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MilsatMagazine

MILSATCOM

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MEETING DEMANDING KA-BAND REQUIREMENTS

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A SPATIAL ROUTER

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NETWORK MANAGEMENT, THE NEXT STEP

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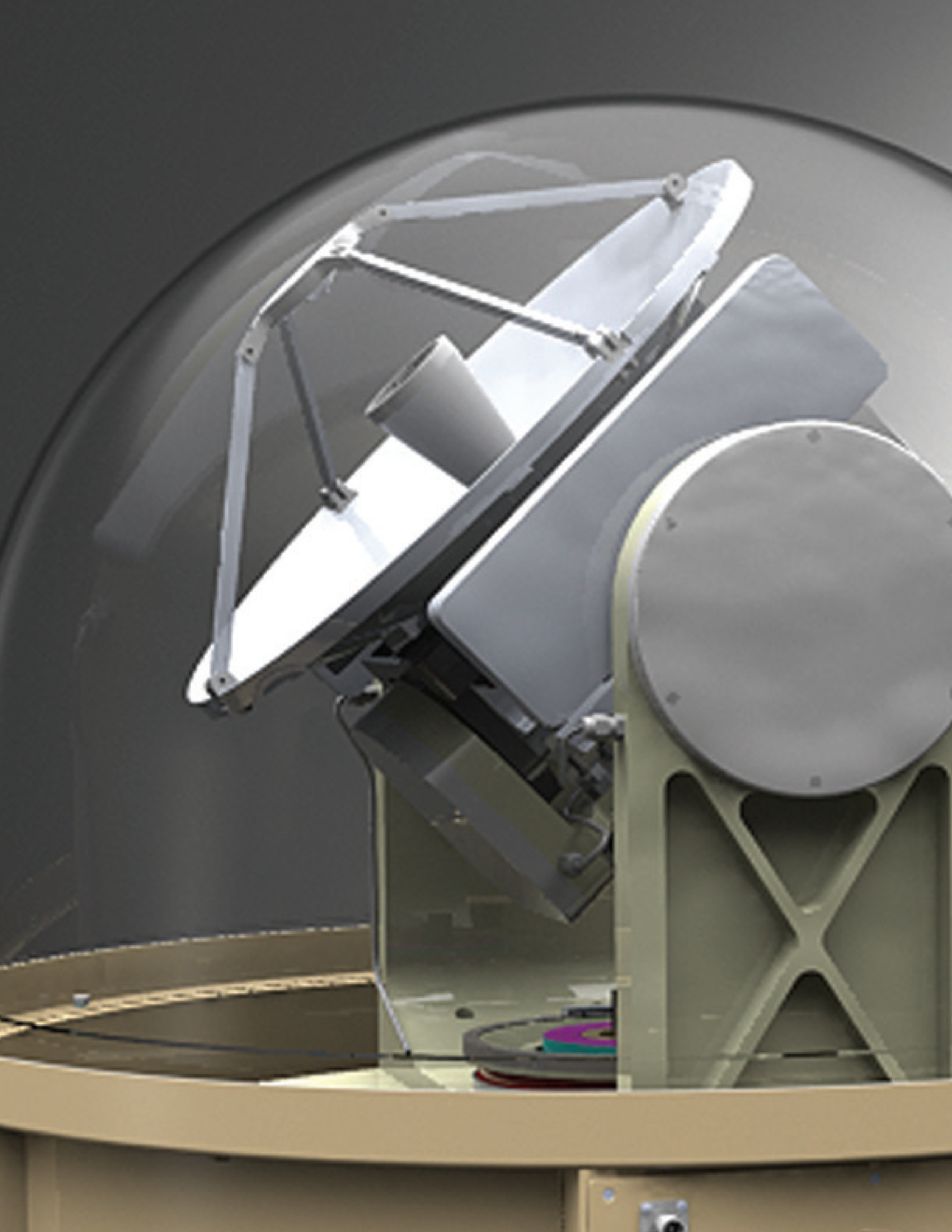


