leak within the upper stage RL10 engine system was the direct cause of the lower than expected engine performance on the GPS IIF-3 launch. To prevent a recurrence of this sort of fuel leak, the engine and vehicle systems have been very thoroughly inspected and also launch vehicle hardware modifications and changes to how the engine is operated during launch were implemented.

Engine testing that was performed to support this ULA investigation replicated fuel leaks like those observed in the GPS IIF-3 launch. The mitigations that have been implemented include extensive engine and launch-vehicle inspections to ensure that there is no damage and that there are no foreign objects that could cause problems for the operation of the engine system during launch. Additionally, launch vehicle hardware modifications and operational changes have been implemented to mitigate risks for the WGS-5 mission and future launches. The hardware modifications include the addition of in-flight helium purges to critical areas of the engine system. The operational changes to reduce risk include changes to how the engine is thermally conditioned in-flight to prepare for the first engine start following the booster phase of flight.

ULA program management, engineering, test, and mission support functions are headquartered in Denver, Colorado. Manufacturing, assembly and integration operations are located at Decatur, Alabama, and Harlingen, Texas. Launch operations are located at Cape Canaveral AFS, Florida, and Vandenberg AFB, California.

Radarsat-1 Retirement



A Ball Aerospace & Technologies Corp. Earth observation satellite built for the Canadian government has concluded its mission after serving the organization for more than 17 years— that's 12 years longer than its mission life.

Radarsat-1 launched in 1995 for an expected five-year mission. It was Canada's first and oldest Earth monitoring satellite and conducted the first complete radar survey of Antarctica. Ball Aerospace built the spacecraft bus and a portion of the ground station for the advanced operational synthetic aperture for Spar Aerospace and the Canadian Space Agency. Ball also provided technical services to Spar (MacDonald Dettwiler), including system engineering and system integration planning. Radarsat-1 represented several firsts for Ball Aerospace:

- » *First fixed price and commercial spacecraft bus, introducing a cost-effective solution for Earth observation and remote-sensing missions*
- » *First Ball Aerospace international spacecraft, which expanded the company's profile into new markets*
- » *Inaugural satellite bus for the company's successful Ball Configurable Platform (BCP) line of spacecraft*

By circling the Earth once every 101 minutes, Radarsat-1 relayed images for use in resource management with details about the Earth's geologic features, oceans, ice, weather and vegetation. The satellite's powerful synthetic aperture radar instrument acquired images of the Earth, day and night, in all weather and through cloud cover.

Radarsat-1's legacy included mapping regions of the Earth never mapped before including areas in South America, Africa and Asia; and completing a survey of the Antarctic continental ice shelf that helped monitor the effects of global climate change.

Ball built the Radarsat-1 spacecraft bus based on technical experience gained developing the Earth Radiation Budget Experiment for NASA and the Relay Mirror Experiment satellite for the U.S. Air Force. More recently, Ball continues its contributions to NASA's Earth science program with the launch of the Operational Land Imager aboard the Landsat Data Continuity Mission to extend the 40-year record of continuous land surface observations.

Frontline Support

Harris Corporation has been awarded a $45 million contract to support Department of Homeland Security (DHS) Immigration and Customs Enforcement (ICE) tactical communications networks.

Harris will team with Computer Sciences Corporation and other subcontractors to provide round-the-clock technical support for the frontline operations of approximately 15,000 law enforcement officers.

The Harris team will support the agency's existing tactical communications networks at multiple locations in the continental U.S., Puerto Rico and the U.S. Virgin Islands.

The team brings more than 20 years experience delivering world-class integration services to some of the largest networks in the world.

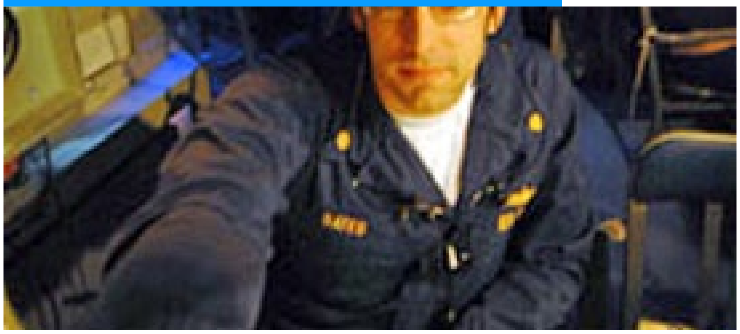
"Harris and its teammates will sustain legacy systems and provide cost-effective, interoperable services for those who depend on reliable communications," said Wayne Lucernoni, president, Harris IT Services. "Tactical communications systems must integrate seamlessly to support essential operations, and we are committed to helping our first responders to exchange real-time intelligence in support of our nation's security."

The contract was awarded through the five-year, $3 billion DHS Tactical Communications (TacCom) indefinite delivery/indefinite quantity (IDIQ) contract vehicle. Harris was selected to provide land mobile and tactical solutions under all five technical categories of the TacCom contract vehicle.

The IDIQ supports DHS and its partner agencies such as the U.S. Department of State, the U.S. Department of Justice, the U.S. Department of the Interior, and the White House Communications Agency.

In IT Services, Harris designs, deploys, operates and maintains secure communications systems and information networks around the globe.

Special Agent Present



Kratos Defense & Security Solutions, Inc. has revealed that Kratos SecureInfo, Kratos' dedicated business group of cybersecurity experts, has been awarded a license as a Special Agent of the Certifying Authority (ACA) from Air Force Space Command (AFSPC).

Kratos SecureInfo will leverage its satellite and cybersecurity subject matter expertise to provide comprehensive information security assessments in support of space systems.

Kratos SecureInfo's selection is based on 30 years of leadership in the satellite industry, its understanding of the unique security requirements for space systems, and its extensive track record of successfully helping the Air Force secure its information assets.

Kratos SecureInfo will serve as an independent and trusted agent, conduct system security assessments, and make certification determination recommendations to the Space Certifying Authority in direct support of program managers and system owners.

"Kratos SecureInfo is one of the only cybersecurity providers with the expertise to support both general information technology and specialized space systems," said Christopher Fountain, Sr. Vice President of the Kratos SecureInfo business group. "This award builds upon our existing work supporting the Air Force Senior Information Assurance Officer (AF SIAO) with security assessments of IT systems."

Recently, Kratos SecureInfo also introduced its new SATCOM Cybersecurity Assessment service that addresses the increasing threats and unique requirements for the commercial satellite industry.

The assessment delivers a detailed view of satellite network preparedness along with recommended steps to mitigate risks and ensure compliance with applicable regulations, standards and guidelines.

A New ICON For Science


Artistic rendition of Orbital's LeoSTAR-2 platform.

Orbital Sciences Corporation has been selected by the National Aeronautics and Space Administration (NASA) to design, manufacture, integrate and test a new heliophysics science satellite that will investigate the connection between space weather storms in the ionosphere, located at the edge of outer space, and Earth's terrestrial weather.

Orbital will provide its LEOStar-2 spacecraft platform and conduct systems integration and test for the Ionospheric Connection Explorer (ICON) mission at its Dulles, Virginia, satellite design and production facilities.

Orbital's contract for the two-year mission is valued at $50 million. The mission, which will be led by the University of California at Berkeley, is currently planned for launch in 2017.

The mission of the ICON satellite is to study the interface between the upper reaches of the Earth's atmosphere and outer space in response to a recent scientific discovery that the ionosphere, positioned at the edge of space where the Sun ionizes the air to create charged particles, is significantly influenced by storms in the lower atmosphere. ICON will also help NASA better understand how atmospheric winds control ionospheric variability.

The mission, selected for its scientific value and low-risk development plan, will improve the forecasts of extreme space weather by probing the variability of Earth's ionosphere with in-situ and remote-sensing instruments. Fluctuations in the ionosphere can disrupt satellite and radio communications from low- and geostationary-orbit communications spacecraft, creating a direct impact on the nation's economy.

The scientific findings resulting from the ICON mission could, for example, benefit commercial aircraft, as GPS signals can be distorted by charged-particle storms in the ionosphere.

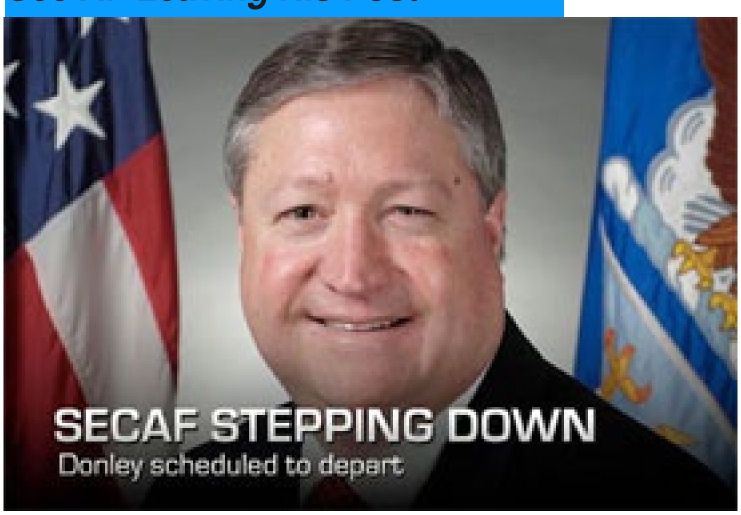
ICON was awarded under NASA's Explorer series of lower-cost and highly-productive space science satellites. Orbital has built multiple Explorer satellites for NASA, including the in-orbit NuSTAR, Swift, GALEX, AIM and IBEX spacecraft. In addition, Orbital was recently awarded a $75 million contract to design, build, integrate and test, as well as to perform mission operations, for another Explorer satellite, the Transiting Exoplanet Survey Satellite (TESS).

The ICON program is being led by Principal Investigator (PI) Dr. Thomas Immel of the University of California/Berkeley's Space Sciences Laboratory (UCB/SSL) and mission management is performed by UCB/SSL under NASA's Goddard Space Flight Center Explorers program.

The PI-led ICON mission features partners from the Naval Research Laboratory and the University of Texas/Dallas. Mission Operations will be performed by the UCB/SSL Mission Operations Center, which is currently operating the Orbital-built and launched NuSTAR astrophysics Small Explorer satellite.

The current LEOStar-2 product line has demonstrated an exceptional record for reliability, with four currently in orbit, another in production, and the TESS and ICON programs to be started later this year.

Sec AF Leaving His Post



Secretary of the Air Force Michael Donley has announced his plan to step down on June 21st as the Air Force's top civilian after serving for nearly five years.

"It's been an honor and a privilege to serve with our Air Force's great Airmen," Donley said. "Their accomplishments have been nothing short of impressive and I'm humbled to be a part of this team. The Air Force has been a way of life for so much of my career, I know it will be bittersweet to say farewell."

Donley was confirmed as the 22nd secretary of the Air Force Oct. 2, 2008. He served as the acting secretary since June of that year, as well as for seven months in 1993, making him the longest serving secretary in the history of the Air Force. He also served as the service's top financial officer from 1989 to 1993.

Better BLOS For Asian Nations

Harris Corporation has received a $29 million order to provide a nation in Asia with Falcon III® wideband tactical radios.

The radios will provide the country's armed forces with critical country-wide data communications and improved mission capabilities as part of an overall modernization effort. The nation is acquiring the company's new RF-7800H high-frequency wideband manpack and RF-7800W High-Capacity Line-of-Sight radios—the former is the world's first HF radio with high-speed wideband data capabilities. These advanced capabilities allow users to efficiently transmit large data files such as video images over very long range beyond-line-of-sight links. The radio is 20 percent smaller and lighter and offers data rates that are 10 times greater than other HF radios.

Navy Combat Ops Assistance

The U.S. Navy has awarded Northrop Grumman Corporation (NYSE:NOC) an $80 million contract to upgrade and enhance the Next Generation Command and Control Processor (NGC2P).

The NGC2P system is a tactical data link communication processor that provides critical real-time information about friendly and enemy activity during combat operations. The five-year, indefinite-quantity, indefinite-delivery NGC2P Technology Refresh and Link 22 contract was awarded on January 9th by the Space and Naval Warfare Systems Command (SPAWAR), San Diego. An additional two-year option would bring the total value to $95 million.

Northrop Grumman will provide software and hardware system development, engineering services and technology refresh field change kits for the communications processors aboard naval surface ships. Northrop Grumman will first provide designs addressing obsolescence issues in the current system. These improvements will increase computational capacity and later support system capability enhancements and new capability insertion, such as integration of the Link 22 secure digital radio link.

Northrop Grumman was first selected to develop NGC2P in 2008. The Northrop Grumman NGC2P team includes GET Engineering, El Cajon; FUSE Integration, Inc., Long Beach; and Technology Unlimited Group, San Diego, all based in California.

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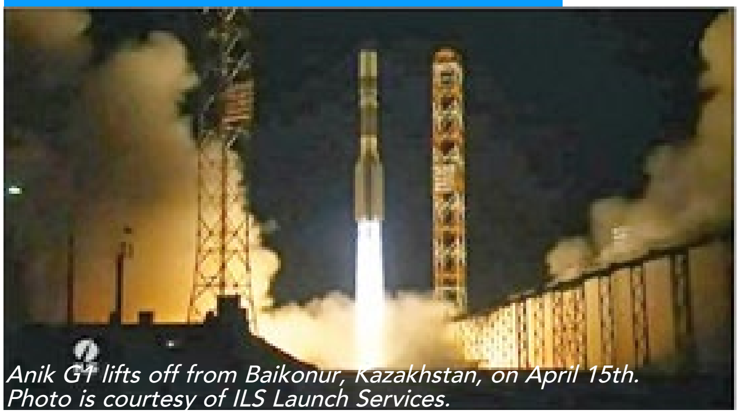
X-Band For MAG With Anik G1



Anik G1 lifts off from Baikonur, Kazakhstan, on April 15th. Photo is courtesy of ILS Launch Services.

International Launch Services (ILS) launched their Proton-M rocket with Telesat's Anik G1 satellite aboard from the Baikonur Cosmodrome in Kazakhstan on April 15th.

The Anik G1 is a commercial communications satellite that was built by SSL for Telesat. The multi-mission, 55 transponder satellite will be located at 107.3 degrees West longitude. This satellite offers military X-band coverage and doubles C- and Ku-band capacity over South America, and more.

The ILS Proton booster that was used to launch the satellite was 4.1m (13.5 ft) in diameter along its second and third stages, with a first stage diameter of 7.4m (24.3 ft). Overall height of the three stages of the Proton booster is 42.3 m (138.8 ft).

The Proton-M that launched with Anik G1 was powered by one RD-0213 engine, the third stage develops thrust of 583 kN (131,000 lbf), and a four-nozzle vernier engine that produces thrust of 31 kN (7,000 lbf). Guidance, navigation, and control of the Proton M during operation of the first three stages is carried out by a triple redundant closed-loop digital avionics system mounted in the Proton's third stage.

In total, the 4,905kg. satellite sports 24 C-band transponders, 28 Ku-band transponders, and 3 X-band transponders. The satellite, based on the SSL 1300 platform has an anticipated service life of 15 years.

This was the second ILS Proton launch in 2013, the 79th ILS Proton launch Overall. It was also the ninth Telesat satellite launched on ILS Proton and the 26th SSL satellite launched on ILS Proton.

Ku- Vs. Ka- Bandwidth

From DISA's Emerging Technologies Corner comes their take on the Ku- vs. Ka- bandwidth debate...

While many have likened the comparison of Ku- and Ka-band to the well-known Blu-ray versus HD DVD, or VHS versus Betamax format wars of the past, our situation is not a frequency band duel to the death, and we should not even assume the winner will be one or the other.

In this situation, the winner will ultimately be the consumer. The recent emergence of commercial Ka-band as a serious challenger to commercial Ku-band is not due to a specific advantage one has over another. It is actually tied more closely to the fact that the consumer's requirements are changing and thus drawing attention to throughput limitations of existing satellite systems.

For instance, typical existing Ku-band systems were designed with wider spot beams for widely dispersed VSAT networks that primarily focused on simplicity, video teleconferencing, and reliability. These lower Ku-band frequencies required smaller margins to overcome rain fade and thus wider spot beams provided regional service at lower costs.

On the other hand, wider spot beams limit frequency reutilization. This, combined with limited throughput, made these Ku-band payloads less desirable to modern high throughput users with an increased focus on mobility.

Due to these existing satellite systems, consumers have developed associations with suitability of frequency bands that are not truly characteristic of the frequency band, but rather the satellite business progression.

The new Ka-band systems, such as Inmarsat-5, are coming onto the market and promise to deliver substantially greater throughput than current Ku-band offerings.

This fact has led some in the industry to conclude that Ka-band capacity is a superior evolution of Ku-band capacity.

However, the reality is that there are high throughput Ku-band satellite systems also being developed that offer similar throughputs with smaller spot beams.

With the investment in both bands, today's debate to determine whether Ku-band or Ka-band is better continues.

One element is certain—we will continue to experience more technological advances, and satellite manufacturers will continue to launch newer, faster, stronger, and more flexible satellites.

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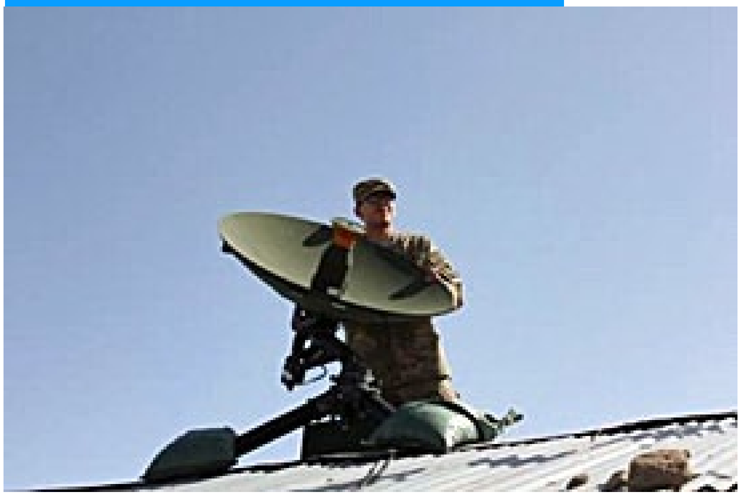


U.S. Army Spc. Jose Santos, assigned to the survey section, Headquarters and Headquarters Battery, 2nd Battalion, 15th Field Artillery Regiment, aligns a global broadcasting system dish to connect with a weather satellite at Forward Operating Base Sharana, April 30, 2013. The weather data he collects allows the field artillery units to fire accurately. (U.S. Army photo by 1st Lt. Justin Brooks, 2nd Battalion, 15th Field Artillery Regiment)

Accurate indirect fires require more than just well-trained crews with the knowledge and training to effectively operate the systems. It requires accurate and up-to-date global positioning system coordinates and weather data, as well.

As a military occupational specialty 13T, field artillery surveyor and meteorological crew member, U.S. Army Spc. Jose Santos of 2nd Battalion, 15th Field Artillery Regiment, has a mission to provide indirect fire and target locating assets with a common grid and valid weather data.

Common grids permit the massing of indirect fires, delivery of surprise observed fires and transmission of target data from one unit to another to aggressively neutralize or destroy enemy targets. Valid weather data allows for correct charges and adjustments to be made to guns or tubes to put rounds on target.

"Being the only 13T in Afghanistan with 2-15 FA," said Santos, "I've had to take the initiative to ensure all survey missions were accurate and successful."

Due to the various locations of the firing units, Santos has had to adjust his training for the current mission, a decentralized artillery fight. This is something not done often within the field artillery community.

"We rely on one person and one person alone to maintain our meteorological systems and provide survey support throughout the province, and he is our guy," said Chief Warrant Officer 2 Christopher Ludwick, 2-15 FA's sensor manager.

Being responsible for two of the five pieces of accurate and predictive fires (GPS coordinates and weather data), the other three being accurate target location, firing unit location, and weapon and ammunition information, Spc. Santos' training helps provide an essential piece of the unit's artillery power, helping to ensure accuracy.

"Accurate firing unit location is one of the five requirements for accurate predictive fires," said Capt. Brian Reynolds, operations officer for 2-15 FA. "Without the skilled work of a survey soldier, our firing units would not be as precise as this fight demands them to be."

Having accurate artillery allows the ground commander to call for artillery more often which helps to reduce coalition casualties in a fight and significantly reduces the possibility of civilian casualties.

Due to constraints on the deployable size of the Security Forces Assistance Brigade, the battalion could bring only one; the most qualified and highly trained of the 13T's. Having practiced this mission at numerous training events, including two national training center rotations and a division level exercise, Santos was the right choice.

The 13Ts normally use the improved azimuth determining system to make their computations. However, iPads use is not suited for the mission in Afghanistan. Instead, Santos uses an older method he learned during his initial training.

"Not having the iPad, I have managed to come up with an effective way for providing command survey control," explained Santos. "I use a surveying transit and a global location position system to turn angles into known azimuths and the global broadcasting system, which pulls weather data from a satellite."

In order to connect the GBS to the satellite, Santos adjusts a dish on the system manually to obtain a lock that is able to provide accurate meteorological data for all firing systems.

"The experience brought to the tactical operations center by Santos has proven invaluable during the opening months of our deployment," explained Ludwick. "Without him, our capabilities to provide accurate and predictive fires decreases."

FAB-T Enters New Phase

The Boeing family of Advanced Beyond Line-of-Sight Terminals (FAB-T) wideband communications program has entered a new phase by delivering the first two engineering development models to the U.S. Air Force. Able to perform nearly all FAB-T production terminal mission functions, the models will be tested through June under realistic operational conditions aboard aircraft and at Hanscom Air Force Base, Massachusetts.

"These models will allow the Air Force to test how actual terminals will perform in their deployed configurations," said Paul Geery, Boeing vice president and FAB-T program manager. "With tests conducted in 2012, Boeing has demonstrated that FAB-T can perform effectively even in the extreme vibration and harsh temperatures found on airborne platforms."

FAB-T will carry protected communications for the command and control of U.S. nuclear forces via Advanced Extremely High Frequency and Milstar satellites. The terminals will be used aboard B-2 and B-52 bombers, RC-135 reconnaissance aircraft, and E-4 and E-6 Special Air Mission aircraft, as well as in fixed and transportable configurations on the ground.

"These milestones validate that Boeing has a mature design that meets operating requirements for all mission environments," Geery said. "Our solution offers the quickest and lowest-risk path to putting all the FAB-T functions into warfighters' hands."

Blasting Toward The CDR

The forward segment for ATK's five-segment motor test, QM-1, scheduled for later this year, was recently installed in test bay T-97 in Promontory, Utah. The motor is expected to be completely installed in its test stand this fall. A successful Preliminary Design Review was recently completed with NASA for the five-segment solid rocket booster. (PRNewsFoto/ATK)

ATK has successfully completed its solid rocket booster Preliminary Design Review (PDR) with NASA for the new Space Launch System (SLS).

The PDR milestone indicates the booster design is on track to support first flight of the SLS in 2017.

The SLS vehicle will support NASA's human spaceflight exploration to all destinations beyond low-Earth orbit.

"This is a tremendous milestone for ATK as we work toward building the boosters for our country's Space Launch System," said Charlie Precourt, vice president and general manager of ATK's Space Launch division. "NASA's SLS will enable human exploration for decades to come."

With the successful completion of PDR, the SLS booster design can now proceed with the associated activities required to advance the design toward Critical Design Review (CDR). Additionally, a ground static firing of qualification motor-1 is planned for later this year at ATK.

The SLS booster PDR is a significant step toward providing the necessary technical and programmatic information needed for NASA to obtain approval to proceed with development of the Space Launch System—which will support a variety of missions of national and international importance.

This GPS Exercise Is On Track

Raytheon Company successfully completed the second launch readiness exercise for the U.S. Air Force's next generation Global Positioning System (GPS) operational control system (OCX).

Successful completion of Exercise 2 is a key milestone demonstrating that Raytheon's OCX software meets mission requirements and is on track to support the first GPS III satellite launch.

Completed over a three-day period in late February, the joint industry and government exercise demonstrated OCX mission software capability.

The exercise, building on the functionality tested in Exercise 1, simulated a liquid apogee engine burn to insert the GPS III vehicle into transfer orbit and evaluated vehicle telemetry, maneuver planning and execution.

The Lockheed Martin-built GPS III satellites and Raytheon's OCX are critical elements of the Air Force's plan to affordably replace aging GPS satellites while improving capabilities to meet the evolving demands of military, commercial and civilian users worldwide.

"Successful completion of Exercise 2 is a clear indicator that the solid design and strong command and control and mission planning capability meet the requirements to support the GPS III launch," said Ray Kolibaba, a vice president of Raytheon's Intelligence, Information and Services business and GPS OCX program manager. "The entire government-industry team is working hand-in-hand to successfully deliver the OCX ground system and GPS III space vehicles for a successful first launch."

Space Domain Is Vital To Nat'l Defense

It is critical for the Defense Department to develop and implement space programs and policies to maintain U.S. space advantages in a perpetually changing environment, a senior defense official told Congress yesterday.

Douglas L. Loverro, deputy assistant secretary of defense for space policy, appeared before the Senate Armed Services Committee's subcommittee on strategic forces regarding the fiscal year 2014 budget proposal for military space programs.

"[It's a] basic reality that space remains vital to our national security," he said. "But the evolving strategic environment increasingly challenges U.S. space advantages—advantages that both our warfighters and our adversaries have come to appreciate."

As space becomes more congested, competitive and contested, Loverro said, the department must formulate programs and policies that will secure those advantages for years to come. But reality, he added, is juxtaposed with providing these capabilities in an environment with increasingly restrained budgets.

Loverro said the growing challenges of budgeting, in addition to increasing external threats, compels the department to think and act differently.

But Loverro noted that while he thinks these realities present the Defense Department with a clear challenge, he does not view them with "a sense of 'doom and gloom.'"

"New entrepreneurial suppliers, alongside our legacy suppliers, are creating an ever-burgeoning commercial space market that can provide significant advantages to DOD if we formulate the policies and strategies to encourage their growth and use," he said. "Similarly, there has been a growth worldwide in allied space investment capability."

This growth, he added, provides the Defense Department a significant opportunity in helping to build resilience into its space capabilities.

Loverro said the policies and strategies under discussion begin to address challenges and opportunities.

"But they are just the initial steps in an area that will continue to demand attention and action from all of us," he said.

Story by
Army Sgt. 1st Class Tyrone C. Marshall Jr.
American Forces Press Service

PointOfView: DoD + SATCOM

by Kay Sears
President, Intelsat General Corp.

We have all had this experience: you hear about a mistake a person or a company made and you say something like, "Well, why didn't they just use common sense?"

We don't always realize that what we call "common sense" is often the wisdom that has come over many years of trial and error, learning what works and what doesn't. This kind of "common sense" is at the heart of a document presented to the Department of Defense earlier this year by an industry group consisting of Intelsat General, SES Government Solutions, XTAR, Telesat and Eutelsat America.

The DoD had asked commercial companies for suggestions under its Better Buying Power initiative of how to take better advantage of what commercial satellite operators had to offer. The looming budget cuts that the Pentagon faced under sequestration gave new urgency to this effort at the end of 2012.

The companies came up with a document called "Seven Ways to Make the DoD a Better Buyer of Commercial SATCOM" and presented it in January.

To an outsider, the seven suggestions might seem obvious practices to follow. But remember that the DoD has only become a heavy user of commercial satellite capacity in the last decade.

Both the industry satellite operators and the government users have learned what has worked and what hasn't in that time and are beginning to see what "common sense" might mean.

Here is what we proposed:

1. *Establish a baseline of how much COMSATCOM the DoD needs, and then budget and contract for it. The problem here has been that historic DoD procurement procedures have not allowed for such contracts to be longer than a year. This needs to change.*
2. *Develop accurate comparisons of the cost of commercial vs. the cost of military SATCOM. For an agency used to procuring and launching its own satellites, such cost comparisons have usually been apples against oranges.*
3. *Use IDIQ contracts only to supplement baseline requirements. This goes back to not being able to sign contracts of more than a year, so the DoD has been stuck buying capacity on the spot market, at higher prices, rather than engaging in long-term agreements at lower prices.*
4. *Build an architecture that fully integrates commercial and military capabilities. Once again, not enough planning for future needs, so we end up with redundant capabilities.*
5. *Partner with industry to build protected communications infrastructure for space systems. With long-term contracts, the industry would be willing to invest in better protecting satellite networks.*
6. *Use Hosted Payloads. Five years ago, "Hosted Payload" was a term few could define, but at last, the DoD is beginning to see how this could be a major way of saving money and getting capabilities to space more quickly.*
7. *Have a single office that handles all commercial and military satellite capabilities. Right now, DISA procures commercial capacity for the military while the Air Force is responsible for capacity on military satellites. Combining this function would be more efficient.*

We have proposed nothing radical. And we are heartened that Pentagon officials at many levels are beginning to realize that the practices, such as those outlined above, will actually save the government a great deal of money. *Seems like common sense to us!*

About the author

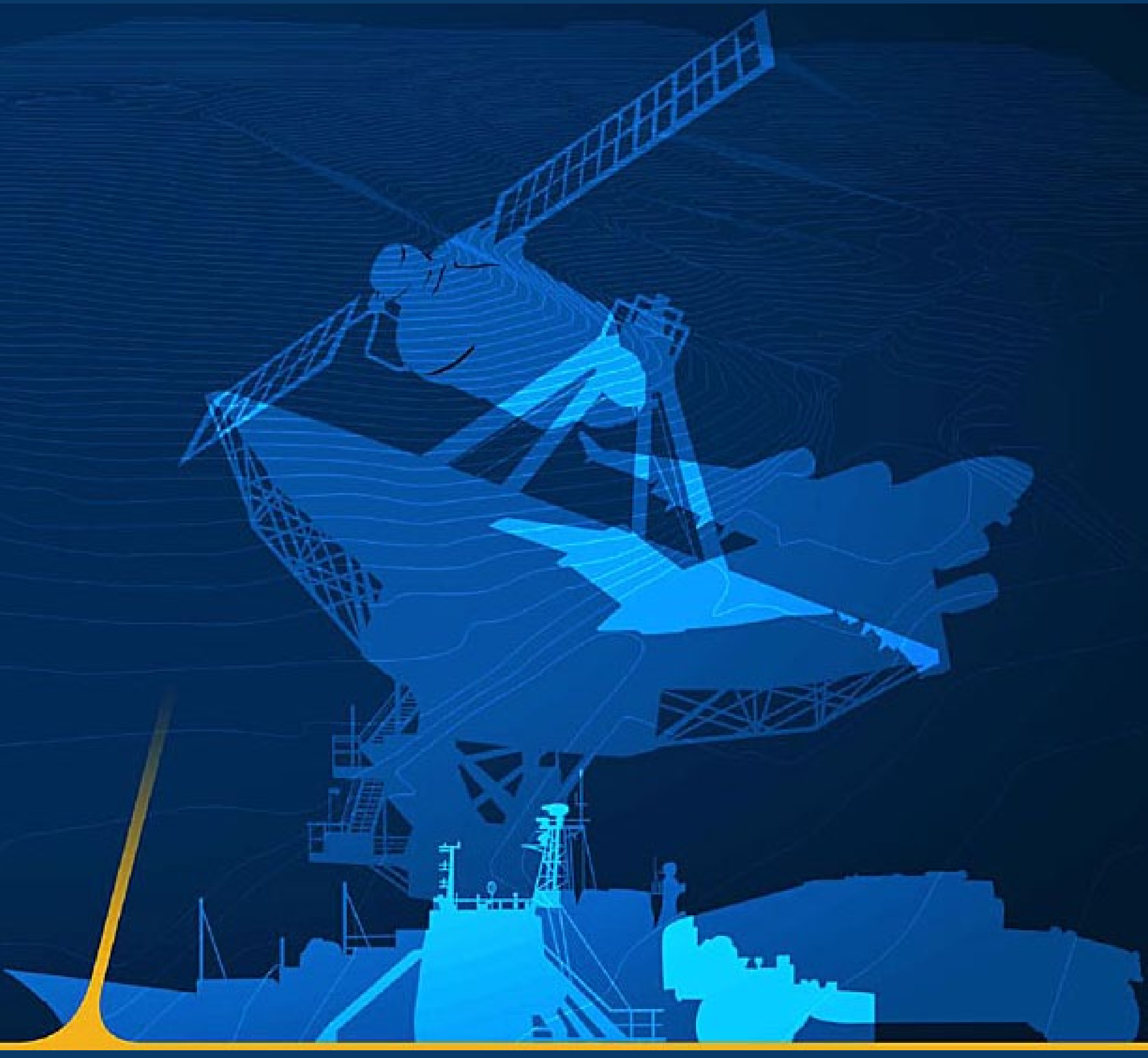
Kay Sears was named President of ***Intelsat General Corporation*** in 2008 and is responsible for the overall leadership of the organization.

Airborne Satellite COTM

by Karl Fuchs
Vice President of Technology, iDirect Government Technologies

Successful communication network design, whether terrestrial, satellite, static or *Communications-On-The-Move* (COTM), is successful only when user applications and requirements are fully understood.

Designing a satellite airborne COTM infrastructure for the military is challenging. The end-user applications range from routine data and email through flash override *Voice over IP* (VoIP), to high-definition *Intelligence, Surveillance and Reconnaissance* (ISR) video. These demanding, end-user applications necessitate high bandwidths



that must be supported on a fast-moving aircraft using a very small antenna, while providing global coverage under stringent *Communications Security* (COMSEC) and *Transmission Security* (TRANSEC) requirements. This article presents the challenges and the current state of technology enabling a global airborne COTM network for the Department of Defense (DoD).

Traditional Data Applications

There are two primary sets of applications for airborne COTM. The first is what are considered traditional data applications, such as email, video conferencing and VoIP. The second is ISR video backhaul and dissemination. The military's unique demands on the transmission of these data types can greatly impact network design.

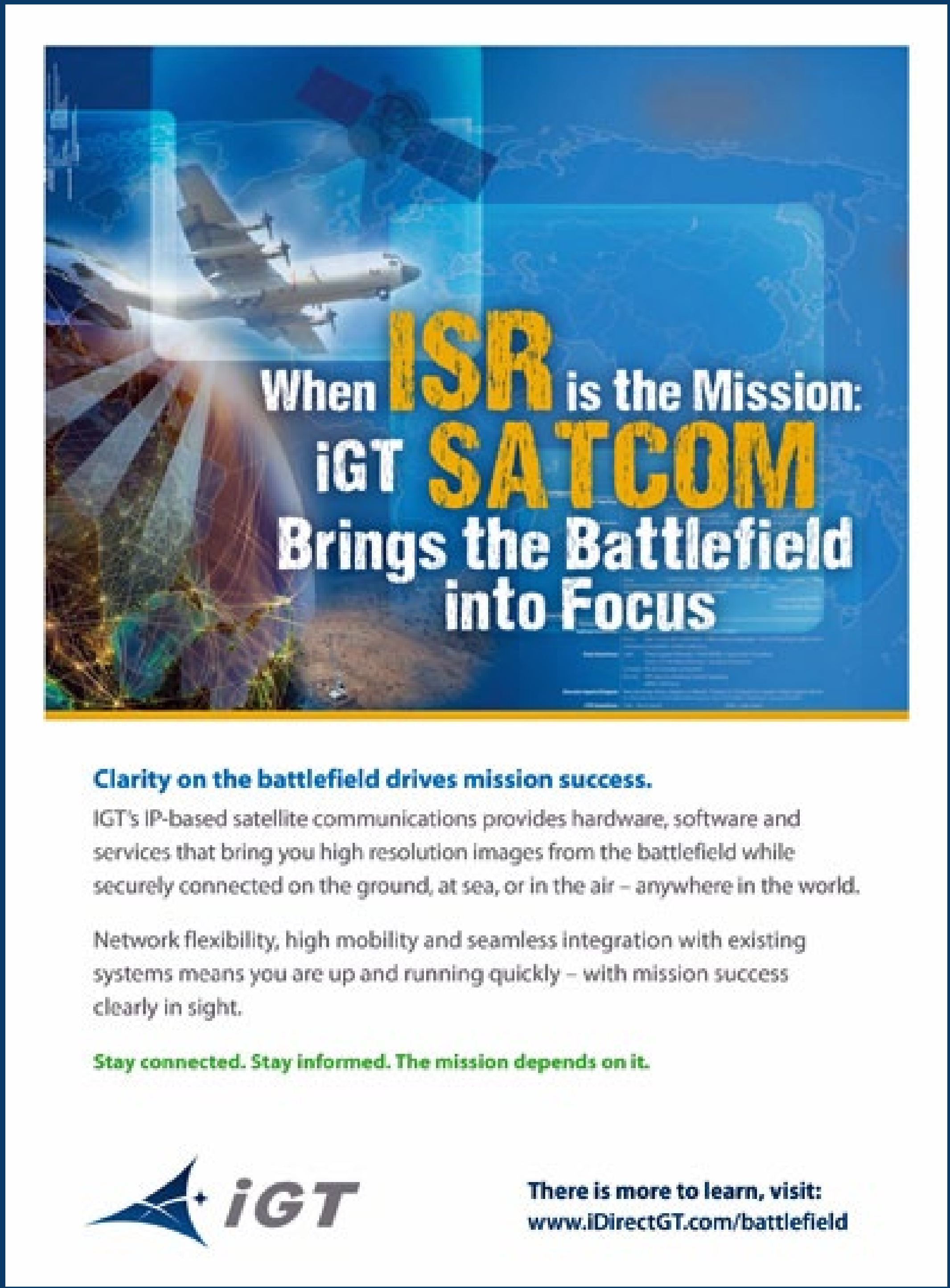
Whether traditional data applications are encrypted or not, it is important to understand how IP data is transported in a satellite network. *Transmission Control Protocol* (**TCP**) acceleration is used to ensure link efficiency when transmitting over a high latency media, such as geostationary satellite. With unencrypted data, the TCP acceleration occurs transparently in the satellite router. When the end-user encrypts the data prior to transmission, the TCP headers are not available for TCP acceleration.

Therefore, the acceleration has to occur prior to encryption. Introducing TCP or *Wide Area Network* (**WAN**) accelerators to a network can dramatically change the architecture, IP addressing and cost of deployment.

Prioritizing voice and data traffic is imperative to the military. In the case of *Multilevel Precedence and Preemption* (**MLPP**) VoIP, multiple levels of prioritization with strict priority queuing must be supported. This exceeds the quality of service capabilities of most commercial-grade satellite products on the market today, making military grade networks necessary.

TCP, WAN and MLPP capabilities are now being deployed on military aircraft executing data transfers. While the bandwidth requirements of a given mission will vary, typical data applications being used on an aircraft is usually on the order of a T-1 (1.544Mb/s). Such data rates are easily obtainable in the Ku-band using a 12- to 18-inch parabolic antenna or the equivalent aperture flat panel, using a *Time Divisional Multiple Access* (**TDMA**) return channel.

Airborne COTM frequency band and return-channel architecture are particularly important to ensure secure data transmission. Due to the proximity of adjacent satellites and the need for such small diameter antennas on aircraft, the Ku-band often necessitates using spread-spectrum technology to lower the power spectral density of the waveform.



Airborne Satellite COTM (Cont.)

ISR Design Considerations

The second application driving the airborne COTM market is ISR video backhaul and dissemination. High-definition video transmission from an aircraft is a daunting challenge because it requires a great deal of bandwidth. Using the appropriate *Coder/Decoder* (**CODEC**), high-definition video can be transmitted in as little as 2Mb/s on an in-route carrier. With aircraft challenged by adjacent satellite interference and power-limited transponder transmission rates, while using very small aperture antennas, this data rate begins to push the transmission limit of an aircraft using TDMA in the Ku-band.

ISR Requirements

There are network design decisions that can improve ISR video data rates—14Mb/s and greater data rates off an aircraft are possible with the right combination of technologies. Frequency band is important because the proximity of the next satellite transmitting in your frequency band determines the need for spread spectrum. While most Ku-band satellites have another satellite in the next orbital slot, usually spaced at 2 degrees, X-band satellites are spaced at 3 degrees, allowing higher transmit power without *Adjacent Satellite Interference* (**ASI**). While it is not always practical, either X- or Ka-band can allow for greater data throughputs.

Another important design choice when building an ISR airborne COTM network is network topology. TDMA is a very bandwidth efficient technology, but only when transporting intermittent, packetized data.

A better choice for ISR transmission off an aircraft is a *Single Channel Per Carrier* (**SCPC**) link. Video links are effectively always-on, so there is no statistical sharing to leverage in TDMA. With their simplicity, SCPC carriers have much lower *Layer 2* overhead and more efficient spectral efficiencies. In addition, as SCPC channels are not as dynamic as in TDMA, the demodulators often have 1 to 1.5dB better C/N characteristics. An SCPC modem is often the simple solution for a network that supports only one ISR platform.

Most networks need to support multiple platforms simultaneously. That, coupled with the fact that ISR data transmission is very asymmetric, with most of the data being transmitted off the aircraft, indicates a shared out-route with SCPC return channels is the optimal network configuration.

Antenna Limitations

One of the greatest airborne COTM challenges is the requirement for extremely small, equivalent aperture antennas. The practical limit for an antenna on an aircraft is between 30 and 45cm. There are notable exceptions of course, including the 1.2 M Ku- antenna mounted in a ***Global Hawk***. However, this article describes the requirements and limitations of approximately 45cm equivalent aperture antennas. Antennas of this dimension severely limit the achievable link budgets of a COTM network. In addition, the pointing error and focus of such antennas often require using Spread Spectrum technology to mitigate ASI.

Spread Spectrum

Spread Spectrum is a technology used to lower the *Power Spectral Density* (**PSD**) of a given waveform. While lowering the PSD of a waveform lowers the interference with other satellites adjacent to the target satellite transmitting in the same—this comes with a price.

To lower the PSD of a waveform, a *Pseudo-Noise* (**PN**) Code of the appropriate chip rate must be *XORed* with the transmitted data. The net result is a transmitted waveform at the same data rate that occupies a greater amount of transponded bandwidth.

The large bandwidth required for an airborne network is detrimental to the proliferation of *World Wide Airborne Networks* (**WWANs**). All Spread Spectrum implementations on satellite routers are not alike. Spread Spectrum for transponded satellite systems can be implemented in two broad ways.

One way to implement Spread Spectrum for transponded satellite systems is *Code Division Multiple Access* (**CDMA**). In CDMA, the network uses multiple, orthogonal PN codes to differentiate remotes in the network. The main disadvantage of using CDMA to mitigate ASI is that the power transmitted by multiple remotes on the same frequency stacks effectively. This means the chip rate required to stay below the PSD required is based on the combination of link budget, satellite band, proximity to nearest satellite transmitting in the same beam, antenna off-axis characteristics and the number of remotes in the network.

For an airborne network of any size, this would lead to an unacceptably high use of satellite bandwidth. A more cost-effective approach is using a TDMA-based direct sequence Spread Spectrum. In a TDMA-based network only one remote at a time will transmit. Therefore, the chip rate needed, and the occupied bandwidth required, will be independent of the number of aircraft in the network.

Two of the factors determining if Spread Spectrum is required is the satellite band being used and the proximity to the nearest satellite using the same band. As stated earlier, Ku-band satellites are closely packed in the orbital slots, virtually guaranteeing Spread Spectrum use for Airborne COTM networks using this band. This is contrasted to X-band. There are fewer X-band satellites in orbit, so their spacing is much greater. In most cases, an airborne network operating on X-band will not need to implement Spread Spectrum.

The use of Spread Spectrum exacts a toll beyond the extra bandwidth it occupies. All satellite modems have a maximum transmission rate, known as the *symbol rate*. As Spread Spectrum requires more occupied bandwidth for a given data rate, a satellite modem using spread spectrum may be limited by its maximum symbol rate.

Doppler Effect

The *Doppler Effect* has been a consideration of satellite modem manufacturers for some time. The Doppler Effect is the change in frequency of a wave, as perceived by a receiving station, as either the transmitter or the receiver moves.

Historically, the Doppler Effect in satellite transmission has been a secondary consideration arising from the satellite's motion in its station-keeping box. With high-speed COTM vehicles such as aircraft, the Doppler Effect has a great impact on the effectiveness of demodulators. The amount of Doppler Effect observed from a moving vehicle is dependent on the geometry of motion.

For example, whether the aircraft is moving toward or away from the satellite (+/-), as well as the angle (θ) the velocity, and the acceleration of the vehicle, all impact the Doppler Effect. These formulas quantify frequency shift based on the pertinent variables.

UNIFORM VELOCITY

$$\text{Time Drift} = \frac{\pm v * \cos(\theta\ E1) * 10^9}{c} \ (ns/s)$$

$$\text{Frequency Shift} = \frac{\pm V * fcarrier * \cos(\theta\ E1)}{c} \ (Hz)$$

$$\text{Frequency Drift} = 0$$

UNIFORM ACCELERATION

$$\text{Time Drift} = \frac{\pm (v * at) * \cos(\theta\ E1) * 10^9}{C} \ (ns/s)$$

$$\text{Frequency Shift} = \frac{a * t * fcarrier * \cos(\theta\ E1)}{c} \ (Hz)$$

$$\text{Frequency Drift} = \frac{a * fcarrier * \cos(\theta\ E1)}{c} \ (Hz/s)$$

Terrestrial and maritime vehicles travel relatively slow, so the Doppler Effect does not come into play. It is, however, a major factor on airborne platforms. For comparative purposes, at Ku-band, an aircraft travelling at 1,188Km/h, and experiencing 1.7G acceleration with a zero degree look angle, will have an uplink frequency shift of 15,950Hz. Such large frequency shifts must be compensated for. For the in-bound, in the **iDirect**® system, such frequency shifts have been accommodated through advances in demodulator code, primarily by adopting a multiple correlator structure.

Antenna Skew

Flat-panel antennas can cause skew angle issues. This off-axis *Effective Isotropic Radiated Power* (**EIRP**) problem must be addressed.

Some antennas, particularly vehicle mounted antennas, have apertures that are not round. As a consequence, the beams coming from these antennas have a peculiar shape— they are elongated, with the large width of the beam along the narrow width of the antenna. As these antennas are mounted on the tops of vehicles, the beam leaving the aircraft is wide in the vertical direction and narrow in the horizontal direction, as seen from the aircraft.

For a mobile terminal, this presents some particular challenges. Antennas with wider beams hit the adjacent satellites with more power, for a given bore site power. For antennas with beams that are not round, the adjacent satellite interference will depend on the location of the antenna on the Earth.

As illustrated in *Figure 1*, the satellite is due north of the antenna's longitude, and the wide angle of the beam is perpendicular to the geosynchronous arc. The ASI is low for a given bore site power. However, if the antenna moves to a location west of the satellite, as shown in *Figure 2*, then the wide part of the beam is exactly along the geosynchronous arc, and the adjacent satellites see a significant amount of radiation from the terminal. The angle between the short axis of the beam and the geosynchronous arc is the skew angle.

Figure 1 (on the next page) illustrates 0 degrees skew, which is the best case, while *Figure 2* (also on the next page) illustrates 90 degrees skew, which is the worst case. The challenge is having an adaptive system respect the ASI limits in the bad skew case, while taking advantage of the better spectral efficiency in the good skew case.

The beam width of a terminal, combined with the appropriate regulatory ASI limits, inhibit the spectral power density that the terminal can radiate on the bore site. This, in turn, affects the allowable C/N and the spectral efficiency achievable.

Figure 3 (two pages away) illustrates how a given antenna is characterized. The X axis is the skew angle, with 0 on the left and 90 degrees on the right. The vertical axis is the allowable spectral power density allowed for a given regulatory regime. This curve can be computed for a given antenna pattern and regulatory regime by looking at the beam pattern as sliced along different skew angles, and comparing them to the regulatory limits.

If the vehicle tilts, the skew angle is affected. For example, if the aircraft in *Figure 1* banks by 45 degrees, and is flying due south, then the skew angle will be 45 degrees. Sometimes local tilt will make the skew angle worse, and sometimes better, depending on the direction of tilt. So, given an antenna with an elongated beam, how can we maximize the spectral efficiency while guaranteeing that the off-axis regulatory requirements are met?

Airborne Satellite COTM (Cont.)

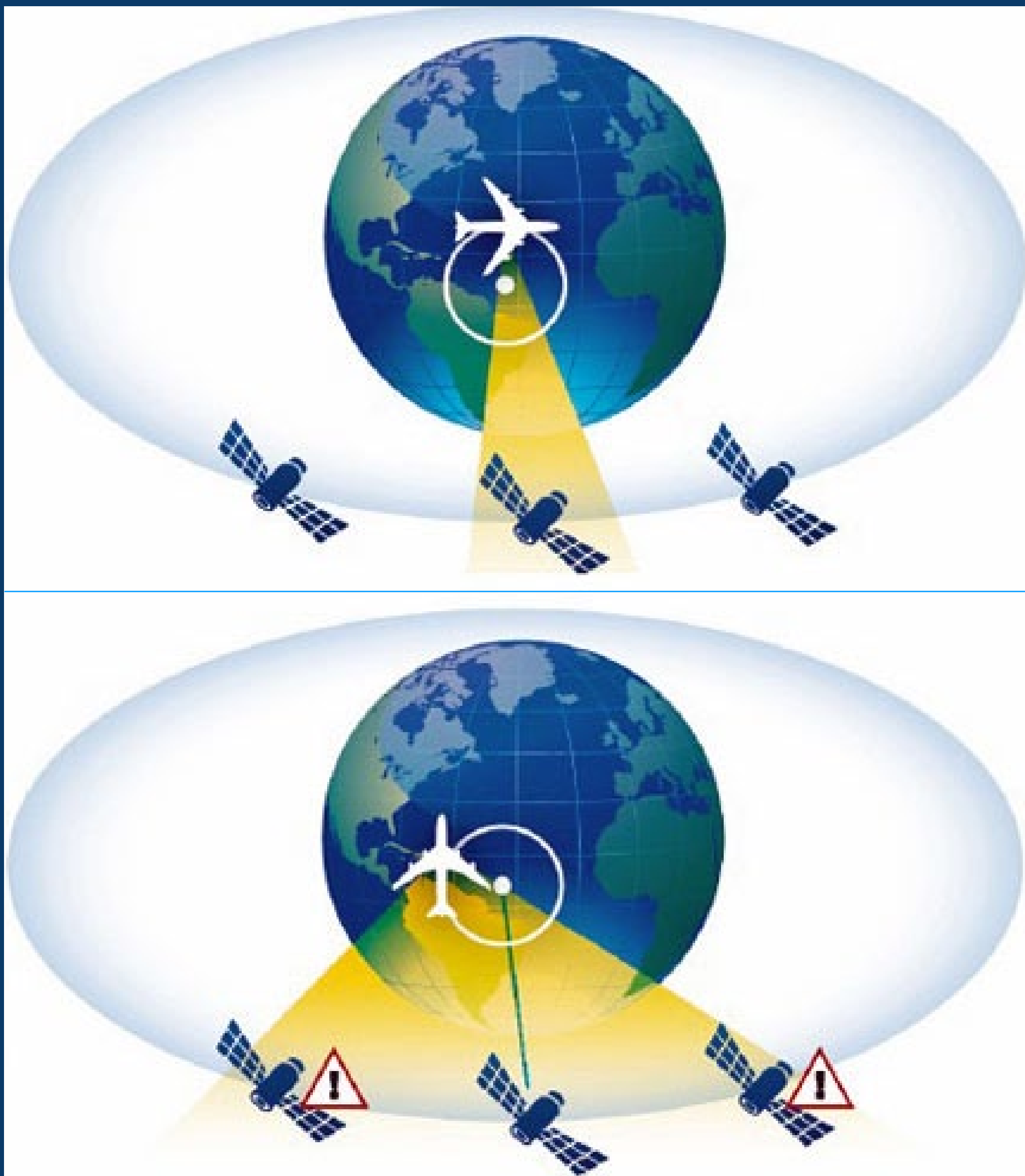


Figure 1 (top). Flat Panel Antenna—Favorable (low) Skew
Figure 2 (bottom). Flat Panel Antenna—Unfavorable (high) Skew

Terminal and Network Configurations

Terminal Configuration

The **iDirect Government Technologies** (**iGT**) system allows a terminal to be configured with a maximum operational C/N. This is controlled by a combination of an accurate uplink power control, and only assigning TDMA bursts to a remote on carriers with a low enough C/N to respect this limit. To determine the C/N, the customer must do a link budget to translate the allowable uplink power spectral density into a C/N. This approach allows the transmitted spectral power density to be increased above the clear sky regulatory limit in the event of rain fade. This is consistent with existing regulatory standards, which assume adjacent satellites see the same rain fade as the targeted satellite. However, the maximum C/N can change, based on two factors:

1. For a given PSD, the C/N will depend on the satellite G/T for a particular spot on the Earth. Hence, in spots with higher G/T values the maximum allowable C/N can be increased

2. For different skew angles, the allowable PSD can be increased, which allows for higher C/N values

The first case is catered to by using a map of the G/T contours, which is stored on the remote for avionic terminals.

The second factor is discussed in this article. Ultimately the terminal will determine how much it can increase its C/N from the map and the skew considerations, and report these to the hub. The hub will then use this information to assign slots on carriers which will respect the maximum C/N. The map that is created should be done with only the G/T contours, and without any skew angle considerations.

Determining the maximum PSD as a function of skew angle under the regulatory regime of interest should be completed first. This is usually done by the antenna manufacturer or terminal integrator. Next, a completed link budget determines the lowest C/N carrier needed to support the worst-case skew angle you wish to support. Depending on the satellite parameters, it may be possible to support

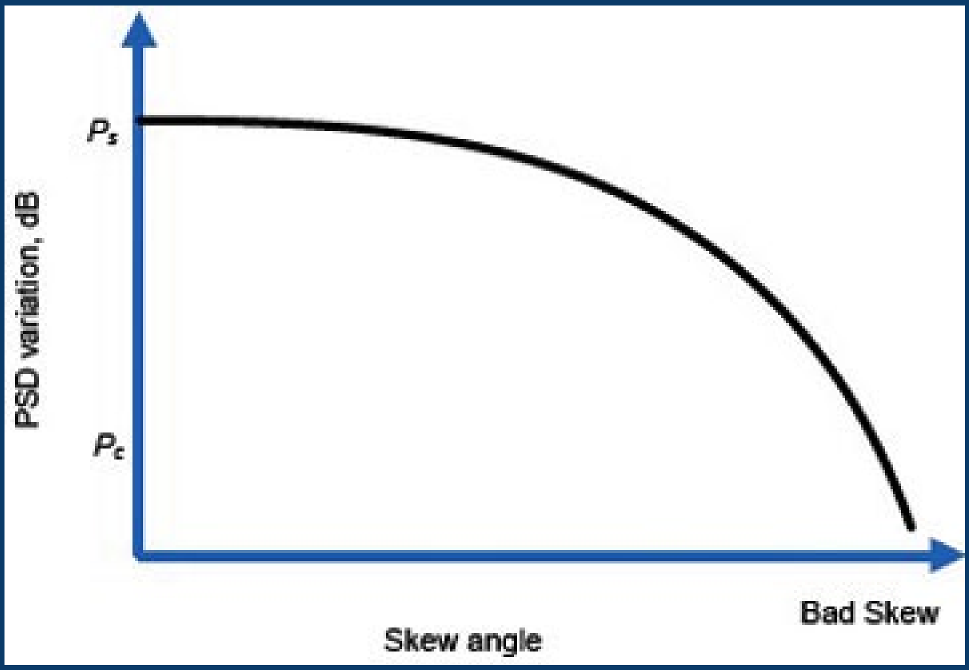


Figure 3. Maximum Allowable PSD as a Function of Skew Angle

skew angles to the maximum of 90 degrees. However, the carrier required may be so inefficient as to not make business sense. In this case, a smaller maximum skew can be chosen. The link budget will give an operational C/N for the worst case skew and G/T. Carriers must be included in the in-route group which will support this worst case condition.

Once the worst case (or "cut off") skew angle is determined, the maximum local tilt must be configured. A local tilt maximum value will allow the remote to stay in network during more extreme maneuvers, but force the remote to use a less efficient carrier. This is explained in more detail in the next section.

Once the parameters have been determined, the relative C/N as a function of skew angle is entered in the *Network Management System* (**NMS**) for the antenna. In addition, the maximum local tilt is configured for the remote. Adaptive inroute groups with appropriate carriers for the different conditions are configured including low C/N carriers for the high skew cases, and higher C/N (and more efficient) carriers for the low skew cases. Once the parameters above have been configured, then the system operates as follows:

1. *When the terminal acquires, it only sends burst invitations on carriers for which the regulatory limit is met under the worst case skew and G/T for the beam. The terminal sends the maximum configured skew angle to the antenna control unit (ACU) using OpenAMIP (Antenna Modem Interface Protocal). By using OpenAMIP, any antenna could be integrated to any vendor modem*

2. *If at any time the ACU determines the skew exceeds that specified in the OpenAMIP command, it ceases transmission and signals this to the remote. This is treated as a blockage*

3. *Once the remote has acquired, it determines its "level flight skew" based on its geo-location and the satellite position. It adds the local tilt to this value, and computes a new current maximum skew. With this maximum skew, it does two things. First, it signals this value to the ACU over OpenAMIP. Next, it uses the configured C/N versus skew curve to compute the C/N adjustment over the worst-case skew which is allowed, and signals this to the hub. This is illustrated in Figure 4 below. A_a is the level flight skew, and A_e is the skew with the maximum local tilt. The increase in C/N is P_s-P_c in the diagram. The remote also reads the increase in C/N from the local map, and signals this to the hub as well.*

4. *The hub takes the total allowable increase in C/N, and uses this to allow more spectrally-efficient carriers to be used by the terminal.*

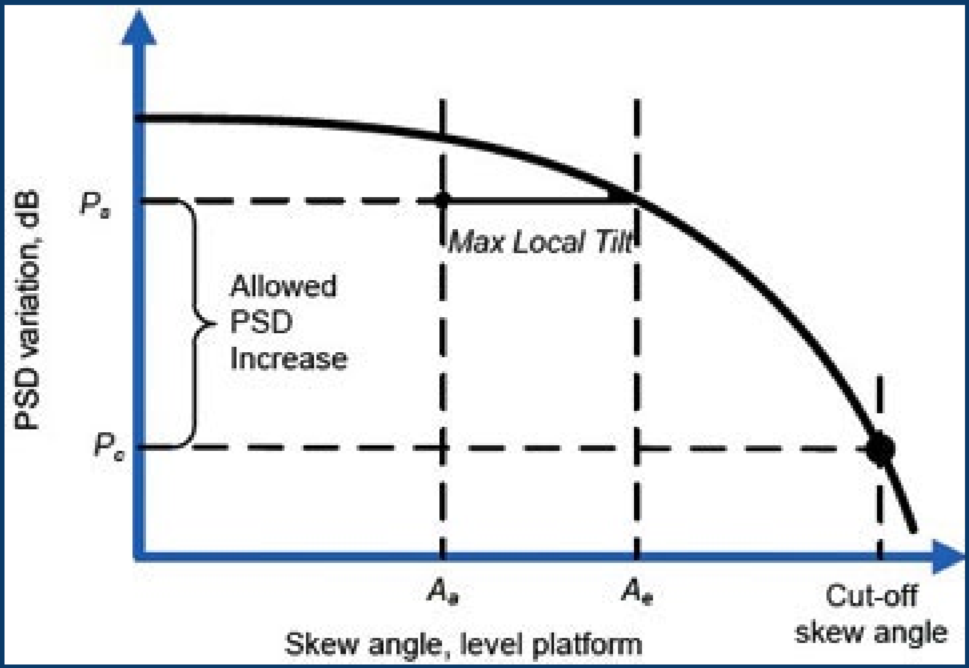


Figure 4. Picking Operational Parameters

Automatic Beam Switching

The antenna systems used on airborne platforms have become remarkably sophisticated. The strides made in improving the performance and effective aperture of flat panel antennas are very impressive. Whether the designer chooses a parabolic or flat panel antenna, the integration of the antenna with both the aircraft flight systems and the satellite router requires a great deal of development. To understand why such a level of integration is required, all the steps necessary to seamlessly hand off an aircraft from one satellite beam to the next must be considered.

Consider an aircraft leaving the east coast of the United States heading for a location in Western Europe. While the aircraft is in the U.S., the antenna is locked on a particular **DVB-S2** out-route carrier from a satellite and landed at a teleport on the east coast of the U.S. The satellite router's IP network is a part of a system and all IP traffic destined for the aircraft router is being sent to the east coast teleport upstream router.

As the aircraft travels east, at some point over the Atlantic, the current satellite coverage ends and the transition to another, hopefully overlapping satellite beam needs to take place. The question is, where and when is the right place to make the switch, and how would either the remote satellite router or the antenna control unit know when to make the switch?

The only feasible solution is to provide the satellite router and antenna control unit system with the EIRP contour maps of the available satellites. The ***iDirect Global Network Management System*** (**NMS**) includes global mapping, which has the EIRP contour maps for most geosynchronous satellites in orbit. The challenge now becomes one of communications. The aircraft IRU has the current geographic location of the aircraft and the satellite router is in communication with the hub and can receive the appropriate EIRP maps.

Using the OpenAMIP protocol, different devices in the network can communicate with each other. Therefore, the IRU can provide the geo coordinates to the remote, and the remote can command the antenna's ACU. Internet Protocol networking requirements present the next set of challenges faced by anyone designing a World Wide Airborne network.

Global Network Management

Fast moving and long distance airborne terminals will need to be handed from one beam to another and from one teleport to another. This mobility poses a number of challenges for IP networks and network management systems. Basic IP network design assumes core network devices like routers and switches will remain at a fixed location even if host devices come in and out of the network.

Dynamic routing protocols such as **OSPF**, **RIP v2**, **ISIS**, **BGP** and others are designed to accommodate subnets being added to and deleted from a network, and for interconnecting links to come in and out based on backhoes and power outages.

iGT AIMS High

iGT's Airborne In-Flight Monitoring System (AIMS) is iGT's solution for customers to view satellite information with respect to a moving aircraft while in flight. The software, which is loaded onto a PC, communicates with the iDirect modem, as well as the Antenna Control Unit (ACU) to display the real-time position of the aircraft and allows a user to quickly see when the aircraft will leave one satellite coverage footprint and enter another. AIMS displays:

- *Contour maps with respect to aircraft location in real-time*
- *Current beam as well as distance to beam switch using a distance circle*
- *Network name of satellite beam boundary*
- *Modem's transmit—whether enabled or muted*
- *Status information from modem and ACUs*
- *Status messages that indicate when communications interruption will occur due to beam switch*
- *Alert banners for easy troubleshooting*

With AIMS, an operator is able to quickly determine the position of the aircraft and whether or not a communications interruption might occur due to switching satellite footprints. The operator has the ability to manually switch to an available network, or view a countdown timer before the automatic beam switch occurs. Through the Graphical User Interface (GUI) a beam information window is provided that displays information on all the beams the modem is configured for, including:

- *Beam name/number*
- *Beam contour qualities*
- *Satellite longitude used on a network*
- *Downstream carrier size*
- *Upstream carrier size*
- *Currently active beams*

AIMS provides the option for a user to log flight statistics into a KML file format for future analysis. These flight statistics are logged every two minutes and include iGT's Modem and ACU parameters, such as:

- *Modem LED status lights*
- *Rx SNR*
- *Tx power*
- *Modem temperature*
- *Current beam number/name*
- *Downstream carrier size*
- *Upstream carrier size*
- *Latitude and longitude coordinates*
- *Heading*
- *Ground speed*
- *Altitude*
- *Timestamp*

Additional information here...

The new mobility in the satellite market allows for IP routers, built into remote terminals, to move from beam to beam and roam from teleport to teleport and from continent to continent. COTM requires a new approach to the design and management of mobile networks. To address this challenge, iDirect has developed a global NMS, within which a single COTM remote may have multiple instances in teleports around the globe. This allows IP addresses to remain fixed while allowing for configuration differences across beams, including varying out-route and in-route sizes, as well as different QoS profiles.

Security

COTM and itinerant terminals pose new challenges from a security perspective. The need for advanced encryption over the satellite link is obvious. As a remote moves from location to location and beam to beam, one never knows who may be listening to the link. Satellite service providers will need to offer strong encryption, such as 256-bit keyed AES. For government users, FIPS 140-2 certified encryption will be required.

TRANSEC

iDirect has developed Transmission Security (TRANSEC) for TDMA-based COTM systems to meet very high security requirements. TRANSEC has a number of components, including the ability to obfuscate any traffic volume or remote terminal activity information, which may allow an adversary to infer useful information based on activity levels.

It is doubtful any commercial applications will require the level of security TRANSEC provides. There is one aspect of TRANSEC, however, that may prove beneficial in a commercial network. The more mobile and dynamic a network is, the more vulnerable it becomes to rogue remote terminals gaining access to the network. Most satellite NMS systems authenticate a remote terminal by verifying a physical hardware address in the remote terminal, similar to a MAC address in Ethernet. It is theoretically possible for an adversary to change the hardware address of a remote. Once a remote's hardware address has been changed, it could be acquired into a restricted network.

There is a component of TRANSEC for TDMA VSAT systems known as X.509 certificates which could be employed in both commercial and military networks to stop such intrusions. X.509 certificates are a standard RFC 2459, and are simply a digital certificate issued by a Certificate Authority (CA). The X.509 certificate uses the Public Key Infrastructure and leverages RSA public key encryption. In this way, a remote can be authenticated to a teleport and a teleport to a remote. By employing X.509 certificates, a network operator can be assured all remotes acquiring into the network are authorized and that remotes in the field will not acquire into an adversary's network. The iDirect NMS has the capability to accept third party certificates or to generate its own.

iGT's Router Reveal

The e8000 AR meets the unique needs of Airborne satellite communications (SATCOM) requirements. The 19-inch rack-mountable enclosure is ideal for roll-on/roll-off use and integrates the iDirect® e850mp FIPS Level-2 iConnex board to provide fast, secure and reliable military grade communications.

Greater Mobility

Combined with leading edge spread spectrum technology, this Evolution series router enables use of ultra-small and phased-array antennas on aircraft. The e8000 AR series is fully enabled for iDirect's Global Network Management System (GNMS) and automatic beam switching technology, allowing for true global roaming while on the move. With embedded Open AMIP™ standard, the e8000 AR easily integrates with multiple antenna platforms and can support all antenna varients.

Greater Flexibility + High Performance

The e8000 AR series offers the choice between iNFINITI TDM or DVB-S2/ACM on the outbound, providing even more flexibility for network design and bandwidth optimization. Additionally, the e8000 AR can be operated in either MF-TDMA or SCPC return, providing return carrier symbol rates up to 15Msps, for multiple HD video acquisition. Built into the unit is a fully integrated pC/104 computer for maps and additional applications.

High Security

Compliant with the highest military security requirements, the e8000 AR features embedded AES encryption and TRANSEC with advanced FIPS 140-2 Level 2 compliance. Also, to support Wideband Global Satellite (WGS) frequency ranges, the e800 AR series is equipped to cover wider IF ranges, providing flexibility in secure network deployment.

QoS

With advanced Quality of Service, high-priority traffic designation can be recognized by advanced encryption devices, and traffic can be segregated by groups of remotes, multiple sub-networks, and multiple applications.

Additional information here...

Airborne Satellite COTM (Cont.)

The advent of airborne COTM technology will be very beneficial for DoD operations, if implemented correctly. However, COTM presents a number of physics, operations and security challenges. A holistic approach to COTM network design is needed, taking into account satellite frequency bands, antenna sizes, integration of a satellite remote with a global key distribution for seamless roaming between secure networks and an antenna control unit for uninterrupted communication.

About the author

Karl Fuchs is the Vice President of Technology for iDirect Government Technologies. He may be reached via email at ***kfuchs@idirectgt.com***.

"The need to be mobile and ensure continuity of communications to keep military and emergency response government agencies informed in real-time has never been greater. To support end-user satellite communications, iGT's Airborne In-Flight Monitoring System (AIMS) provides situational awareness with in-flight monitoring that allows customers to view the status of the entire airborne communications system while in flight," said John Ratigan, President of iGT. "This capability arms military, government agencies and emergency response personnel with the position of the aircraft and information on when it is leaving one satellite coverage area and entering another so they can plan for satellite beam hand-off and potential communications interruptions. Knowing when satcom could be disrupted is critical to real-time communications for military, government agency and emergency response missions."

— John Ratigan, President,
iDirect Government Technologies (iGT)

*The demand for airborne applications continues to increase dramatically—in order to meet these needs, **iDirect Government Technologies** (**iGT**), a wholly owned subsidiary of **VT iDirect** (**iDirect**), has launched new, airborne solutions for secure connectivity and for monitoring SATCOM functions while in flight.*

*This technology provides situational awareness and enables reliable command, control and intelligence, surveillance and reconnaissance (**ISR**) operations. Meet iGT's new **Airborne In-Flight Monitoring System** (**AIMS**), which provides situational awareness with in-flight monitoring and allows customers to view the status of the entire airborne communications system while in flight.*

AIMS displays locally to the communications officer on board, providing the real-time position of the aircraft and information on when it is leaving one satellite coverage area and entering another.

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- **Stuart Eves**, Lead Mission Concepts Engineer, **Surrey Satellite Technology Limited**
- **Rick Greenwood**, Director of Space and Engineering, **Astrium Services - Government Communications**
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SATCOM-On-The-Move
Why One Size Doesn't Fit All

by Timothy Shroyer
CTO, General Dynamics, SATCOM Technologies

Satcom-On-The-Move (SOTM) offers true broadband communications capabilities for civil and military users. While the ultimate desire is to use satellite Earth stations, which are as small and light as possible, several trade-offs affect the ultimate coverage areas and communications data rates these systems can provide. This article considers several of the factors that drive the selection of a specific SOTM Earth terminal configuration.

SOTM Offers True Broadband

SOTM offers broadband satellite communications to mobile users, on land, at sea, and in the air. Due to vehicle mounting and other constraints, there is a desire to implement SOTM terminals with the smallest possible size and weight. If it was possible to provide very high data rate SATCOM service with an exceptionally small antenna aperture, there would be no need to use anything other than the smallest possible terminals.

As larger apertures are needed to support higher data rate services, SOTM system designers must optimize terminal size to satisfy the "best" trade of performance, size, weight, and power. Just as there is no single SOTM communications requirement, there is no single optimal SOTM terminal configuration.

This article considers several of the most significant factors affecting SOTM terminal implementation—maximizing communications performance with suitable terminal size, weight, power, and cost.

The fundamental problem facing all satellite communications systems is to provide suitable performance on the RF link through the desired satellite, while minimizing interference energy towards adjacent satellites, as shown in

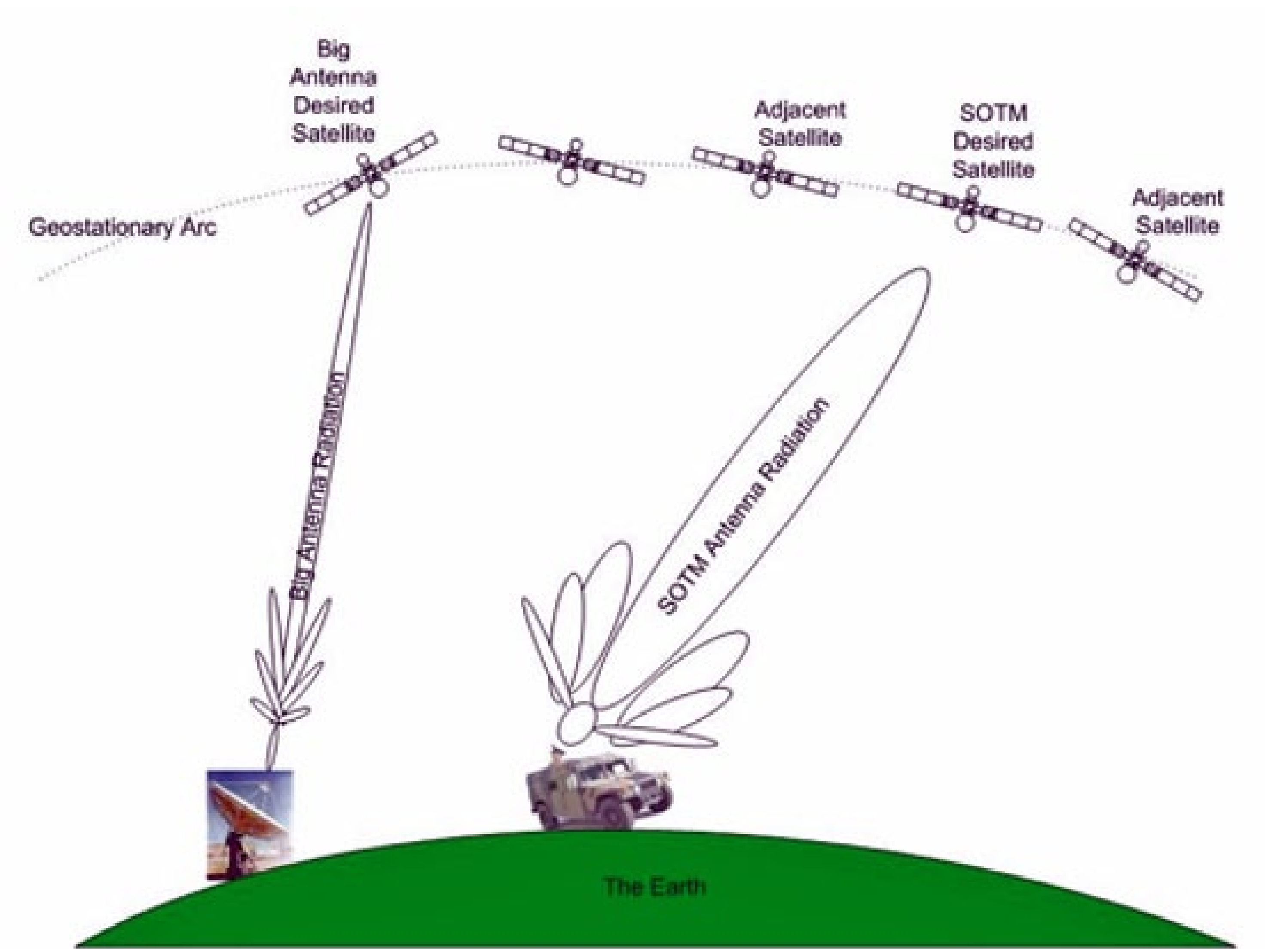

Figure 1. Adjacent Satellite Interference Constraints

Figure 1 on the previous page early satellite communications systems used rather large Earth terminal antennas, which exhibit high discrimination of energy to and from adjacent satellites.

SOTM Earth terminal antennas are so small that they have exactly the opposite effect. The small aperture size offers relatively low gain towards the satellite of interest and simultaneously radiates a significant amount of energy towards adjacent satellites.

Adjacent Satellite Interference Constraints

While the effective function of any satellite communications Earth station is the radiation of RF energy to and from the satellite of interest, the principal limitation on RF power is not the energy radiated towards that satellite of interest. It is, instead, the limit of RF energy permitted to be transmitted towards adjacent satellites—*Adjacent Satellite Interference* or **ASI**. This limit is expressed in terms of EIRP power spectral density rather than absolute power and is intended to ensure that multiple satellites can effectively use the geostationary arc.

In satellite communications systems, a systems engineer performs a link analysis to determine the characteristics of the link through the desired satellite. The link analysis considers the data rate to be provided, the modulated signal structure, the propagation and atmospheric losses, and the required uplink power. It then determines required satellite power and bandwidth. Link analyses performed for large Earth stations typically then confirm that the ASI conditions are satisfied after designing the link. With earth terminal antennas as small as those used in SOTM links, it is often necessary to first consider the permitted ASI levels and then design the link modulation such that the on-satellite performance is sufficient under those constraints.

International treaties have been established which provide the ultimate limits for acceptable RF power density. On a global basis, these agreements are codified in the Recommendations of the **International Telecommunications Union**. For FSS Ku-band and FSS Ka-band operation, some of the most significant IRU Recommendations are **ITU-R S.524-9**[1]—limits for FSS C, Ku, and Ka-band off-axis EIRP density and **ITU-R S.728-1**[2]—limits off-axis EIRP density from VSATs.

Each country is responsible for administrating satellite communications transmissions from within their own territory, and they establish their own regulations to comply with the ITU Recommendations. In the United States, the **Federal Communications Commission** (**FCC**) is responsible for administering civil communications, including satellite communications on FSS Ku-band and FSS Ka-band.

Federal communications in the United States, including military X-and Ka-band satellite communications, are administered by the **National Telecommunications Information Agency** (**NTIA**). The FCC has recognized the need for SOTM systems and has implemented regulations for FSS Ku-band operations from land vehicles in **FCC Regulation 25.226**[3]—Blanket licensing for VMES, and from maritime vehicles in **FCC Regulation 25.222**[4]—Blanket licensing for FSS Ku-band ESVs.

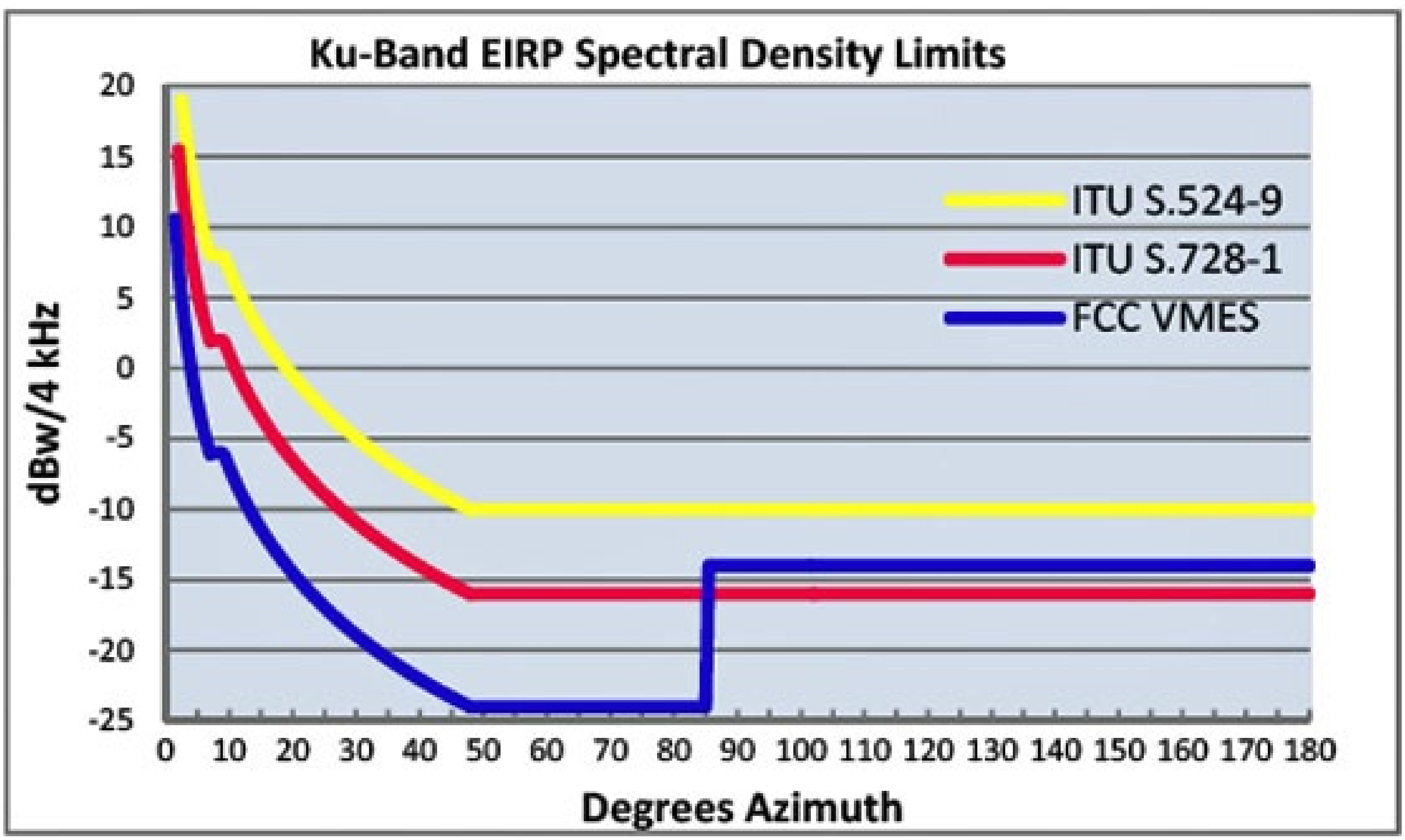

Figure 2. ASI Regulation Comparison

SATCOM-On-The-Move (Cont.)

Considering FSS Ku-band operation, for example, the VMES Regulations apply to SOTM operation from land vehicles in United States territory. The VMES Regulations are actually more restrictive than the ITU Recommendations, mostly due to the FCC's desire to operate FSS Ku-band satellites spaced every 2 degrees over CONUS.

Figure 2 illustrates the EIRP power spectral density limits imposed on FSS Ku-band SOTM operation due to ITU S.524-9, ITU S.728-1, and FCC VMES Regulations. A SOTM terminal operating anywhere in the world will always have to satisfy the limits of S.524-9 or S.728-1. In the United States, an FSS Ku-band SOTM terminal must satisfy the ASI limits imposed by the VMES Regulations.

On other civil frequency bands, such as FSS Ka-band, there are other applicable regulations but similar ASI limits apply. U.S. DoD SATCOM operations are conducted per NTIA administration, which essentially results in compliance with the requirements of **Mil-Std-188-164**[5] – Interoperability of SHF Satellite Communications Terminals. The Mil-Std-188-164B requirements contain different absolute levels for EIRP power spectral density, but provide similar constraints that limit SOTM ASI.

SOTM Operational Trades

Aperture Size

The aperture size of the SOTM Earth terminal has a significant effect on both the uplink and downlink performance of the satellite communications link, just as with all satellite communications systems.

On the downlink, the aperture drives both the signal energy available from the satellite of interest as well as discrimination against downlink energy from adjacent satellites. On the uplink, the aperture size drives the EIRP transmitted towards the satellite of interest as well as discrimination of uplink energy radiated towards adjacent satellites that forms ASI.

To examine the effect of downlink aperture on power required from the satellite of interest on the link, a series of link analyses has been performed for a normalized 1 MBPS link.

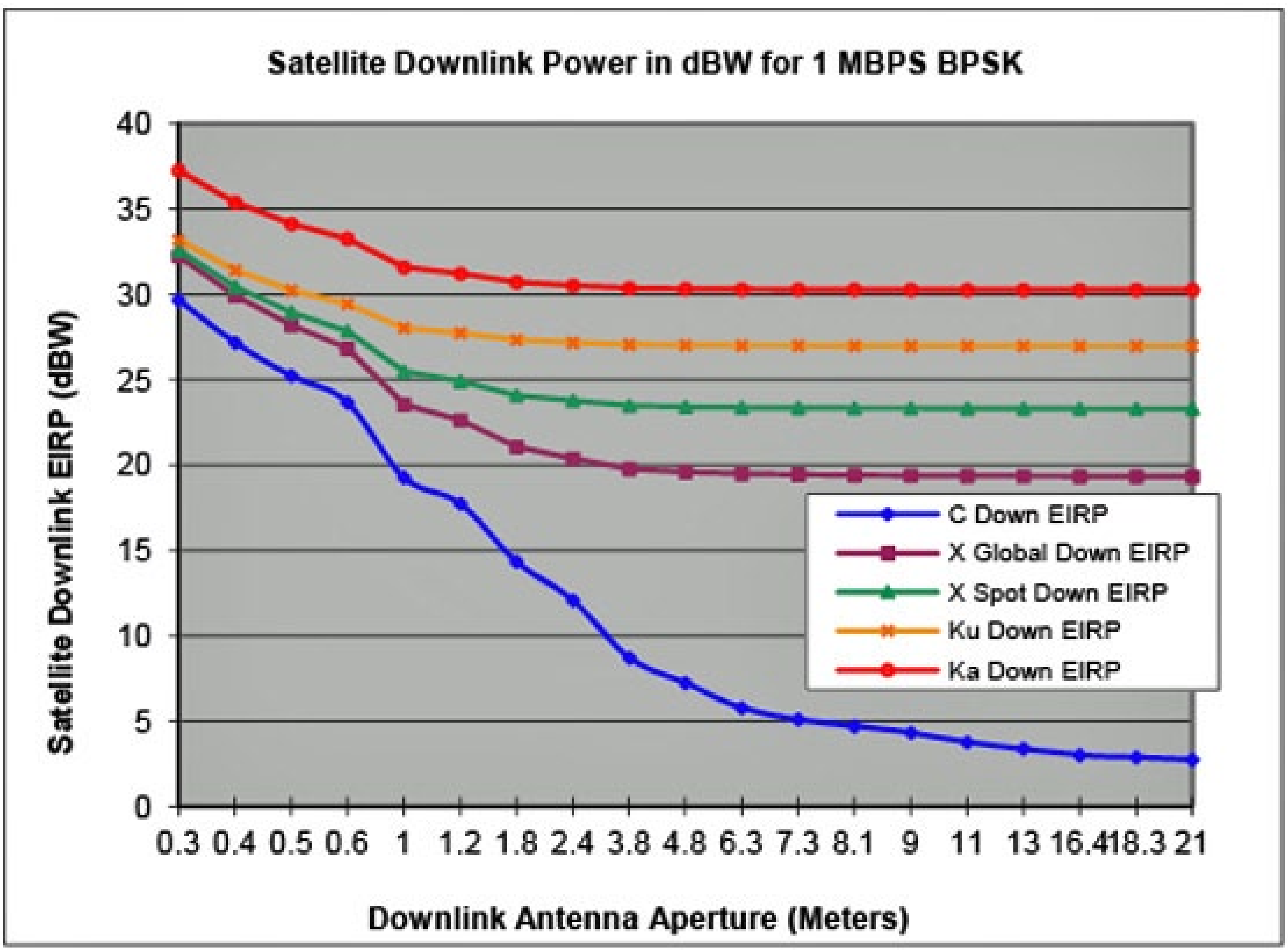

Figure 3. Downlink EIRP Comparison

Figure 3 provides a graphical representation of the downlink power required for different downlink aperture sizes on various typical satellite frequency bands. These link analyses were performed using typical satellite transponder characteristics operational in 2012. G/T of the various downlink apertures are driven mostly by the downlink aperture size and utilize the same typical LNA Noise Temperature for the appropriate frequency band.

The downlink EIRP requirements illustrated in *Figure 3* are normalized to the same 1 MBPS data rate, assuming BPSK R-1/2 LDPC FEC operation. Scaling to higher or lower data rates effectively scales the EIRP required by the same ratio to 1 MBPS, assuming similar modulation characteristics. For fully-compliant operation it may be advantageous to change modulation format, which would effectively trade satellite transponder EIRP and bandwidth, but the scaling can be considered relevant.

In most frequency bands, as the aperture size exceeds about 3.8 meters, there is essentially no reduction in EIRP required as the link Noise level is dominated by satellite transponder noise floor instead of receive terminal G/T.

As SOTM apertures are always relatively small to accommodate vehicle mounting, they require significantly more EIRP than larger Earth station apertures to provide the same data rate communications service.

From *Figure 3* it can be observed that smaller apertures drive the requirement for higher EIRP from the satellite transponder. To satisfy specific link requirements and downlink power density requirements a trade in downlink aperture as well as satellite power and bandwidth will often be appropriate. Under some operating conditions higher data rate services will thus only be possible using larger apertures simply due to limits in downlink EIRP if no other factor.

On the uplink side a similar series of link analyses confirms the uplink EIRP required to implement the same 1 MBPS data rate link, assuming BPSK R-1/2 LDPC FEC operation. *Figure 4* graphically illustrates the resulting uplink EIRP requirements using the same series operational transponder characteristics as the downlink evaluation described in *Figure 3*.

The uplink EIRP requirements illustrated in *Figure 4* often have an even more dramatic impact on SOTM aperture selection than downlink EIRP. As ASI limits are expressed in

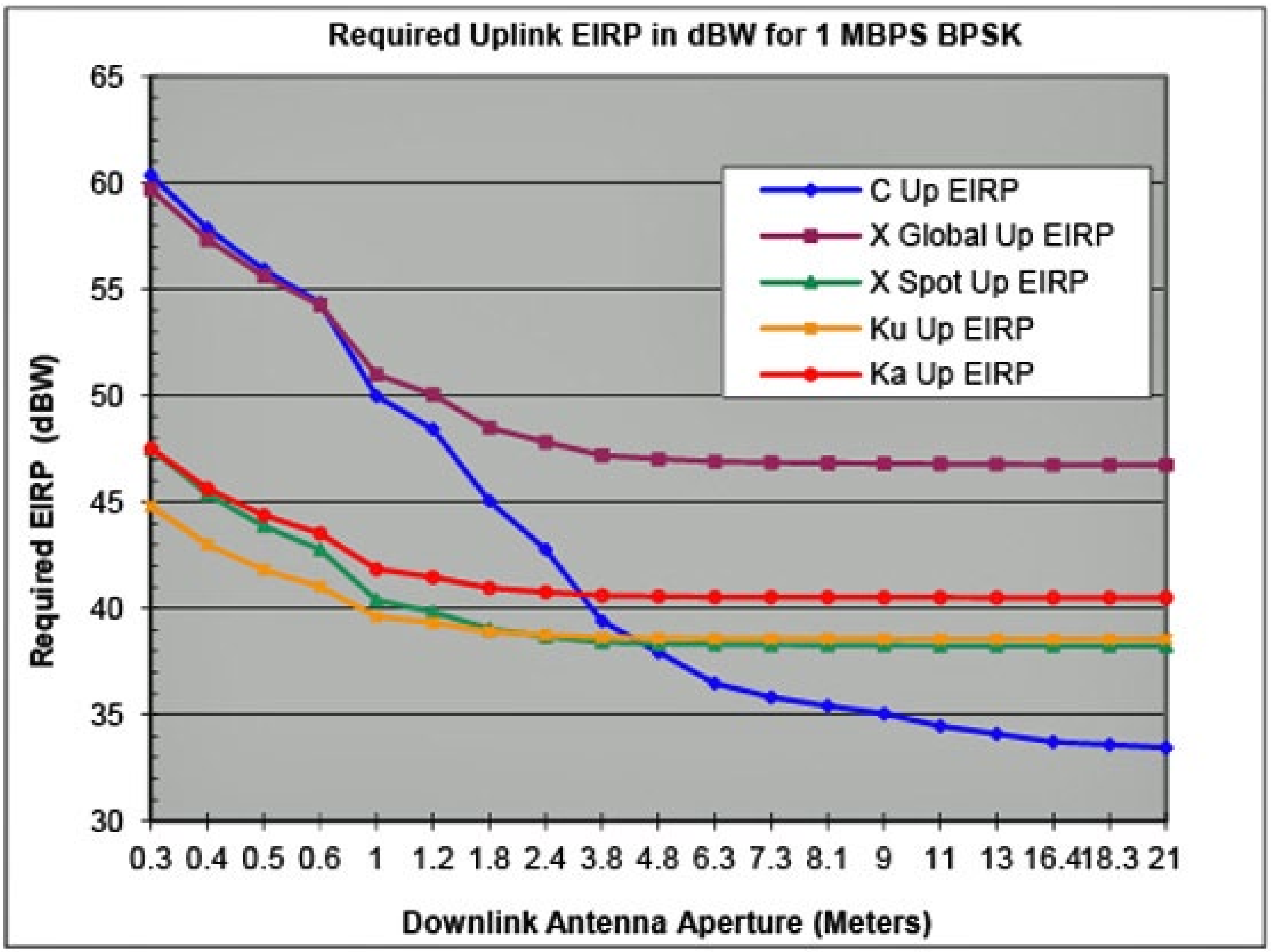

Figure 4. Uplink EIRP Comparison

terms of EIRP power spectral density, and not absolute EIRP, smaller apertures with higher EIRP requirements can easily exceed ASI limits with conventional PSK modulation. This situation directly drives a trade on the SOTM uplink signal which includes:

Link data rate
Modulation order and FEC rate
The use of spectrum spreading techniques

The ultimate limit in capacity of the satellite channel has been shown to be limited by the Shannon-Hartley theorem[6], which states:

$$C = B\,log_2\left(1 + \frac{S}{N}\right)$$

Where: **C = capacity of channel in bits per second**
B = channel bandwidth in Hz

$\frac{S}{N}$ = Signal to Noise ratio in linear units

The bandwidth of the satellite transponder is always finite, and the combined transponder power and bandwidth is relatively costly. As SOTM antennas decrease in size, the same desired communications capacity can only be provided with the same power, or EIRP, yet the EIRP power spectral density must be maintained below the appropriate regulatory limits.

This process can be extended through FEC coding and spectrum spreading techniques until the limit of available transponder bandwidth is exceeded. Doing so is costly in terms of transponder resources.

One can observe that at some point the available transponder power and bandwidth could no longer support a desired capacity. In such cases the only trade is to reduce the desired capacity or increase the power available on the link—by increasing the size of the SOTM aperture such that total EIRP can be supported with suitable EIRP power spectral density.

Aperture Pointing Accuracy

There is a further trade which also significantly affects the performance of the SOTM terminal on both the uplink and downlink paths—antenna pointing accuracy. On the downlink, decreased accuracy in pointing towards the desired satellite both decreases the effective received Signal energy and increases the downlink ASI. As downlink ASI levels depend upon the spacing of adjacent satellites and the presence of downlink RF energy on exactly the same downlink frequency and polarization, this may or may not be a problem in practice.

On the uplink side, the effect is similar in that uplink Signal energy towards the satellite of interest is decreased and additional ASI is generated towards other satellites. The loss of uplink Signal energy can be overcome by simply increasing the uplink EIRP. However, the small size of SOTM terminal apertures result in significant levels of energy radiated in directions other than those desired.

In an operational sense, suitable link performance could, theoretically, be obtained through any combination of gain towards the desired satellite, antenna pointing accuracy, and ASI limitation. If only one satellite were ever present on the desired operating frequency, the only potential interference source on the downlink would be terrestrial emitters and thermal noise. Without the need to worry about uplink ASI, the energy radiated in undesired directions would be inconsequential.

Of course, this is not the case. Not only are there ITU Recommendations which mandate uplink ASI limits and the tolerance of other satellite downlink energy, but no satellite frequency band can be considered exclusive.

Some of the Regulations governing the operation of SOTM terminals, such as the FCC VMES3 and ESV4 Regulations, combine limits on EIRP power spectral density with antenna pointing accuracy.

In the FCC ESV and VMES Regulations satisfying the best specified pointing accuracy of +/- 0.2 degrees permits operation at the highest permitted EIRP power spectral density. Reductions in antenna pointing accuracy must be accommodated by a reduction in on-satellite EIRP power spectral density to ensure ASI limits are maintained or through coordination of uplink signals with adjacent satellites.

Other regulations, such as ITU Recommendations S.524-91 and S.728-12 specify only the absolute EIRP power spectral density limits and presume that steps are taken in antenna gain, pointing, and EIRP power control to stay within the limits.

To place this in perspective as to its impact on FSS Ku-band SOTM terminals, we can consider various potential SOTM terminal antenna gain patterns and how they affect ERIP power spectral density. *Figure 5* illustrates the uplink radiation patterns of four different SOTM terminals and shows how their respective EIRP power spectral density can be controlled to satisfy the FCC VMES limits.

Figure 5 illustrates the EIRP density of four different SOTM apertures and the FCC VMES EIRP power spectral density limits in the region from bore sight toward the satellite of interest and 8 degrees. Each of the example antennas illustrated exhibit different gain and 3 dB beamwidth. Assuming the antennas are pointing within the specified accuracy of +/- 0.2 degrees, the EIRP power spectral density can be adjusted as illustrated to remain within the FCC VMES limitations.

As can be observed in *Figure 4*, a larger antenna, such as the 30-inch aperture shown, can then provide higher EIRP power spectral density towards the satellite and remain within the ASI limits. Smaller antennas not only have lower gain, but their EIRP power spectral density must also be reduced to remain below the ASI limits because their 3 dB beamwidth approaches the limit curve.

If the antenna pointing accuracy were to be reduced, such that a larger pointing error is permitted towards adjacent satellites, the EIRP power spectral density would have to be further reduced to remain compliant with ASI limits. The effect of a 1 degree pointing error on the 30-inch SOTM aperture is illustrated in *Figure 6.*

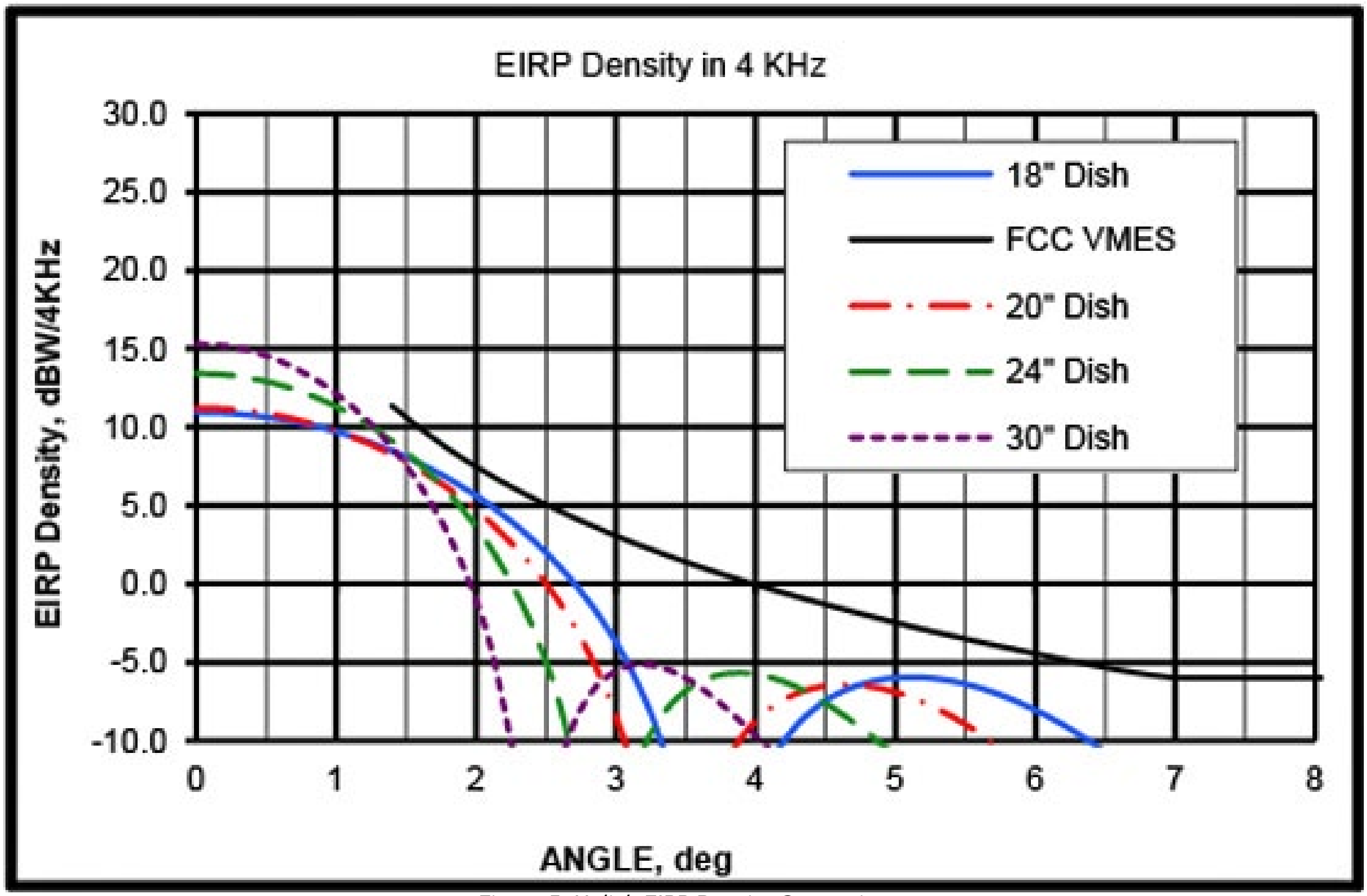

Figure 5. Uplink EIRP Density Comparison

In this example, a pointing error on the order of 1 degree would induce a reduction of permitted EIRP on the order of greater than 5 dB. The combined effects of shifting the gain peak due to mispointing and reduction of permitted EIRP would result in a reduction of EIRP towards the satellite during off-pointing conditions of greater than 10 dB.

For normal SOTM operations this 10 dB reduction in on-satellite performance would have to be factored in to link performance either as expected outage or further changes in modulation format. Since the limitation is one of EIRP power spectral density rather than absolute EIRP it would not be possible to simply compensate with uplink power control.

The analyses described previously all considered apertures consisting of circular parabolic antennas. Other antenna architectures are certainly possible and offer additional advantages and disadvantages. If a non-circular parabolic antenna is utilized it can be considered to radiate with a beamwidth inversely proportional to the dimension along the related axis. Along the narrow axis, such an antenna will exhibit its widest beamwidth and vice versa. The use of this type of antenna in SOTM terminals can effectively reduce the size of the terminal itself, but all potential impacts on the energy radiated towards the desired and adjacent satellites must be considered.

The FCC VMES Regulations, for example state, “For non-circular VMES antennas, the major axis of the antenna shall be aligned with the tangent to the arc of the GSO at the orbital location of the target satellite, to the extent required to meet the specified off-axis EIRP spectral-density criteria.”

Other types of antennas are also of interest for SOTM operation. Phased-array antennas, for example, offer much lower mounting height on a vehicle than parabolic antennas. This characteristic alone makes phased-array antennas worth evaluation for SOTM operation.

When considering the performance of such an antenna in SOTM operation, system designers must satisfy the same on-satellite gain and ASI limitation as previously described. This class of antenna offers the advantage of significant potential reductions in height on the vehicle but the disadvantage of potential complications in control of antenna gain towards the desired and adjacent satellites. Typical phased-array antennas exhibit gain which is a function of the antenna area perpendicular to the satellite, just as with parabolic and other antennas.

For the general case this can be modeled, to the first level of approximation, as a function of sine (θ), where θ is the radiation angle, from parallel to the antenna surface. *Figure 7* illustrates the modeled reduction in gain as the radiation angle diverges from perpendicular to the array surface.

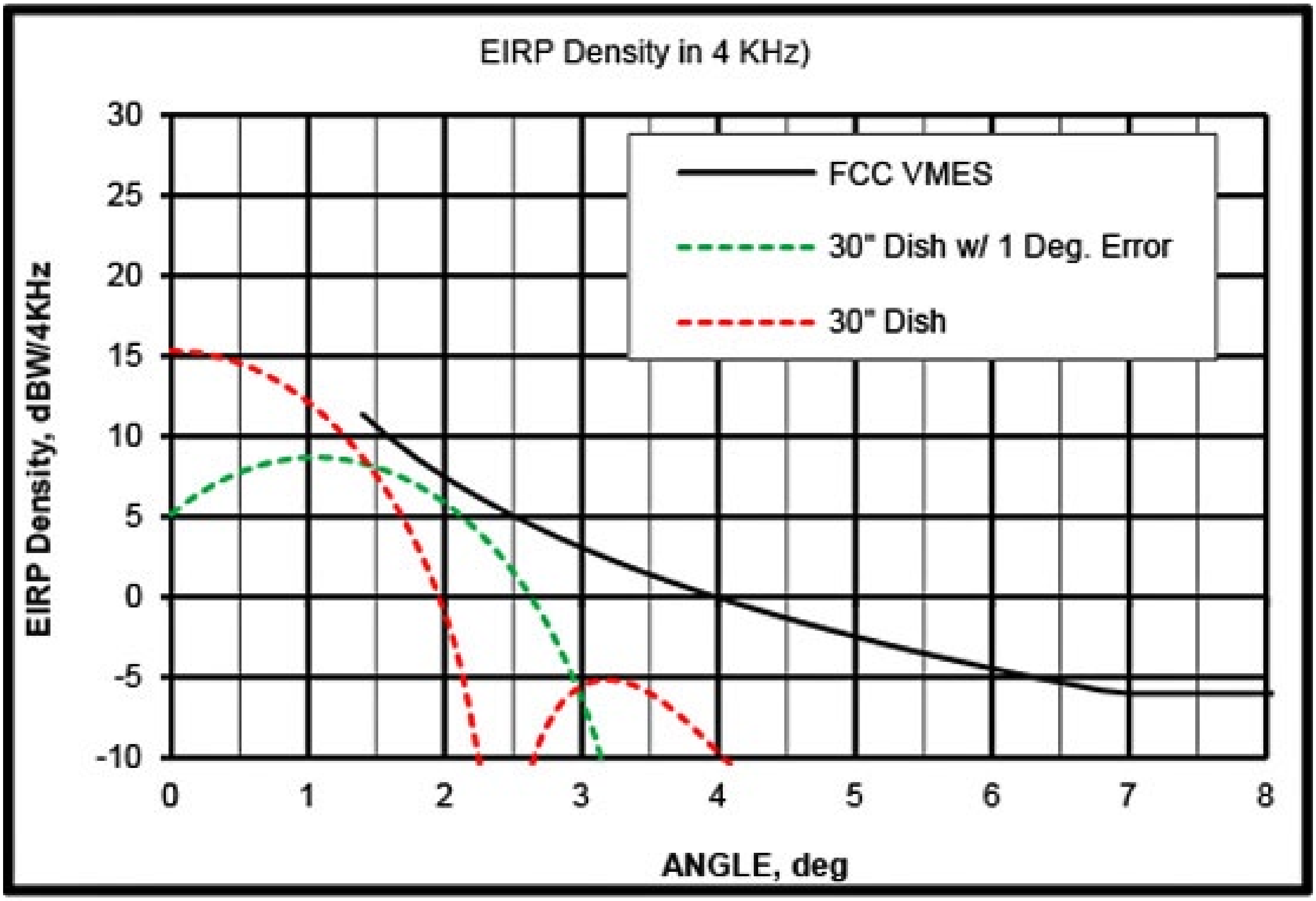

Figure 6. Uplink EIRP Density with Pointing Error

Terminal Hardware Cost

Terminal hardware cost is a significant factor in any satellite communications system and the same holds true in SOTM operation. Some applications may be driven by the communications link itself—to provide a suitable data rate link regardless of the implementation cost.

Most SOTM systems, however, will continue to be driven by a need to provide cost-effective communications. The cost trades for the RF equipment in SOTM terminals are similar to other types of Earth stations in terms of the antenna itself and High Power Amplifier, but must additionally consider the relative cost and complexity of the antenna pointing and tracking system.

High Power Amplifiers can be considered just as they are with other Earth stations. HPAs with higher output power are physically larger and heavier, consume more primary power, and generate more waste heat.

One of the first HPA cost trades driven by typical SOTM terminals is the appropriate size, weight, and power. If the required uplink power can be satisfied with an HPA mounted directly on the antenna itself, the terminal will exhibit higher efficiency and less total weight. HPAs mounted off the antenna result in more RF losses between the HPA and antenna feed—driving further increases in HPA output power as well as higher primary input power and more weight.

With current GaAs and GaN SSPA technology the relative cost of SSPAs suitable for SOTM operation can be considered roughly proportional to output power levels. This approximation remains valid until at some higher power level significant changes must be made in packaging and heat dissipation which results in a disproportionate increase in cost.

In general, the cost of a parabolic antenna itself changes little from the smallest to largest apertures that are practical for vehicle mounting. Larger apertures, however, drive the antenna pointing and tracking system costs.

A larger antenna has a narrower beamwidth and, therefore, must be pointed and tracked with better accuracy to satisfy link and ASI constraints. Larger antennas also have more mass so the pointing and tracking system must utilize more drive power to maintain the same or better pointing accuracy.

SOTM systems require some reference mechanism to both determine their operating location as well as terminal attitude, in terms of roll, pitch, and yaw, to acquire the desired satellite. GPS receivers provide a very cost-effective means for determining earth terminal location so they are used by virtually all SOTM systems.

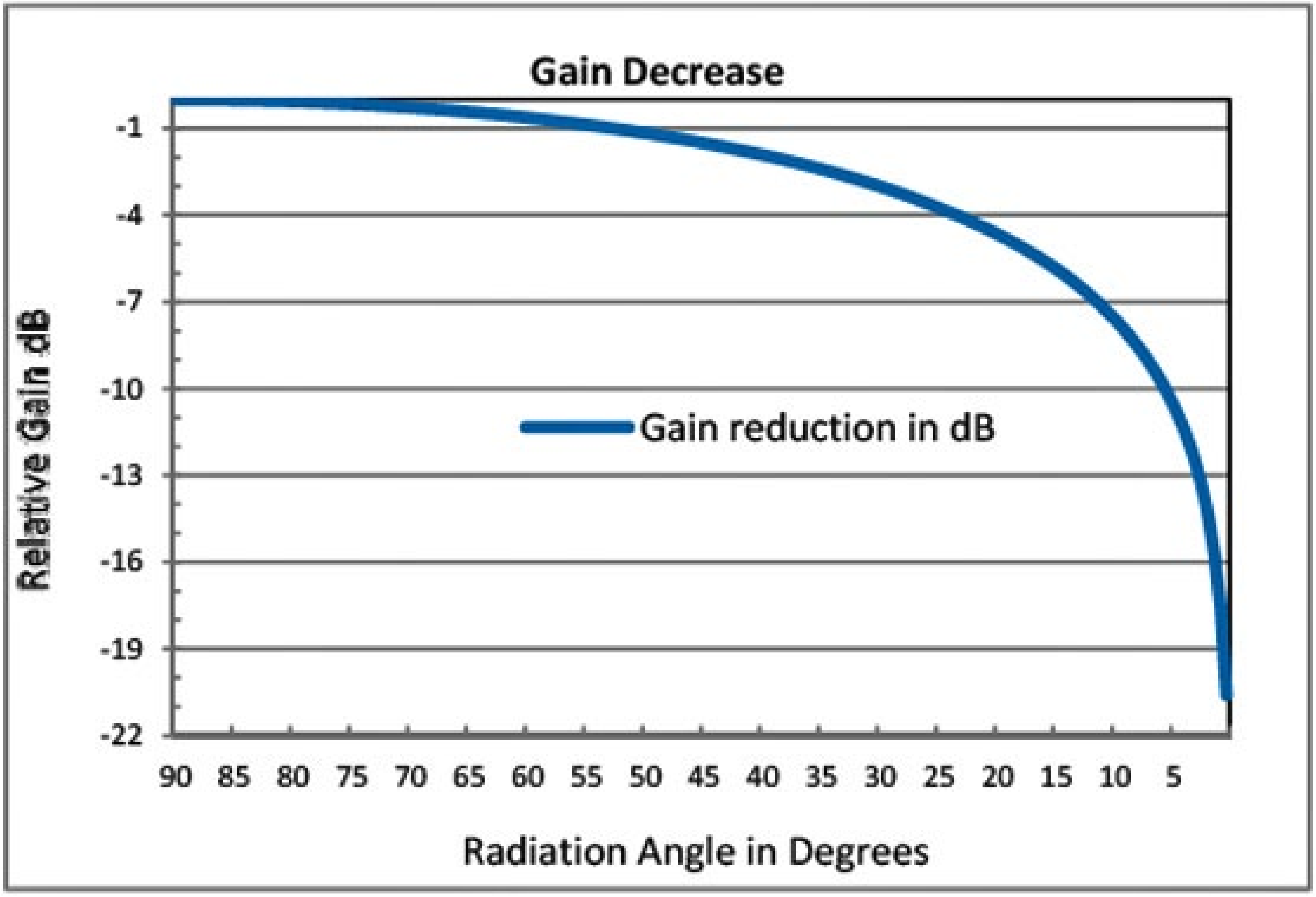

Figure 7 – Gain Decrease of Array with Angle

Determining Earth terminal attitude, however, adds significant complication. Without a high accuracy terminal attitude reference system it may take an unacceptably long period of time for a SOTM terminal to search for the desired satellite. As SOTM operation experiences significant periods of signal blockage due to physical obstructions this process must then be repeated after every satellite signal interruption—possibly reducing link availability to an unacceptable level. The accuracy of the SOTM terminal attitude reference system is critical to acceptable operation and it can become a cost driver.

From this top level analysis, it is clear that SOTM terminals using larger antennas are more costly to implement than those with smaller antennas. If terminal cost were the only consideration the choice would be clear—use smaller antennas.

As can be seen from the earlier analysis, however, terminal cost is only one factor in the overall system design, and it is rarely the most significant factor in SOTM system implementation.

The Optimal SOTM Terminal

As can be observed through the analysis provided, the effective size of the SOTM antenna aperture has a significant impact on operation. There are advantages and disadvantages to each. At the system level one can consider general advantages and disadvantages such as:

__Larger Antennas__

—Advantages

Lower satellite transponder costs
Improved overall efficiency
Supports higher data rates

—Disadvantages

More costly hardware
Must be pointed and tracked accurately
Less desirable physical size

__Smaller Antennas__

—Advantages

Less costly hardware
Easier to point and track
More desirable physical size

—Disadvantages

Higher satellite transponder costs
Reduced overall efficiency
Can be too small to support data rate

The optimal selection depends upon the specific system requirements. As smaller SOTM antenna apertures are physically incapable of supporting link data rates above a limited throughput, they are not a universal solution.

From the analysis above concerning Aperture Efficiency and Adjacent Satellite Interference, one could surmise that a significant increase in satellite transponder EIRP and G/T could drive the use of much smaller SOTM apertures. International agreements in place via the ITU establish a basis for satellite characteristics that permit multiple satellites to share the geostationary arc so this does not appear to be a practical alternative unless a new spectrum assignment is agreed.

Similarly, although larger antennas make more efficient use of satellite transponder resources, they are too large to mount or otherwise inappropriate in some situations.

SOTM system designers must continue to trade the relative merits of alternatives in selecting the optimal solution to specific requirements.

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[2] ITU-R S.728-1 - Maximum permissible level of off-axis e.i.r.p. density from very small aperture terminals (VSATs).

[3] 47 CFR 25.226 - Blanket Licensing provisions for domestic, U.S. Vehicle-Mounted Earth stations (VMESs) receiving in the 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), and 11.7-12.2 GHz (space-to-Earth) frequency bands and transmitting in the 14.0-14.5 GHz (Earth-to-space) frequency band, operating with Geostationary Satellites in the Fixed-Satellite Service.

[4] 47 CFR 25.222 - Blanket Licensing provisions for Earth stations on Vessels (ESVs) receiving in the 10.95–11.2 GHz (space-to-Earth), 11.45–11.7 GHz (space-to-Earth), 11.7–12.2 GHz (space-to-Earth) frequency bands and transmitting in the 14.0–14.5 GHz (Earth-to-space) frequency band, operating with Geostationary Orbit (GSO) Satellites in the Fixed-Satellite Service.

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[6] C. E. Shannon (January 1949). "Communication in the presence of noise" Proc. Institute of Radio Engineers vol. 37 (1): 10–21.

About the author

Tim Shroyer is the Chief Technology Officer of ***General Dynamics Satcom Technologies***, one of the world's largest manufacturers of satellite earth station equipment and systems. He is a satellite communications systems engineer and has managed, designed, built, installed, and operated satellite earth stations around the world since 1975.

Mr. Shroyer's first satellite communications experience was as an officer in the United States Navy and with the Defense Information Systems Agency. While at Stanford Telecommunications he served as the Program Manager for the development and installation of the Network Control system that still manages U.S. military communications satellites. Since that time he has managed the development and installation of satellite Network Control and TT&C (Telemetry, Tracking and Control) systems for many satellite networks around the world. He also was the founder and president of a VSAT (Very Small Aperture Terminal) transceiver manufacturing company.

He has designed and installed uplink stations of all types in many countries, in all the world's continents, and developed new earth station architectures including pioneering the development of L-band IF (Intermediate Frequency) systems, now common in commercial and military satcom. Among his other responsibilities at General Dynamics, Mr. Shroyer is one of the principal architects of the Company's Satcom-On-The-Move System and products. He has worked closely with the Federal Communications Commission in the United States to create a licensing class for this entirely new generation of satellite communications systems.

Shroyer holds a Bachelor of Science in Electrical Engineering Degree from the University of Southern California.

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The HPA Corner
A Workshop On Key Issues
by Wendy Lewis
Director of Communications, SS/L

Continuing its ongoing efforts to facilitate open dialogue between government and industry, the Hosted Payload Alliance produced the "*Hosted Payload Key Issues Workshop*" on Monday, April 8, 2013 at the Broadmoor Hotel in Colorado Springs in conjunction, with the *National Space Symposium*.

Two years ago, at the same venue, the Hosted Payload Alliance began to take shape at its first workshop with a panel of senior U.S. government officials presenting their perspectives on the opportunities and challenges associated with executing on the guidance outlined in the 2010 National Space Policy.

Two years later, we might ask—has any real progress been made? There have been grumblings that, despite all the talk, there haven't been many hosted payload contracts awarded in the last year. However, the open discussion between industry and government at the *Key Issues Workshop* demonstrated that progress has been made and that we will see more operational payloads hosted on commercial satellites in the future. The questions of "when" and "how soon" are, as of yet, unanswered.

The format of the workshop itself demonstrated both industry and the U.S. Government's ingenuity in finding cost-effective solutions in the face of widespread budget cuts. Despite current restrictions on travel, officers at the **Air Force Space & Missile Systems Center** at **Los Angeles Air Force Base**, and **NASA** officials at headquarters in Washington, DC and at the **NASA Langley Research Center** in Hampton, Virginia, were able to participate in a lively discussion together with the attendees onsite at the 29th National Space Symposium by video teleconference.

The format worked well in promoting an active exchange among all of the sites, and the program included keynote addresses by Lt. Gen. *John Hyten*, who was onsite at the conference; NASA Deputy Administrator *Lori Garver* who addressed the audience from Washington; and Col. *Scott Beidleman*, who addressed the audience from the Los Angeles Air Force Base.

General takeaways from the meeting were that hosted payloads are a real and viable tool for creating a more cost-efficient, timely, disaggregated and resilient space architecture. The SMC noted that a Hosted Payload Solutions (HoPS) IDIQ request for proposals would come out in May and will provide an opportunity for the Air Force, NASA and the industry to work together to explore how hosted payloads for operational systems can become a reality.

NASA stated that it has already contracted with industry on several hosted payloads, including the Laser Communications hosted payload and the Atomic Clock and that it has additional missions under discussion.

During the course of the workshop numerous references were made to the success of ***CHIRP***, the *Commercially Hosted Infrared Payload*, hosted on the ***SES-2*** satellite, which is providing valuable insight into the potential for future wide field-of-view technologies and the benefits of hosted payload arrangements.

In addition to CHIRP, other recent hosted payload demonstrations include:

The HPA Key Issues Workshop — General Hyten presenting... Photo courtesy of the HPA.

The HPA Key Issues Workshop, Lori Garver of NASA presenting.... photo courtesy of the HPA.

- *The Intelsat launch of its Intelsat 22 satellite with a UHF hosted payload for the Australian Defence Force.*
- *A Harris Corporation contract award for multiple hosted payloads on the Iridium NEXT constellation for the Aireon global aviation surveillance service, to be launched starting in 2015.*
- *An SSL announcement of a contract with NASA Goddard to host the Laser Communications Relay Demonstration (LCRD) on a commercial satellite, which will be launched in 2016.*

These are significant steps demonstrating more widespread use of hosted payloads and there is support at the highest levels of the U.S. Government for the use of hosted payloads, as demonstrated by the participation in the workshop. However, despite these recent successes and this support, the use of hosted payloads is still far from commonplace with only a handful of pending procurements.

The **Hosted Payload Alliance** continues its mission to uncover and mitigate the deterrents that prevent the widespread use of hosted arrangements. The Key Issues Workshop at the National Space Symposium was another positive and important step in the effort to tackle these obstacles.

Members of the Hosted Payload Alliance commented on the value of the Key Issues Workshop and the progress in the acceptance of hosted payloads over the last couple of years.

"The Key Issues Workshop was an important opportunity for dialogue about the most pressing deterrents to more common use of hosted payloads. We are glad there has been progress in examining the value of hosted payloads, but we need to see more business and operational solutions that truly leverage the benefits of government payloads on commercial satellites to reduce the cost of government missions." —**John Celli, President, SSL.**

"The Government is moving in the right direction to make Hosted Payloads more mainstream. Having the discussion in an open format like this was very insightful. The HoPS IDIQ acquisition will be another leap forward toward overcoming some of the typical barriers like knowledge of available hosting opportunities, access by participants to a contract vehicle, business and technical frameworks for connecting Payloads with Hosts, etc. We are very optimistic about the steps they are taking." —**Tim Ellis, Harris Corporation, Sr. Manager of Strategy and Development**

"While the preparations were more involved than originally planned, the VTC format proved to be very effective for engaging in robust government-industry dialogue on hosted payloads while maintaining compliant to gov't travel restrictions. Messages from the VIP keynote speakers, as well as participation from both the Air Force and NASA, speak volumes toward the continued support for hosted payloads. The HPA looks forward to continued collaboration." —**Janet Nickloy, HPA Chair**

"The format, content and participants in the Workshop all point towards an interest in building upon the momentum to further take advantage of commercially-provided means of accessing space via hosted payloads—especially considering this budget constrained environment. The HPA membership and the participating government officials are to be applauded for finding ways to continue this dialogue and collaborate towards enabling affordable solutions even when in-person participation isn't possible." —**Nicole Robinson, HPA Vice Chair**

"The Workshop brought together a familiar group of hosted payload leaders from industry and government agencies. It is clear that while there are growing pockets of hosted payload advocates within the USG, it remains a challenge to change the mindset of the majority of those fully entrenched in major programs of record. Hosted payload proponents would like to believe that as procurement budgets are tightened, those responsible for bringing capabilities to our warfighters would gravitate to whatever solution has the highest probability of actually delivering needed services.

"While there is progress in this direction, until the procurement paradigm shifts and acquisition regulations adapt to allow long-term service commitments by the USG, the advantage of using hosted payloads to provide operational capabilities will remain unrealized."— **Dr. Bryan Benedict, Commercial and Civil Hosted Payloads Product Line Manager, In-Orbit Servicing Product Line Manager, Intelsat General.**

The HPA Corner (Cont.)

"Over the last two years we have seen some significant progress in moving hosted payloads from theory to practice. The Commercially Hosted Infrared payload is a current example of success at hosting a government instrument on a commercial satellite but it is not the only example. Other successes include the Australian Defense Forces hosting a military UHF payload on Intelsat 22 and the Federal Aviation Administration hosting GPS augmentation on several commercial satellites. Last summer, the HPA hosted an information exchange between the newly formed Hosted Payload Office at Space and Missile Systems Center in New York City where industry and government had a productive discussion on the way ahead.

"The Critical Issues Workshop held in conjunction with the 29th National Space Symposium continued the open dialogue. We also hosted a panel on Wednesday of the NSS and used video teleconferencing to connect senior leaders in Washington DC to participate in the panel. USAF leadership has announced that they expect to release a draft request for proposals to industry to provide a resource to contract for future commercial hosting of government payloads. We expect the contract to be awarded late in 2013. This contract will be open to both USAF program offices and the broader Federal community of interest. So the progress is tangible thanks to the hard work of our USAF aided by a highly capable industrial base."
—Tim Frei, Vice President, Communication Systems, Northrop Grumman Aerospace Systems

"There is general consensus among government and industry that hosting government payloads on commercial satellites is an innovative approach (1) to providing access for payloads that would not otherwise have an opportunity for flight; and (2) for delivering robust and survivable architectures to meet critical mission needs. However, the challenge for both sides is learning how to operate in each other's environments and being able to co-exist on a shared platform without interfering with each other's respective mission(s)."
—Rich Pang, Senior Director for Hosted Payloads at SES Government Solutions

HOSTED PAYLOAD ALLIANCE

Here are some key thoughts from the panel, courtesy of the ***Space Foundation's National Space Symposium website:***

Nickloy*: Engineering isn't the challenge with hosted payloads, its typically the business side ... We are looking for win-wins, 100 percent dedication to making hosted payloads successful ... we need to look at issues from a systems engineering standpoint, taking everything into account ...*

Beames*: We can now look at what it means to rely on something operationally on hosted payloads ... I'm optimistic for the next five years ...*

Kaufman*: When your payload is being hosted, your control over your data and equipment is significantly diminished ... If something goes wrong on the satellite, whose payload has operational priority? ... If you're on a craft that has a predetermined schedule, you have to think in advance how your payload fits into that schedule ... Cultural issues with hosted payloads are not unique to the military, but industry as well ... Hosted payloads have tremendous benefits for all parties ...*

Loverro*: Hosted Payloads have changed the dynamics of how we get things to space ... there are no policies prohibiting certain types of hosted payloads, however, we are limited by sensitive data ... it will take a concerted effort from both industry and military to make progress in the realm of hosted payloads ... Hosted payload are not necessarily an American-born or -owned idea; we all benefit from one another's experiences ... hosted payloads provide us the ability to complete missions that otherwise wouldn't have been cost effective.*

Whelan*: The sky is the limit, but we need to take calculated, gradual steps in expanding hosted payload capabilities ... hosted payloads are not an electrical engineering problem, but a social engineering problem ... Standard interfaces have upsides and downsides, but would be very helpful ... At some point we will face failure, but we are going to have to get by that in order to advance ...*

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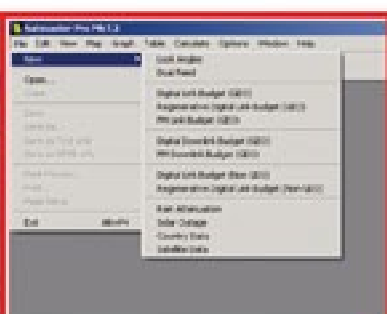
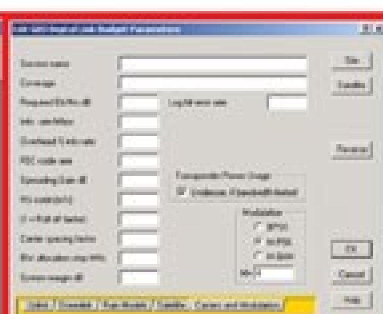




http://www.satnews.com/satfinder

The Top 5 SATCOM Innovations Of 2013

by Tom Cox
President, Coolfire Solutions

Innovation is amazing. Frequently, innovation creates *evolutionary* change in industries and technologies in the form of minor improvements, cost reductions and increased quality.

However, sometimes innovation creates real disruption in the form of *revolutionary* changes in technologies and business models. This is when innovation changes entire paradigms and turns conventional wisdom completely on its head.

I like to think of this kind of innovation as the "*constant-to-variable*" phenomenon. Meaning, that what we have always held as a constant suddenly becomes a variable. Interestingly, this is precisely why we are all geniuses at age 18, and realize we don't know anything at age 40.

For example, we've reached a point where satellite Earth terminals have maximized their potential in terms of gain and efficiency. You can only bend metal so many ways—at some point physics applies hard limits to incremental gains in optimization. Now a fascinating phenomenon is taking place. The thing that satellite Earth terminal engineers hold constant, the satellite, is, itself, changing.

Recently, several companies have either launched, or have announced a planned launch, of *High Throughput Satellites* (**HTS**). These new satellites are altering the standard equation engineers use to close links. Innovation such as this, when it changes what we hold constant (in this case, the throughput and capability of the cold, bent-pipe satellite) into a variable, changes industries forever. The technology changes, certainly, but so does the business model.

That's what is truly exciting to me. Business models can always use a good shakeup every now and then. Without innovation, our industry could wind up like The Telephone Company in the 1980s—providing the same equipment and level of service as in the 1960s.

As I've always enjoyed working on the "bleeding edge" of technology in our industry, I've tried to keep pace with the most current innovations. After a fantastic Washington D.C. conference, I worked with the product team here at **Coolfire Solutions** to derive what we believe are the top five innovations in our industry for 2013.

#5: Miniaturization Of Terminals

I'm continually impressed by what I see systems integrators doing with VSAT terminals, especially

MILSATCOM terminals. I was a systems integration engineer for 12 years and made a living on finding creative ways to cram more capability into an ever-shrinking envelope. Customers demand lighter, faster, less expensive and simpler. And integrators are delivering.

Harris, for example, has found a way to pack a 1.3m tri-band (X-, Ku-, Ka-) terminal into a single airline checkable case. The ***Seeker*** terminal comes with the RF electronics and a satellite modem, along with the manual point antenna, weighing less than 90lbs., and packs all into a 67-inch linear case that is (airline approved). Theter terminal is incredibly simple to set up and assembles extremely neatly. Returning the terminal into the case isn't a jigsaw puzzle, either.

Harris' 1.3m Seeker terminal.

Tampa Microwave has possibly redefined the Microsat market with their technology. To me, these terminals are—hands-down—the simplest, most robust, and easiest to use VSATs in the market. They're beautiful. Tampa Microwave has developed a technology where they can attach "*slices*" together. Each slice is either a modem or an RF package. This means they can modularly replace any RF module (changing frequency band or RF power output) or any modem module (swapping **iDirect** for a **Radyne**, for example). This modularity and simplicity are really the class of the Microsat industry.

Tampa Microwave's T<-X850MP X-band manpack satellite terminal.

L3, **ND SatCom**, and a few others have also come a long way in the miniaturization of their terminals—many others are just starting to catch on to this wave of terminal innovation.

#4: Wide Adoption Of Ka-Band

Back in 1985, when Ku-band was just starting to be adopted by global video distribution companies, many engineers wrote numerous white papers about how Ku-band would fail due to rain fade issues, a higher impact by scintillation and other atmospheric distortions, and linear polarization that would cause huge problems with the effectiveness of frequency re-use.

Sound familiar? It should, as a new generation of engineers are now saying the same thing about Ka-band.

Now, those engineers are, indeed, correct. Ka-band has a host of problems that include massive rain-fade issues. Ka-band is quite near the frequency of water absorption, which is about 22.7GHz. The high end of Ka-band receive is 21.2GHz. Rain can definitely have a significant impact on the quality and stability of a signal. Modem manufacturers have had to account for wild swings in power level to avoid continuous carrier unlocks, and network planners have to put in much higher margins to assure continuous communications when a cloud rolls by.

However, despite these issues, Ka-band brings too many benefits to ignore. First up? More frequency bandwidth. We've used up quite a bit of C-, X-, and Ku-band bandwidth already—terrestrial providers are chomping at the bit to take over most of C-band. Just having another frequency band in which commercial providers can operate is helpful.

Additionally, Ka-band beams are tighter, so satellites are able to steer smaller beams towards the surface of the Earth. This translates to the ability to aim several dozen beams at the Earth, but each beam reusing the same frequencies without interfering with one another. So frequency reuse on a massive scale is possible at Ka-band unlike in the lower bands.

Finally, passive gain is richer at higher frequencies, meaning reflectors can be smaller. This is part of what is driving the miniaturization of Earth terminals. Users can obtain more throughput for the same reflector size the higher the frequency. We all know that a synchronous 256Kbps circuit simply doesn't cut it anymore.

#3: Smartphones in SATCOM

My favorite innovation in SATCOM is the introduction of smartphones. In 2009, when I purchased my first *iPhone*, I quickly realized that this device had every sensor and capability I needed to conduct a site survey and point an antenna—compass, inclinometer, declination map, GPS, and an intuitive user interface. By clipping the smartphone directly to a manual-point antenna and following a simple set of on-screen instructions, non-SATCOM trained people can now find and acquire a satellite.

The uses for smartphones go far beyond

the installation and troubleshooting of terminals. Smartphones and tablet computers are fast becoming the primary user interface for computing and communications in our society. This means that more mobile devices are connecting with the bandwidth provided by satellite links.

It will not be uncommon to see integrated solutions delivered to customers that use smartphones to set up, align, troubleshoot terminals, and then turn right around and use that same smartphone or tablet to conduct the business of using the satellite bandwidth in user-specific applications.

I'm obviously a bit of a homer when it comes to mobile devices in SATCOM. Coolfire Solutions does some amazing things with smartphones. But one of the coolest things I've seen in a long time in our industry came from another company—**Thuraya**.

The ***SatSleeve***, released this year, is, hands down, currently the coolest satellite terminal on the planet. This technology turns a regular *iPhone 4* or *4S* into a satellite phone that fits in the palm of your hand and weighs next to nothing. You can operate at speeds above 64Kbps anywhere within Thuraya's global coverage areas.

Thuraya's SatSleeve for iPhone

You can now play *Words With Friends* from the top of Mount Everest, the middle of the Sahara, the Indian Ocean, or in the Australian Outback. I can't wait to see what other innovations Coolfire, Thuraya, and hopefully a number of other companies will come up with nextas to what is that involve smartphone technology.

#2: Return of the Non-Geo Satellites

In 1999, when **Iridium** launched its 66-satellite network in *Low-Earth-Orbit* (**LEO**), they changed the way people thought about satellite communications. It was no longer necessary to deploy a large parabolic reflector to initiate a satellite phone call—the transceiver was small enough to fit into a cellphone-sized package.

Geosynchronous satellites are great in that they are, well, geo-synchronous... meaning that they don't move much relative to someone standing on the ground. Satellites in other orbits, however, orbit the Earth either faster or slower than the Earth rotates. This means a terminal must track a satellite across the sky, and once that satellite sunsets (goes below the horizon), it has to go and locate another satellite to track across the sky.

This is why there are few communications satellites that operate in non-Geo orbits. However, over the past decade, auto-pointing and auto-tracking solutions for antennas has come a long way in terms of reliability, quality, and cost reduction. An auto-acquire terminal today costs about as much as manual-point terminal did 10 years ago. This makes auto-tracking satellite solutions financially viable again.

O3b Networks has bet their business model on this fact. They are launching eight *Medium-Earth-Orbit* (**MEO**) satellites this year. These satellites orbit the Earth four times a day and are 45-degrees apart from one another.

This means as many as eight times a day (depending on the location of the user) the Earth terminal will switch to a new satellite.

Why would anyone want to put up with all of that tracking and switchover? Well, first of all, the satellites are Ka-band, meaning much higher throughput for smaller terminals. Second, the satellites are much, much closer to Earth, meaning latency is cut by about 75 percent of a standard geosynchronous link, resulting in improved synchronous user quality, especially for voice and video teleconferencing applications.

I've heard about other interesting business models involving non-geosynchronous satellite constellations, and I anxiously await with anticipation to see what ideas are coming inext I'm also excited to see how O3b fares once they launch their first satellites, which will occur in just a few weeks.

#1: High Throughput Satellites (HTS)

I gave this one away in the introduction—I firmly believe the biggest innovation taking place in our industry right now isn't coming from component manufacturers, terminal integrators, or even application providers—it's the recent influx of HTS. **ViaSat**. **Hughes**. **Inmarsat**. **Eutelsat**. **Yahsat**. **Echostar**. All of these companies have recently entered the HTS market with satellites that offer between 2x and 200x the available bandwidth on standard *Fixed Service Satellite* (**FSS**) satellites.

Artistic rendition of the ViaSat-1 satellite, courtesy of SS/L

ViaSat-1, launched in October of 2011, has more capacity (140Gbps) than all of the other satellites aimed at the United States combined. Talk about a game-changing innovation.

Northern Sky Research recently released a report that said that as much as 1.34Tbps of bandwidth will be supplied by HTS satellites by 2020. As many as 33 HTS satellites are expected to be launched between now and 2015. The satellite backhaul market can expect to triple in value from $800M to $2.3B by 2021.

The ground terminals, the business models, and all of the peripherals involved in satellite communications, have reached an incredibly high level of efficiency and capability, but everything depends on HTS satellites. The more powerful, the higher in capacity, and the more plentiful they are, the better for the industry.

The innovation happening among the satellite operators will flow down to massive disruptions in the global bandwidth game. Many companies in the satellite industry have been watching a continual shrinking of the pie, and in order to stay healthy, they've been playing zero-sum wargames with one another. With HTS satellites ruling the geosynchronous orbit soon enough, new business models that properly leverage these satellites will grow the pie and take share away from other backhaul solutions, both wired and wireless.

Artistic rendition, Global Xpress satellite, courtesy of Inmarsat.

Better, more bandwidth can reach places never really previously addressed. **Inmarsat** launches the first ***Global Xpress*** (**GX**) satellite in early 2014. The GX constellation, consisting of three Ka-band geosynchronous satellites, will illuminate nearly the entire planet in high-capacity Ka-band. This means high bandwidth will also be aimed at the middle of the oceans—cruise ships and cargo container ships will bask in 50Mbps downlinks for the first time. New customers.

The Future Looks Bright

These are exciting times for the satellite industry. Change is the only constant, and things are changing more rapidly than ever before in the history of our industry.

The more we embrace innovation, the more satellites can compete with alternative communication capabilities. Those who create these disruptive innovations will enjoy the benefits of the disrupted business models of those who simply stand by and watch the developments.

The author, Tom Cox, is the President of ***Coolfire Solutions***.

Broadband-On-The-Move

Satellites Take The Pole Position

by Dr. Rowan Gilmore
Managing Director, EM Solutions Pty Ltd.

Defence forces, first responders, and emergency services and disaster recovery personnel all require reliable and trusted communications to operate in theaters in which infrastructure must often be transported. Backhaul of traffic from multiple devices—phones, cameras, computers, and equipment control systems—to a remote headquarters has, perhaps, become simpler and more integrated with IP-enabled devices and localized Wi-Fi.

However, the migration to IP has also accelerated the need to satisfy two other challenging core requirements that can still remain unmet—broadband backhaul capacity, and providing backhaul from a local management and command node that is itself on the move.

Although VHF and UHF radios have served this purpose for many years, such radios are, inherently, bandwidth limited. Microwave radios offer greater bandwidth, but they require line-of-sight to the horizon for backhaul. They also require stabilized antennas to maintain pointing back to base while the node is moving. Satellite, therefore, offers a solution that provides both bandwidth and the ability to stabilize an antenna that is pointed skywards, rather than towards the horizon, reducing obstruction while in motion.

In this article, we describe how **EM Solutions** (**EMS**) has developed and delivered a ground breaking *on-the-move* (**OTM**) terminal system for a government customer to assist in its future disaster recovery efforts. These terminals were fitted to mobile communications vehicles intended for rapid despatch to impacted areas of the country, and to provide fiber-like data speeds in off-road conditions while the vehicles are still in motion.

Using as a baseline product its existing Ka-band OTM terminal developed for the military and WGS satellites, EM Solutions added support for commercial Ka-band frequencies and provided an additional rotational axis to accommodate linearly polarized carrier signals.

The new terminals were able to maintain their pointing accuracy by using closed-loop tracking data from monopulse tracking information derived from the satellite's low power telemetry signal, supplemented with readings from the system's built in mechanical gyroscope.

An integrated 40W Ka-band linearized *block upconverter* (**BUC**) provided sufficient uplink power for 155Mb/s data throughput from a 650mm reflector.

Within six months of receiving its contract, EM Solutions was able to successfully deliver and demonstrate terminals capable of meeting < 0.2 degree pointing error for off-road and marine conditions, providing exceptional performance and link availability limited only by line-of-sight to the satellite.

OTM Terminal System Specification

In the design of any satellite ground terminal, the link budget must be carefully calculated to determine the *required gain* (**G/T**) of its receiver and the *effective radiated power* (**EIRP**) of its transmitter. These two parameters, and the equivalent system parameters of the satellite itself, ultimately determine the mechanical and electrical characteristics of the terminal that can be developed.

Typically, the customer specifies the maximum possible terminal footprint that can be accommodated on their vehicle—this, in turn, determines the available antenna gain for a given choice of antenna. Next, with the available channel bandwidth and desired uplink data rate given as important system constraints, the link budget can be used to calculate the required terminal EIRP, and, in turn, the linear transmitter power required.

In the EMS system, to minimize the size of the radome and vehicle footprint, while still meeting the EIRP and spurious interference specification, a parabolic antenna of 650mm in diameter was selected. This resulted in an antenna gain of approximately 42.5dB (including the feed and radome losses) at 28GHz, the transmit frequency.

Working backwards from the link budget, the determination was made that a 40W (Psat) BUC was required to achieve the desired 155Mbps data rate. This is an exceptionally high uplink data rate to support from an OTM terminal, made possible only by the combination of high antenna gain and high transmit power together yielding an EIRP (saturated) of 58.5 dBW.

Of course, these are just the first system constraints. For any OTM terminal, there will be other constraints in addition to the data rate that must be met. These include achieving the correct polarization of the signal and pointing the terminal accurately to minimize interference with adjacent satellites.

Broadband-On-The-Move (Cont.)

Figure 1. EM Solutions broadband on-the-move terminal being readied for operation atop a communications node being deployed for disaster recovery operations.

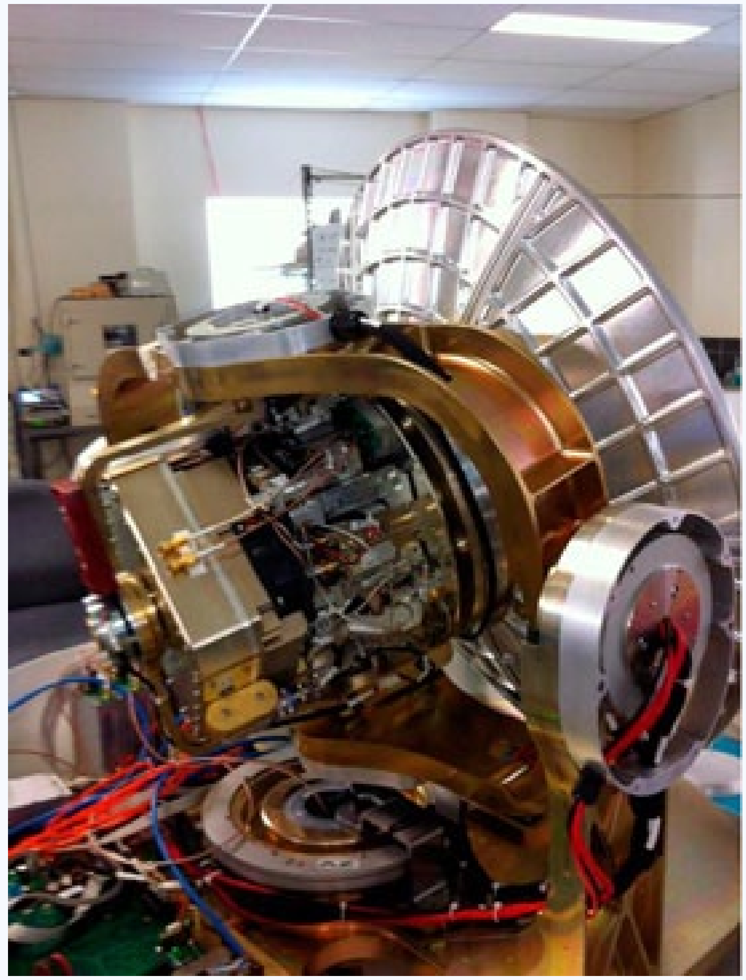


Figure 2. The broadband on-the-move terminal without radome, showing the parabolic reflector antenna and three-axis gimbals. The BUC and associated RF electronics are mounted directly behind the antenna, avoiding an RF rotary joint.

In addition, the terminal must clearly survive as well as also be operable when undergoing severe vibration. This terminal was also required to support standard *bent pipe* and *Asynchronous Transfer Mode* (**ATM**) operation through the satellite, requiring band selection in the BUC and LNB to accommodate this.

At first glance, a phased-array antenna might appear the ideal antenna candidate, as electronic steering is conceptually appealing to partially eliminate mechanical motion. Phased-array solutions can use a combination of mechanical steering for azimuth and electronic steering over a limited range of elevation angles.

However, there are a number of critical problems with a phased-array approach. First, phased-array antennas with a reasonable number of elements have low gain, particularly when pointed off-axis. High data rates can, therefore, be achieved only by operating at much higher power levels than with other antenna solutions.

Secondly, they generate significant energy outside the main lobe and often require waivers to achieve certification status, which need to limit the allowable unwanted radiation that is transmitted via sidelobes to satellites in adjacent slots.

Third, beam squint (*i.e.*, the need to maintain the same pointing angle across the entire frequency band), limits the fractional bandwidth to 5 percent, even for scanned angles as small as 25 degrees.

Finally, at Ka-band, the transmit (28GHz) and receive frequencies (18GHz) are a half-decade apart in frequency, so separate arrays would be needed to cover each frequency—arrays that would need to be synchronized with each other to individually steer each to within a fraction of a degree.

It is the view of EM Solutions that any broadband phased-array antenna would, therefore, be burdened with unacceptable compromises to achieve a practically useful and operational system at Ka-band—in spite of the obvious advantage of lower height profile.

The use of a single parabolic reflector antenna overcomes these limitations. A parabolic reflector and horn with combined waveguide feed for transmit and receive signals will achieve much higher gain, coverage of the entire bandwidth, automatic alignment of receive and transmit beams, and tight control of sidelobes. The disadvantages: The need to mechanically steer the reflector and the difficulty of designing a dual-band feed have been overcome through robust and precision systems engineering of the terminal.

OTM Terminal System Design

A core design consideration is how to acquire, and then track, the satellite. There are two broad approaches. The first, which is an open-loop approach, is to use the known position of the geostationary satellite in the sky to orient the antenna and to reorient the terminal given the terminal's current heading.

However, pointing accuracy to within a fraction of a degree is quite difficult (and expensive) to achieve with an open-loop tracking system that relies solely on inertial measurement systems to steer the antenna. Mechanical tolerances, that can also vary with temperature, are also difficult to compensate for with this approach.

Furthermore, inertial measurement systems that rely on GPS measurements cannot account for Ka-band signal refraction through the radome and are, therefore, susceptible to radome variations and large offset errors that also depend on the angle of elevation.

GPS-assisted *inertial navigation units* (**INU**s) are also quite sensitive to multipath, so moving in the vicinity of buildings or trees could upset the INU, which would then result in pointing errors. To make matters worse, it would be hard to even know that these pointing errors had occurred.

The second approach, based on closed-loop tracking, avoids all of these problems. With this approach, the satellite is tracked using its own transmissions. The terminal, for instance, could seek the orientation that maximizes the receiver signal, or satellite beacon signal, or some other derived signal, as in a "monopulse" system.

Figure 3.The parabolic reflector and Ka-band antenna feed system, which rotates to match the polarisation of the incoming signal

The signal beamwidth is rather broad at its 3dB points. Finding the center of its maximum using a traditional mechanically scanned approach involves pointing a conventional reflector antenna intentionally off center, to the beam edges where the signal strength begins to drop off rapidly.

Two examples of mechanical scanning are conical scan and step-track. These are deployed in so-called *on-the-hop* terminals, which remain stationary in operation once deployed on location. However, a deliberate pointing-error must be introduced to verify the maximum. This reduces the gain and effective power. It also responds too slowly for rapid vehicle motion or acceleration.

For its terminal, EM Solutions uses a system known as *monopulse tracking*, which provides the most certainty and accuracy to the true direction. Monopulse systems are able to estimate the pointing-error without any mechanical scanning and without needing to deliberately mis-point the antenna.

Monopulse antennas generally use a dual feed: The main feed has a normal broad antenna pattern, while the secondary feed internally generates a pattern with a sharp notch along the bore-sight. By comparing the signals from the two feeds, the antenna can be precisely pointed without ever needing to deviate from the maximum signal strength.

This has two advantages: The link budget remains strong and availability is always maximized, as the pointing error is kept small; and power consumption is kept low, as the antenna is held stationary rather than intentionally swept in a constant scanning motion.

Other design considerations also had to be accounted for with a mechanically rotated system. These included:

- *Friction, which causes the tracking mount to lose its pointing angle during vehicle motion, so the motors must apply torque to overcome the friction. Too much friction within the motor and bearings will result in the motors having to use more power to overcome the frictional force that will tend to shift the antenna the same way as the underlying motion of the vehicle. This can be overcome by using high quality bearings and design for a low inertial mass, balanced antenna system.*
- *Balance, which is a critical factor in tracking mount design. A balanced system, where the axis pass through the centre of mass, will have lower power consumption and improved system performance. In an unbalanced mount, linear acceleration of the vehicle will translate into rotational motion about the axes, forcing the motors to consume power just to maintain the original pointing angle. A well balanced design can avoid this effect.*
- *The "keyhole" effect, which occurs when the mount is required to track a satellite at elevation angles approaching 90 degrees from its base (i.e. looking straight up, as at the equator on a ship). In systems using a two-axis drive, to reduce overall vertical height, the antenna cannot directly pass through overhead as the elevation changes. This produces a blind region until the antenna can completely rotate around its azimuth axis and reacquire the satellite.*

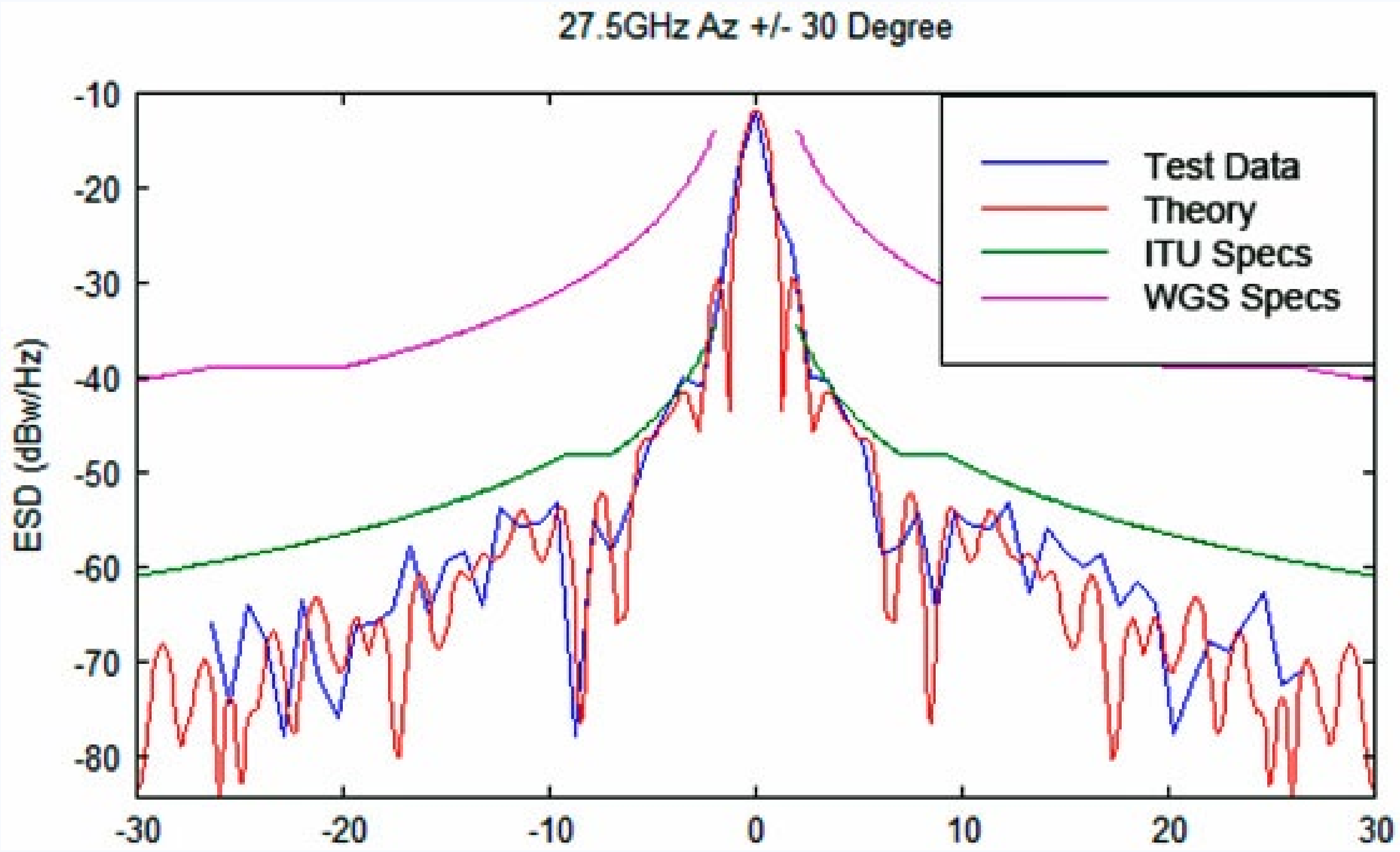


Figure 4 —Plot of the theoretical and measured emitted power spectral density from the OTM antenna. The ITU and WGS specifications are shown for comparison.

EM Solutions' design approach to overcome these issues permits the antenna to point directly overhead, by using a three-axis system, with a *cross-elevation* axis, to allow rotation throughout the entire sky. The additional degree of freedom in elevation allows direct overhead pointing with the base able to rotate to an optimal position, overcoming the keyhole problem. Adding the second elevation axis does slightly increase the cost and height of the terminal as more mechanical and control system design is required, however it will ultimately result in power savings and less wear on the azimuth axis. It vastly reduces the pointing error as well, because the cross-elevation axis allows the antenna to stay still, since it is only friction and residual imbalance that causes transfer of vehicle motion through to the antenna.

The challenges do not end there. As the platform is itself travelling, the satellite beacon, used to estimate the pointing error, suffers *Doppler shift*. Uncertainty in the beacon frequency is consequently quite large. This is due to drift in the satellite's own local oscillator as well as the Doppler shifts caused by vehicle motion. The frequency offset can be several hundred kHz, and the Doppler shift can change at a few kHz per second as the vehicle maneuvers. These frequency offsets are cancelled internally by the system controller.

Compared with the ***Wideband Global SATCOM*** (**WGS**) military satellites, the Ka-band signal in the satellite used for this particular disaster recovery application was linearly polarized, rather than circular. This is uncommon for Ka-band satellites and required a fourth rotational axis, that of the antenna feed itself, to be incorporated into the system design.

The function of this fourth axis is to rotate the antenna waveguide feed to match its polarization with that of the incoming signal. Of course, this varied as the vehicle twisted and turned, as well. An additional control loop was designed and fitted to monitor the polarization of the received signal, and this was used to drive a fourth motor fitted within the antenna and dedicated to rotating the waveguide feed about its axis.

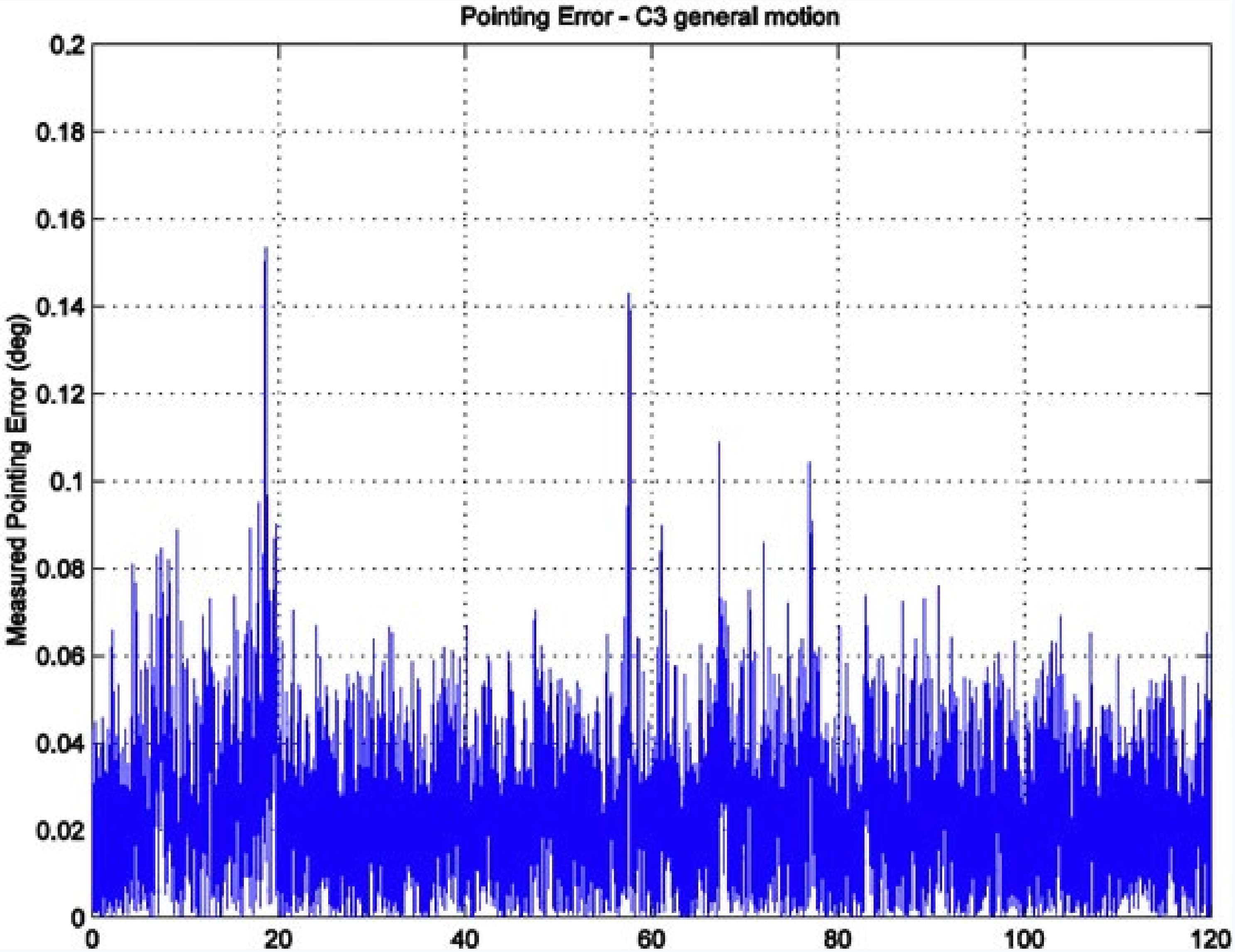


Figure 5. Plot of the pointing error achieved by the broadband OTM terminal while in severe motion off-road. Pointing errors are maintained less than 0.2 degree in almost all motion conditions. The associated signal loss is less than 0.1 dB from nominal bore sight.

Outcomes—Broadband-On-The-Move

The decision to base the system around a parabolic reflector antenna rather than phased array was justified by measurements on its *emitted power spectral density* (**ESD**) made at EM Solutions' outdoor antenna test range. These measurements show the power contained in any sidelobes generated by the antenna and must be maintained within tight limits set by certification authorities, such as **ARSTRAT** (for the WGS system), or in the present case, the **ITU**.

The results with and without the radome were essentially the same in terms of pointing and shape and indicated that the radome's main effect was to attenuate the signal. *Figure 4* on the following page shows the predicted and measured values for ESD, as well as the ITU and WGS specification limits, at an azimuthal (ϕ) range varying about the central beam by +/- 30deg.

The ESD is a maximum when the terminal is operated at the maximum linear power and the minimum symbol rate, and is shown for the worst case condition. All measured and predicted ESD(ϕ) plots are referenced with respect to -12dBW/Hz at bore sight, corresponding to a symbol rate of 6Mbaud and linear power of 44dBm. The figure shows how closely the measured data follows the predicted results, subject to limitations on the step size used for ϕ (+/-2 deg). The ESD falls below the ITU sidelobe mask as required.

Broadband-On-The-Move (Cont.)

Figure 6. Some possible configurations of the EM Solutions broadband OTM terminal for military applications.

Careful attention to system design as described here can result in many benefits that the end-user in the military, or first response situation, will almost certainly appreciate. These include:

- *Maximum system availability—visibility of the satellite is an essential requirement that may not always be under the user's control. However, the system designer can still optimize availability by minimizing signal loss due to mispointing, and by rapidly re-acquiring the signal after tracking has been lost and visibility regained. The former was achieved with best-in-class pointing accuracy, a result of using closed-loop beacon signal processing and tracking. Even in motion off-road, this system maintains pointing loss less than 0.2 degree, well within the antenna beamwidth, which in turn preserves the link budget to within 0.1dB of bore sight, and improves performance on marginal links.*
- ***Quickest re-acquire time****—this is required after the satellite is obstructed from view and becomes visible again, to maximise system availability. We achieved it by incorporating an innovative gyro-lock mode in the control system that predicts satellite direction during the signal loss, and readies the unit for immediate operation after the satellite reappears into view.*

Continuous coverage over all ranges of motion. The user does not want to be restricted from communications by the pitch or gradient of the road over which they are moving. EM Solutions uses a three-axis gimbal mount system to eliminate keyhole effect and annoying synch losses when the satellite is close to overhead, and where other systems need to rotate violently to maintain lock.

- ***Reduced maintenance and power consumption.*** *The power budget of systems used in many vehicles must be restricted to preserve battery life, while most stabilised platforms used in backhaul communications on the move are power hungry. The terminal described here uses high life, sealed brushless motors, and balances the BUC and waveguide feed behind the antenna. Its high moment of inertia is designed to be balanced to minimise internal movement of the antenna, which should remain stable and pointing to the satellite. This reduces both peak and average power consumption to just a few watts greater than the power consumed by the BUC itself. Mounting all the RF subsystems behind the antenna also avoids the use of an RF rotary joint and a failure-prone component.*

- ***Cost effective***. *Users are frequently surprised that while quoted terminal costs can appear reasonable, the "add-on" costs of required accessory INU and GPS systems can prove very expensive. EM Solutions OTM terminals rely on closed-loop tracking of the satellite itself, and GPS and INU data are only secondary data points, used for initial location of the satellite window. As a result, much lower cost INU modules can be used —and these are embedded in the terminal itself.*
- ***Complete end-end design, manufacture, and support.*** *As described above in the section on system specification, the two critical design variables in an OTM system are the antenna size and BUC power. EM Solutions has control over both of these, since it manufactures and designs its own RF and control electronics. With full control over the system supply chain, it can customize its terminals and provide rapid turnaround.*
- ***Configurable to end-user needs***. *EM Solutions terminals are able to track both circularly and linearly-polarized signals, so extension to X-band and Ku-band satellites is straightforward. Such terminals are now being designed. With a variety of terminal sizes, powers, and frequency bands, the customer can optimize their configuration to suit local conditions.*

Maximum Flexibility

The broadband on-the-move system designed in this article was certified and licensed by the customer's national telecommunications authority for use on the satellite in March 2013, less than nine months after EM Solutions received its contract to develop the system. It was successfully demonstrated to the government customer the same month, ready for deployment. Several terminals have already been delivered as part of an ongoing rollout program.

Broadband on-the-move satellite communications terminals now offer true mobility and high data throughputs to military users and first responders, even under the most demanding and severe on-the-move conditions.

In considering the suitability of a terminal for a given application, the user must consider how the requirements below can be solved technically :

- *Linear and angular acceleration for which the platform must compensate*
- *Mobile elevation and azimuthal range*
- *Acquisition time and recovery time following blockage*
- *Regulatory constraints on receiver tracking and transmit pointing-error, sidelobes, and appropriate allowances in the link budget*
- *DC power constraints*

This article has described the design constraints and features of EM Solutions' most recent OTM terminal that provides backhaul of any IP-based traffic, a complete integrated satellite communications solution that includes tracking antenna, satellite receiver and transmitter, closed-loop beacon tracking system, and a terminal management system. It also includes its own integrated GPS compass and INU (inertial navigation unit), unlike other systems where these can be expensive add-ons.

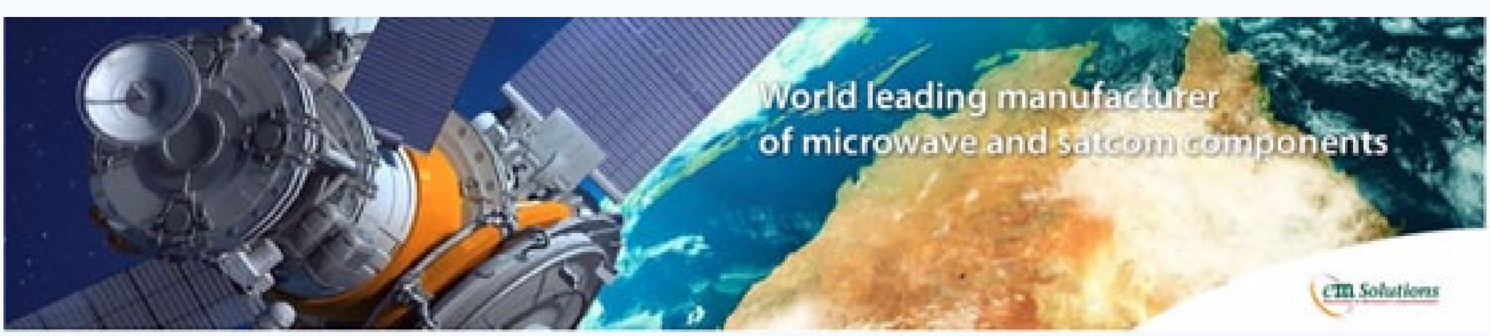
The system described uses a simple, single parabolic reflector and horn with combined waveguide feed for both transmit and receive signals to achieve higher gain, coverage of the entire bandwidth, automatic alignment of receive and transmit beams, and tighter control of sidelobes than any other equivalent antenna or phased-array system.

Gimbal-mounted with three axes to eliminate keyhole effect, and driven by a closed-loop tracking control system, the system achieves unsurpassed pointing accuracy and reacquisition time once locked, providing superb communications availability at previously unheard of data rates up to 155Mbps. Even while traveling at 120km/hour on the highway or 80km/hour off-road, connectivity is assured whenever the satellite is in line of sight.

In the future, X- and Ku-band capability will become available, based on swapping a custom-engineered, modular "kit" comprising feed, SSPA/BUC and LNB's with the Ka-system on the OTM platform. This delivers maximum flexibility in the field for either military or commercial customers across three important satellite bands using a single base terminal.

About the author

Dr. Rowan Gilmore is currently Managing Director of EM Solutions Pty Ltd. The company is recognised around the world for manufacturing technologically superior microwave modules and systems for next generation broadband communications. It offers differentiated products that embed its unique IP, and are available on demand. He was previously a Vice-President with SITA, the global IT and telecommunications service provider to more than 600 of the world's airlines. When based in London, he was responsible for network installation, operations, and service delivery in more than forty countries across Europe. Prior to that, he was based in Atlanta and responsible for the SITA high-speed backbone network in the U.S., Canada, and Mexico, and for the implementation, design, and build of new customer networks. Before joining SITA, he was Manager, Advanced Global Networks, R&D, Telstra Corp, Sydney, which serviced customer telecommunications requirements outside Australia, and delivered offshore telecommunications services to Australian customers, via both fiber and satellite.



A Case In Point
Piercing The Fog Of War

Working with the *NATO Consultation, Command and Control Agency, Globecomm* equipped the troops of the *International Security Assistance Force* in Afghanistan with rugged, suitcase-size units providing *Blue Force* tracking and texting service that saved lives and helped pierce the fog of war.

The North Atlantic Treaty Organization (NATO) was created in 1949 to safeguard the freedom and security of its member countries by political and military means. Nearly 60 years later, NATO found itself with a new mission: Helping to establish the conditions in which Afghanistan might enjoy—after decades of conflict, destruction and poverty a representative government as well as self-sustaining peace and security.

The **International Security Assistance Force** (**ISAF**) mission in Afghanistan would be challenging for any military organization. It is doubly so for a force composed of units speaking different languages and using different equipment. Simply achieving what the military calls situational awareness—knowledge shared by commanders and troops about the battle space—presents an enormous challenge.

NATO's *Allied Command Operations* in Casteau, Belgium, directs ISAF operations. However, a separate group—**Allied Command Transformation** (**ACT**) in Norfolk, Virginia, USA—focuses on preparing NATO for its future.

To support the ISAF, ACT began working with contractors to specify and design a **Force Tracking System** (**FTS**) that could be used by all NATO units in Afghanistan to share information and prevent friendly-fire casualties. The result was a first for NATO: A standard called the **NATO Friendly Force Identifier** (**NFFI**), which defined how existing FTS used by some nations would interoperate with one another and with new systems to be developed by NATO.

Development of the standard was no laboratory exercise. There was enormous pressure to develop a unified system that would protect soldiers and make operations more effective. The requirement went out to contractors in 2005, and after a competitive bidding process and contract award by the NATO Consultation, Command and Control Agency (NC3A), the standard was ready in December 2006. In between were countless technical meetings with contractors as well as ongoing design and testing.

The original bidding was won by **Insight** (now **Comtech Mobile Data Corp.**) and **EMS Technologies of Canada**. The requirement called for vehicle mounted systems with visual displays using GPS to track their own locations. The systems would also share this information with field commanders and other units.

Based on the NFFI standard, the system would fully interoperate with the FTS units brought into Afghanistan by troops from the mission's Participating Nations. Visual displays in each vehicle, and in command centers, used a common database to represent friendly forces on dynamic maps. The plan also called for equipping the vehicles and command centers with keyboards for the exchange of text messages.

The technology appeared promising. The problem was to deploy the system in Afghanistan and integrate it into vehicles, all the while maintaining operations in one of the world's toughest environments. The terrain of Afghanistan is incredibly mountainous, making line-of-sight communications almost useless. The region is dry and dusty—as soon as the dust is disturbed, it rises into the air and seeps into every piece of equipment. Add in the fact that the units of the Participating Nations also rotate out on a regular basis, this means a continuous need to retrain the new forces and reinstall and re-commission systems.

At that time, a team of **Globecomm** engineers and Afghani technicians was already in-country building and maintaining a national mobile phone network and private networks for the Afghan government. In June 2006, Globecomm won a new competition organized by the **NC3A** to manufacture the FTS vehicle systems, integrate ground systems and a control suite, and provide installation, training and maintenance for NATO forces. The company shipped the first suitcase-size units to Afghanistan by October. After systems integration, antenna commissioning and terminal testing, Globecomm had the first units in vehicles by the end of November, even before the final NFFI standard was approved.

"That's when things began to get interesting," said Globecomm vice president *Paul Knudsen*. "There were lots of technology challenges. The complexity of the satellite and terrestrial link was unique. Signals from the FTS units were relayed via satellite to Europe and were then backhauled terrestrially to North America and transmitted to the ISAF HQ in Afghanistan. That's where the control suite compiled and processed the data, which was transmitted back through the same chain to the individual terminals in the vehicles.

Mounting the terminals in the vehicles had its own challenges. "We couldn't drill holes or modify the vehicles in any way," said Knudsen. "Some vehicles were hardened against explosives. Drilling through the exterior or removing protective plates to run cables would put soldiers' lives in danger. All the terminals were going to be removed at the end of their tour anyway, so we decided on a temporary magnetic mounting of the terminals. But a lot of the vehicles are Kevlar. Magnets won't stick to them, and we had to come up with an adaptor plate to be glued on the vehicle. Then it became clear that the laptops we originally supplied were too large, so we switched to tablet systems. The tablets were smaller and easier to use and store."

Some problems did not reveal themselves until the troops were in the field. "The enemy was using radio frequencies very close to the band our transceivers used," Knudsen added. "The electronic countermeasures (ECM) meant to jam them were knocking our systems off the air as well. We solved that by shielding the terminals from the ECM."

On any given day, there are hundreds of vehicles using the terminals.

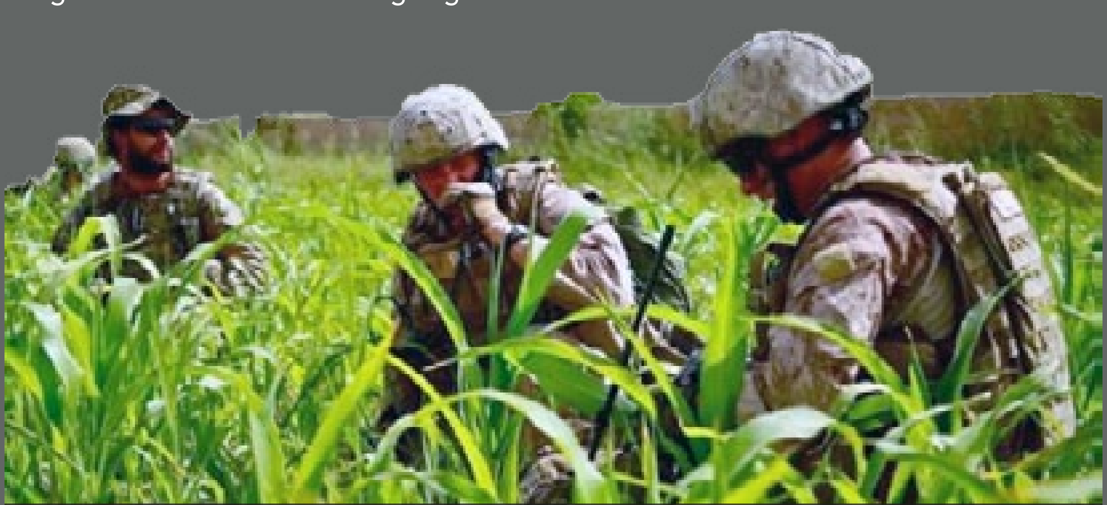
"When a unit heads into the field, they set up a user group of all the terminals. On the display, all of those vehicles are marked with the same color. As it's a GPS system, they can plot their route on the display and use the navigation system to stay on course regardless of conditions. Depending on what they need, they can see the whole battlefield or set the display to 'center on me.' The command post has the same information in real time, and either the troops in the field or command can mark hazards like IEDs as they are discovered. "We were even able to supply dismountable handheld units. Soldiers can leave their vehicles and still have access to the system."

The text messaging has also proven its value. "Young people are used to communicating that way, They really like it."

But there is a far more serious benefit for soldiers on the ground. ISAF in Afghanistan operates in multiple languages, with English as the primary language and French as the backup. But many of the troops have minimal skill in either. Texting allows troops to communicate adequately even when they are not fluent enough to speak. With text, a soldier never has trouble understanding another's accent.

NATO's FTS was declared operational in early 2008 and will continue in use throughout the ISAF's deployment in Afghanistan.

"We're very proud to be contributing to NATO's mission," says Globecomm Chairman and CEO *David Hershberg*. "The FTS system is saving lives by letting NATO's troops tell friend from foe and avoid friendly-fire casualties. It's also creating better situational awareness for everyone in the battle space, which makes soldiers more efficient and effective. The fog of war is very real, but innovative communications technology can go a long way toward clearing the air."



U.S. Marine Corps Capt. Sean P. Cunningham, center, maintains contact with helicopters via radio while Lance Cpl. Aaron Figueroa provides security during a patrol in the Nahre Saraj district, Helmand province, Afghanistan, August 9, 2011. Cunningham is a fire control team leader and Figueroa is a fire support man, both assigned to 1st Air Naval Gunfire Liaison Company. (U.S. Marine Corps photo by Lance Cpl. Daniel Wulz/Released)

Conference Roundup: NSS
An Analysis
by Hoyt Davidson, *Managing Partner, Near Earth LLC*

Congratulations to the Space Foundation for pulling off a highly productive and enjoyable National Space Symposium (NSS) in spite of the challenges of sequestration. Military attendance at the 29th annual NSS was certainly far below normal levels and NASA was totally absent, but the event easily shifted to a most worthwhile industry-to-industry focused networking opportunity.

Innovation, Resiliency + Affordability
If there was a theme to this year's Symposium it had to be the one laid out most convincingly by General *Shelton*, Commander of **Air Force Space Command**. In his opening keynote speech, General Shelton introduced a new aerospace/defense procurement world to be driven by "***Innovation, Resiliency and Affordability***."

This theme carried throughout the week and was firmly secured into attendees' consciousness at the Acquisition Lunch by Brigadier General *Teague*, Director, Strategic Plans, Programs and Analyses, Air Force Space Command. I think I lost count at six uses of the phrase "Innovation, Resiliency and Affordability"—the message was clearly delivered, going down a new path, no more business as usual, money is tight.

Having attended the Symposium on and off for more than a decade, I can attest to the fact that Defense and Civil procurement has always been a hot topic of discussion. That all parties agree the process is broken and unsustainable has become as common knowledge as the lack of easy solutions.

This time seems different. There is nothing like staring into a decade of declining Defense budgets to focus one's attention on actually solving the problem. Of course, we should retain a high degree of skepticism. Plans are one thing, execution another, but this is not the "faster, better, cheaper" pipe dream of a few years ago. That never had a chance. This actually sounds like a new and smarter approach to acquisition. Thanks to numerous advancements in technology, the new options available to us might even allow this strategy to work.

What does "Innovation, Resiliency and Affordability" actually mean? I think we can assume, at the very least, that it means the normal practice of maximum performance at any cost and zero risk, or as one aerospace CEO described their goal, perfect product delivery, is no longer the guiding principle. Apparently, "perfection" is no longer affordable, and apparently not that resilient or flexible either.

I do not, however, think this means a whole new level of risk tolerance by the government customer. Mission assurance is still of paramount concern, just not at any cost and on any time frame. Instead, the idea appears to be to use technological "innovation" and new system architectures to achieve sufficient performance at still very low levels of mission risk and to perhaps even achieve lower levels of risk through higher system level resiliency. Kind of like faster, good enough to get the job done, cheaper.


Hoyt Davidson, Near Earth LLC.

Generals Shelton and Teague stated that this would mean a disaggregation of capabilities, using fractionalized satellite networks based on smaller satellite buses or payloads. It was also said to mean more hosted payloads, fewer dedicated systems and a greater use of commercial services. It sounds like the era of billion dollar super complex satellites that are simply "too big to fail" or lose on launch may have peaked as perhaps have the multi-billion dollar programs such as ***AEHF*** and ***SBIRS*** that have routinely experienced large cost overruns.

In its place is envisioned an era of smaller, more single purpose space hardware, but with many more points of presence. More and smaller is hoped to equal less impact from single unit failures and therefore greater system resiliency. Smaller may also mean simpler manufacturing and testing processes, quicker and lower cost deployment and more flexible response. More importantly, it is hoped to mean accomplishing missions at lower cost.

At **Near Earth LLC**, we do not think this new procurement strategy suggests an abrupt sea change nor a total abandonment of large scale satellite procurements, but rather a gradual shift toward smaller where larger has not worked. For instance, successful programs such as WGS may be safe as well as certain national security programs where there may simply be no substitute for size and complexity—laws of physics being neutral on the whole budgeting issue.

It is, of course, hard to tell at this stage if this new strategy will all work out as hoped. In the commercial satellite communication industry there is still a trend toward bigger is better, with High Throughput Satellites (HTS) in high demand. Larger and hybrid satellites have meant not only more broadcast power and more frequency bands to exploit at a given orbital slot, but also lower average cost per transponder from sharing a common satellite bus and one launch vehicle.

Apparently, this same dynamic is not working as well in a national security environment where design requirements are far tougher, oversight more bureaucratic and costly and production volumes far lower—the push to disaggregation and smaller size: simpler requirements, easier oversight and higher volumes.

Who Benefits?
In addition to the government and us taxpayers benefitting from lower costs, who else should benefit from this new strategy? As *Chris Quilty* notes in his excellent April 15th issue of *Satellite Signals*, this "shift toward disaggregation would undoubtedly benefit small satellite specialists such as **ATK**, **Ball Aerospace**,

and **Orbital Sciences**… also tend to reduce the Pentagon's requirement for large EELV-class launch vehicles in favor of medium class rockets such as Orbital's ***Antares*** rocket and **SpaceX**'s ***Falcon 9***." [Congratulations to Orbital on the inaugural launch of Antares—COTS is proving to be one of the most cost efficient procurement models ever executed. Hint, hint government, we need more COTS style procurement.]

I would also add **Sierra Nevada** to that list of U.S. satellite manufacturers, and for entirely different reasons, **Space Systems/Loral** who, although not a government contractor or smallsat manufacturer (currently), they know how to make small satellites and have decades of experience providing satellites on commercial terms. It may prove easier for a company with commercial best practices to go small than for a government focused smallsat manufacturer to go commercial. On the launch side, there are a plethora of new small launch vehicles under development as well as the ability to deploy CubeSats and smallsats from the International Space Station.

None of this is to suggest that the large incumbent prime contractors are in dire straits. The evolution to smaller satellites has been evident for some time now. Boeing, in particular, has been more aggressive in preparing for this revolution. It has introduced its new ***Phantom Phoenix*** line of smallsats with options from 4kg to 500kg.

Lockheed and **Northrop** may have some catching up to do in the sub 200kg. size range, but in the 200 to 500kg. range, Northrop has been providing its ***Eagle*** line of smallsats to **NASA** and Lockheed has its ***LM 900*** bus at just under 500kg. Of course, the near term financial significance of this capability gap will remain unproven until the sub 200kg class proves its worth to the Defense Department and becomes more widely adopted. **Skybox Imaging** will soon provide an interesting test case for these new smallsat capabilities with their first remote sensing satellite launch planned later this year.

There is also the important question of just how much can be accomplished with the smallest of satellites (*e.g.*, ***SeeMe***, ***Kestrel Eye***), particularly the increasingly ubiquitous CubeSats. Miniaturization of electronics and sensors has come a long way in allowing more to be done with less, but physics does enter the equation at some point in terms of apertures/resolution and power availability. Swarms of satellites and inter-satellite links may address some of these limitations, but the trade-offs are just now being fully addressed.

We should soon have a better understanding of where these CubeSats and smallsats fit into Defense Department's mission requirements and how best to use them. Regardless of the ultimate impact of CubeSat and smallsat technologies on Defense procurement, one thing is almost certainly true—there will be a material impact. To us, that suggests a need for larger companies to quickly develop or acquire these new technologies or at least forge partnerships with the most advanced players so they can prevail in contract proposals. This is looking like an industry sector where those that

NEAR EARTH LLC
Satellite • Wireless • Aerospace

MobileNet has been acquired by ORBCOMM
Near Earth LLC acted as exclusive financial advisor to ORBCOMM
April 2013

MDA
MDA Space Structures, a business unit of MacDonald, Dettwiler and Associates has been acquired by Spacesystems Acquisition Co. LLC an affiliate of ADMIRALTY PARTNERS, INC
Near Earth LLC acted as exclusive financial advisor to MDA
December 2012

NAV CANADA invests up to $150 million in Aireon a subsidiary of iridium
Near Earth LLC acted as financial advisor to NAV CANADA
November 2012

SPACE SYSTEMS LORAL has been acquired by MDA for $875 million
Near Earth LLC provided extensive business and industry analysis to MDA
November 2012

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Senior level attention for every client
Foresight and advice from industry experts
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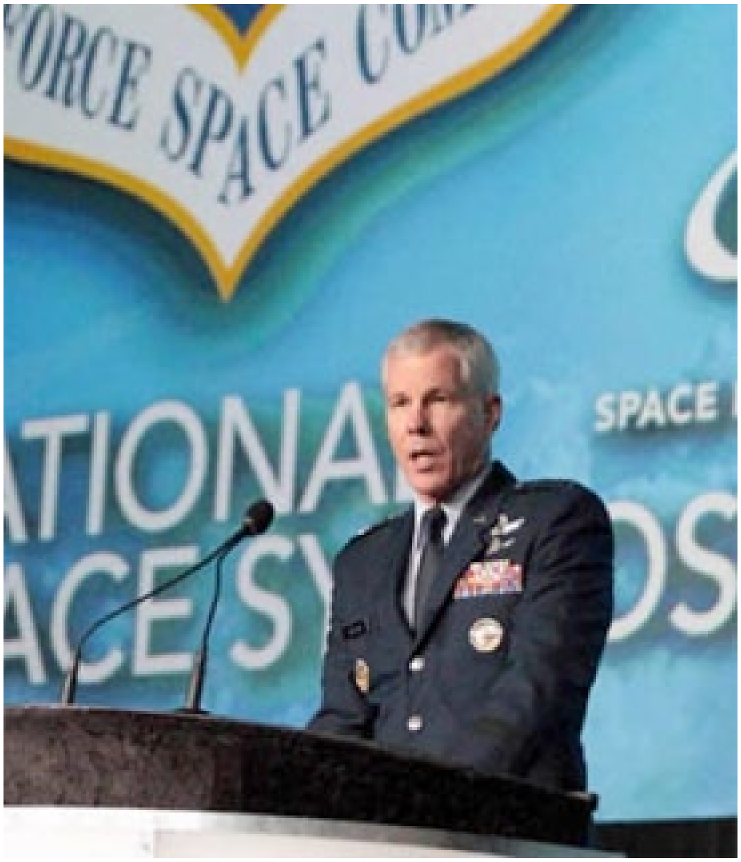


General Shelton, Commander of **Air Force Space Command,** ***presents his keynote speech at NSS. Photo courtesy of Space Foundation.***

develop a market lead will quickly move down the learning curve and up the efficiency curve and have a clear competitive advantage for years.

We also believe this move to innovative (small/clever), resilient and affordable suggests a need for rapid prototyping and rapid flight qualification. If it still takes 5 to 10 years to field a new capability, it will not be affordable or state-of-the art in performance. Luckily, "smaller" opens up several new options such as 3D printing of structures and some components, assembly line production, space environmental testing at ISS with return to Earth, and launch as ride shares, hosted payloads or in large clusters on a wide variety of new vehicles. Providers of these services and capabilities should do well in this new procurement realm.

What this may mean for those developing in-space servicing capabilities (*i.e.*, relocation, repair, maintenance, refueling) is less clear. We would suspect that, in the long term, a move to gaining resiliency through mission architecture will result in lower demand for such services as the value of any given unit of the space segment is less and therefore more "disposable," especially as technical obsolescence is assumed through shorter design lives. The business case for profitably servicing these smaller satellites just may not close.

On the other hand, the new strategy could also mean an enhanced desire to extend the lives of the current fleet of high value satellites since they may not get replaced under this new strategy. The near and medium term prospects for in-space servicing may therefore actually improve. In-space servicing may also evolve to mean in-space manufacturing through the assembly of larger structures from smaller units. We shall see.

Brigadier General Teague, Director, Strategic Plans, Programs and Analyses, Air Force Space Command, presenting at the Acquisition luncheon. Photo courtesy of Space Foundation.

Lastly, if there are going to be far more satellites in orbit then several other space disciplines and services should benefit:

- *Space situational awareness*
- *Mission planning and software (e.g.,* ***Analytical Graphics****)*
- *Telemetry, tracking and control (e.g.,* ***Universal Space Network****)*
- *Interference detection and avoidance (e.g.,* ***Glowlink****)*

Government 2.0

A key ingredient to the success of this new procurement strategy will be securing sufficient funding for the early stage development and deployment of smallsat technologies and systems. We have already seen strong interest from **DARPA** and NASA to support innovation, but dollar levels are still modest versus amounts required to field large constellations. There are a few attractive programs / contracts being bid, but also many competing teams and inevitably there will be lots of underfunded entities. Meanwhile, although many mid to large aerospace firms are dipping their toes into this market, they are rarely set up to act as venture capitalists or to acquire early stage, negative cash flow businesses.

Luckily for the sector, a few venture funds (*e.g.*, **Khosla Ventures**) are starting to focus on a new investment theme some in Silicon Valley are calling **Government 2.0**. Basically, there seems to be a growing belief among investors that government budgets will be strained for such a long time into the future, that Federal, State and local governments will all have to find new ways to use innovation to lower the cost to taxpayers of the services they provide—not fewer services, but more affordable delivery.

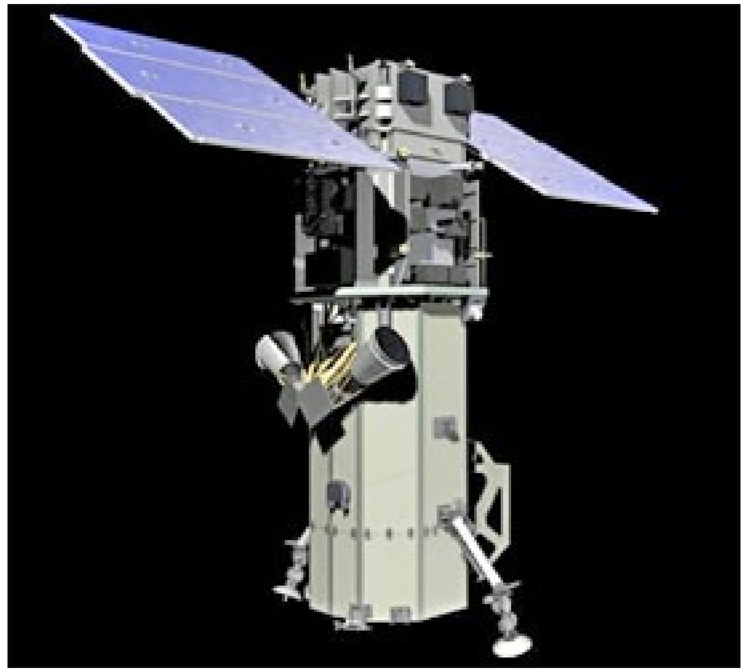
Artistic rendition of the Phantom Phoenix smallsat.
Courtesy of Boeing.

This belief is starting to attract money from investors previously very shy about risking capital on government-dependent businesses either because governments have proven to be fickle customers, or expected growth opportunities have been uninspiring. Now, they see an entire multi-trillion dollar ecosystem that needs rebuilding and lots of opportunity to bring commercial best practices to bear.

Unfortunately, in many cases, more than $100 million will be required to get a constellation into orbit. Venture funds are frequently good for tens of millions and can join forces for larger amounts, but are much less willing to hit nine figure territory, especially if the total amount required begins with a numeral greater than "**1**".

From where will these larger amounts come? It is unlikely the public equity market or private equity firms will back these ventures unless there are large and stable government contracts to support the investments or a multi-year successful track record of commercial revenue growth and profitability. That may eventually develop once these new technologies have proven their worth, but for the next few years we suspect most of the large dollars will need to flow from government to the innovators and often through trusted prime contractors.

This dynamic may create an interesting balance of power between those with the long standing government relationships and those with the new business models and technologies. As power never likes to be in balance, we suspect there will be two outcomes. Those companies with applications relying solely or heavily on the government customer to reach break-even will most likely end up partnering with the primes as subcontractors or being acquired by the more commercially minded and nimble aerospace firms. These companies will tend to either sell dedicated systems to the government or own and operate systems under strong government anchor tenancy.



Artistic rendition of the LM900 satellie bus.
Courtesy of Lockheed Martin.

On the other hand, companies focused on applications with strong commercial, international or consumer demand may be able to break out on their own and eventually acquire government contracts directly. The determining factors will be the mix of business and the business plans scalability. The good thing about "small" is it tends to be scalable. The bad thing about "small" is the size of the market is not yet proven.

If the innovation is powerful enough and the markets do develop, this age of Innovation, Resiliency and Affordability—may actually happen. As a tax payer, that sounds pretty good. As a supporter of American innovators and entrepreneurs, it sounds even better.

About the author
Mr. Davidson is the founder and Managing Partner of Near Earth LLC. Previously, he was a Managing Director in the Telecomm Group at Credit Suisse First Boston. Mr. Davidson's investment banking career began in 1987 as an associate and one of only approximately 100 bankers at Donaldson, Lufkin & Jenrette. He was part of the phenomenal growth and success of DLJ to over 1,000 bankers by the time of its acquisition by CSFB in 2000. At DLJ, Hoyt Davidson was a co-founder of the firm's Space Finance Group, Wall Street's first dedicated industry coverage group for the satellite industry.

Conference Roundup: NSS Retrospective

by Steve Eisenhart, Sr. V.P., Space Foundation

The face of the *Space Symposium* has changed. I think those of you who joined us here in Colorado Springs would agree. We still had lots of U.S. Air Force generals on the agenda and strong support from U.S. Army space warfighters. But this year, the face of the Space Symposium was increasingly international... on the program stage, in the exhibit center, and in the private meetings.

We all know who didn't attend and why. And we've already heard from them about how they regret they couldn't travel, and how they plan to be back next year. But we really should take a look at who was here.

International participation in the Space Symposium is not new. We've had international speakers and delegations for a number of years. What was striking, though, was the value our guests from abroad place on attending, and the very significant effort and investment they made to participate.

Steve Eisenhart, Space Foundation

For example, *Romain Bausch*, president and CEO of **SES**, who flew on consecutive nights from and to Luxembourg to join us and deliver keynote remarks. Similar for *Jean-Jacques Dordain*, the director-general of **ESA**, who made time in a crowded travel schedule to join other officials on our panel of **Space Agency Leaders** (which this year included exclusively global partners).

The extraordinary effort of Dr. *Yasushi Horikawa*, the chairman of the **United Nations Committee on the Peaceful**

Space Agency Leaders Panel was comprised of (left to right): Jean-Jacques Dordain, director general, ESA; Hideshi Kozawe, executive advisor to the president for international cooperation and new business, JAXA; panel moderator Yasushi Horkawa, Ph.D., chairman, UN Committee on the Peaceful Uses of Outer Space; Ger Nieuwpoort, Ph.D., director, Netherlands Space Office; Johann-Dietrich Woerner, chairman of the executive board, German Aerospace Agency (DLR).
Photo courtesy of Space Foundation.

Space Generation Advisory Council Fusion Forum Manager Stephen C. Ringler and Executive Director Andrea Jaime Albalat report on the 2013 Fusion Forum that took place just prior to the National Space Symposium event.
Photo courtesy of Space Foundation

Former NASA astronaut Buzz Aldrin and Space Foundation Vice Chairman Lon Levin were in attendance at the General James E. Hill Lifetime Space Achievement Award luncheon
Photo courtesy of Space Foundation

Uses of Outer Space who made special arrangements to depart UN meetings in Vienna to moderate a Space Symposium panel, was deeply appreciated.

Despite the on-going transition of leadership within the **Japan Aerospace Exploration Agency** (**JAXA**), we were pleased to welcome back the executive director of the agency, Mr. *Hideshi Kozawa*.

While many of the global attendees come to hear the latest from the American presenters and meet with U.S. companies, that isn't always the case. We received four Japanese industry registrations as we were heading on site, specifically for them to be in Colorado to hear the presentation on Japan's new space policy by Mr. *Tomotaka Inoue*.

JAXA and its Japanese industry partners increased the size of their exhibit over the previous year and have already indicated they intend to increase even more next year.

The robust Japanese delegation was matched by the most significant German delegation, headed by Professor *Johann-Dietrich Worner*. The German delegation was with us throughout the week for a number of on- and off-agenda activities, including the inaugural meeting of the **U.S.-German Aerospace Roundtable**, a gathering of interested parties intending to foster better understanding of programs and capabilities and trans-Atlantic collaboration. We were honored to host a significant German military delegation headed by Brig. Gen. *Christian Badia*.

The importance of the Space Symposium as an international forum was also recognized by the presence of State Department representatives, and the participation of Deputy Assistant Secretary of State *Frank Rose*.

The face of the Space Symposium is also younger. For several years, the Space Foundation has conducted special *New Generation Initiatives*, focusing on young space professionals who are now a vital part of the Space Symposium.

The Space Foundation's program is complemented by the *Space Generation Advisory Council*'s (**SGAC**) **Fusion Forum**. We were again proud to be the host organization for the annual Fusion Forum, which brings together top young professionals from around the world for two days of speakers and panels before the formal start of the Space Symposium. In 2014, we look forward to hosting the 3rd Annual Fusion Forum and working with the SGAC again next May.

However, of all the faces at this year's Space Symposium, perhaps none is more memorable or illustrative than that of the young Vietnamese space student sitting in the front row during the panel of **Space Agency Leaders**. While intently listening to the speakers, he made room in the open seat next to him for a gentleman who sat down. As he glanced toward the man, the look of awe when he realized it was none other than *Buzz Aldrin* was priceless.

Yes, the face of the Space Symposium has changed. In fact, we will no longer call the event the National Space Symposium, better reflecting the global nature of our event and our industry. We look forward to seeing you at the **30th Space Symposium** as it is again the center of the space world.

About the author

Eisenhart leads the strategic integration of the public, policy and international affairs of the Space Foundation. He supervises the Space Foundation's Washington, D.C., office, which handles: government affairs and research and analysis efforts; relationships with government agencies, other space advocacy organizations and associations; and corporate interests. Eisenhart is principally responsible for the Space Foundation's global strategy and relationships with international space agencies and organizations, foreign embassies and U.S. organizations involved with international space programs. He is directly responsible for the program development and integration of key Space Foundation activities including the widely acclaimed Space Symposium. Since joining the Space Foundation in 1996, Eisenhart has had a broad range of responsibilities, serving as senior vice president of strategic communications, director of communications and public affairs and communications manager. Eisenhart was a military public affairs official and is a graduate of the United States Military Academy at West Point.

P-SATCOM Is Affordable

By Jude Panetta, V.P. Government Solutions Group, TeleCommunication Systems (TCS)

Arguably, during no time in the history of the U.S. military has the issue of cost consideration been as critical as it is now.

"*Do more with less*" is no longer a catchphrase; it is the "new normal." The military is pushing private industry to develop and produce new technologies —using their own research and development funds—faster and more affordably.

Concurrent with this trend is the fact that the military is becoming more and more dependent upon the latest technology, including telecommunications. Their equipment must be able to handle voice as well as video and data. In addition, as the military must be as mobile as possible in order to meet the nature of today's conflicts, their equipment satisfies such requirements.

As technology becomes more ubiquitous, so does the ability of once technologically unsophisticated adversaries to adapt and use methods such as jamming to cause havoc and destruction. A jammed frequency now has the potential to create as much destruction as a bomb. The reality is that commercially available terminals can successfully jam L-, C-, Ku-, X- and Ka-bands—these terminals are challenged to detect, locate and destroy. Countries such as Iran and North Korea have already revealed that they can quite successfully jam frequencies.

When recognizing such debilitating factors, what do you have? In the eyes of the U.S. military, you have an urgent need for communications equipment that is reliable, secure, easily transportable—and affordable. Even though using protected ***Advanced Extremely High Frequency*** (**AEHF**) satellites, which provide the capability to operate in adverse conditions, existing terminals that support the technology are not widely available, due to their size and cost. The military realized they had an unacceptable deficiency in affordable *Protected Communications-On-The-Move* (**P-COTM**) equipment and capabilities.

A solution was driven by **Lockheed Martin** and **Northrop Grumman**—the companies initiated research and development efforts on a P-COTM solution. After three years (half the time of development cycles for fielded ***Milstar***- and AEHF-compatible terminals) they created a baseline terminal that is interoperable with the satellite systems currently in orbit.

The P-COTM solution is tactically rugged, complete with a low-profile vehicle antenna. Affordability is achieved by leveraging existing designs, technology and government and commercial investments, all the while implementing commercial best practices for product production and procurement.

The hardware and software are extensible to other form factor terminals, such as small, fixed terminals that can be packed in transit cases, shipboard terminals for small deck ships, and low-cost airborne terminals for *unmanned aerial vehicles* (UAVs) and piloted aircraft.

However, having a superior protected terminal was not enough. Lockheed Martin and Northrop Grumman needed a partner that possessed deep experience with highly secure, deployable satellite communications systems in order to create a complete solution. The companies partnered with **TeleCommunication Systems, Inc**. (**TCS**), a company with more than 25 years of experience as a trusted provider of communication technology solutions. The goal for TCS was to solve the government's toughest technical challenges, under conditions that demand the highest level of reliability, availability and security.

TCS created a **Protected SIPR/NIPR Access Point** (**P-SNAP**) terminal, which incorporates **SNAP** and **P-COTM** components. The P-SNAP system is significantly smaller and lighter than currently available protected communication alternatives; the complete terminal system is packaged in three transit cases and two people can easily set the system up within 30 minutes. P-SNAP is designed to support modular quick-change feeds and upgrade kits to provide backward compatibility for traditional SNAP operations in Ku- and Ka-bands.

Protected Communications-On-The-Move

The resulting combination of P-COTM and P-SNAP forms the **Low Cost Terminal** (**LCT**) solution, which takes advantage of Lockheed Martin's and Northrop Grumman's proven knowledge and engineering experience in protected military SATCOM through Milstar and AEHF anti-jam satellites. The LCT builds on TCS' highly secure, deployable satellite communication systems and is based on a modular architecture with plug-and-play interfaces and integrated logistics support. LCT combines the P-COTM and P-SNAP terminals to provide highly affordable, protected communications on the move and at the halt.

The LCT solution addresses the military's need for technologies and systems to enable secure communications for tactical warfighters in contested environments. The LCT provides secure, assured, protected networks with anti-jam, *low probability of interception* (**LPI**)/*low probability of detection* (**LPD**) communications and resistance to cyber attacks.

As the next generation of AEHF satellites launch, the LCT solution will allow warfighters to quickly and affordably take full advantage of the satellites' improved capabilities and expanded capacity. The LCT offerings are designed to work cooperatively with existing systems and also possess the flexibility to accommodate future network architectures with minimal software/firmware upgrades.

With the more affordable LCT solution, *protected satellite communications* (**P-SATCOM**) will become a viable option for tactical warfighters in the next few of years. No other existing or developing terminals provide P-SATCOM for the tactical warfighter at similar price points or timetables. The LCT solution at full production levels is priced at one-tenth the price of fielded *Extremely High Frequency* (**EHF**) terminals.

With the battlefield continuing to become more and more digital in nature, technologies such as LCT have become entirely feasible and ensure that our military will be able to use the latest communications technologies that will save lives as well as ensure mission success.

Additional information is available at...
http://www.telecomsys.com/products/deployable-coms/lctsolution.aspx

About the author

As Vice President of Strategy & Product Development for TeleCommunication Systems' Government Solutions Group, Jude Panetta oversees operations, supply chain management, engineering and product development. His other responsibilities include technology roadmap design, program and product line management and supplier and customer relations.

Mr. Panetta brings 23 years of experience in managing manufacturing and engineering operations and product-based businesses. His experience ranges from electromechanical equipment to advanced telecommunications and satellite technologies. Most recently, he contracted as an operations specialist, market strategist and financial analyst for a range of enterprises. In these roles, Mr. Panetta managed diligence processes related to operations, marketing and engineering and devised product development strategies. Prior to his work as an independent contractor, Mr. Panetta served as president and CEO of ASC Signal Corporation and held senior positions at Andrew Corporation, Celiant and Adtran, Inc.

He is a graduate of GE's Manufacturing Management Program and holds a bachelor's degree in mechanical engineering from the University of Virginia.