COTM CHALLENGES

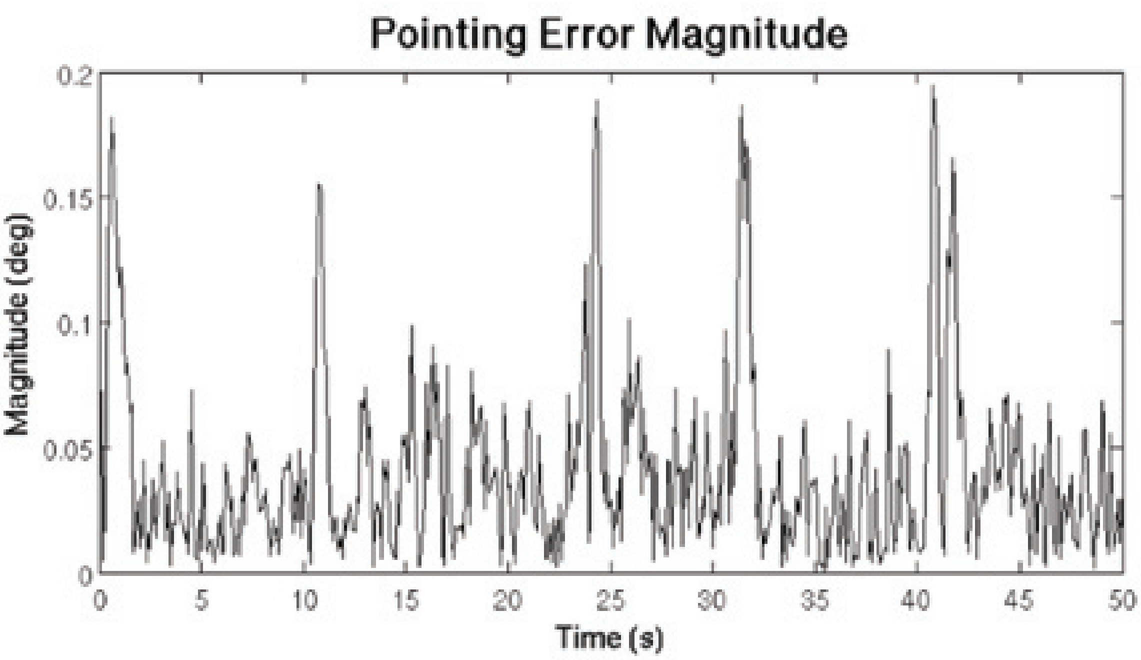
Peter Woodhead

There are many X-band and Ku-band satellite tracking antennas for On-The-Move (OTM) applications, but only a few products have been developed for Ka-band. With the deployment of the Wideband Gapfiller Satellites (WGS) the demand for OTM Terminals at Ka-band will increase.

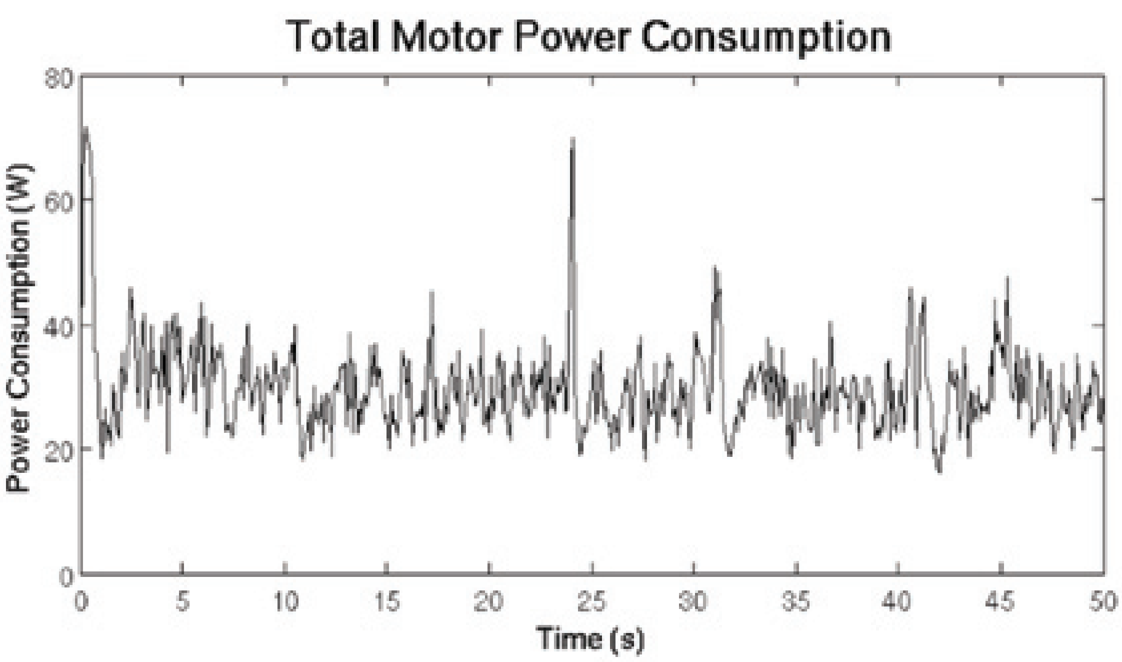
EM Solutions is currently developing a Ka-band On-The-Move Satellite Communications System under *Australia's Defence Capability & Technology Demonstrator* (**CTD**) Program. The CTD program is designed to investigate and demonstrate technology, and EM Solutions has taken the opportunity to explore a number of innovations to determine the performance thresholds for a Ka-band OTM Antenna system. Some of the challenges in working at Ka-band are presented in this article.

Mechanical Design to Physical Control System Modelling

Design simulation tools today will import mechanical designs, created using a 3-D CAD package, into a physical model of the control-system. This modelling extracts mass and inertia properties, joint locations and the physical appearance. EM Solutions used ***SolidWorks*** and ***CosmosWorks*** for mechanical design, and ***Simulink*** and ***Matlab*** (MathWorks products) to create mechanical and system control models. This provided a design platform to optimize and update the system.



The entire antenna control system was incorporated into the model including non-linear effects such as noise and bearing friction to make an accurate physical model. The design process was iterative where the model was updated to match measurements made on constructed jigs.



Recorded data (real or simulated) can be fed into a system model in order to verify performance. EM Solutions used recorded vehicle motion data from a test vehicle (Bushmaster) in the system simulation model. Typical simulation inputs included limits up to: 65 degrees per sec for velocity; 300 degree per sec2 for acceleration; and 10Hz frequency response. Simulations allow the control loop design to be optimized. The following image shows plots of the pointing error magnitude and motor power consumption of a Ka-band tracking antenna simulation model.

Antenna Tracking Mount

Motors/Amplifiers combinations need to be optimized as part of the control loop design. This process involves sending test waveforms through each motor in order to characterise the motor response to various inputs. Modifications to the amplifier circuit may be required to meet design control loop parameters of the tracking mount.

Encoders are required as part of the motor drive circuit and to determine axis position. There are two options for rotary encoders — absolute and incremental. Absolute encoders have the advantage that they provide axis position at any instant without needing to move the axis. The drawback is that absolute encoders are more complicated and they are mostly optical, which may not be robust enough for certain applications. Incremental encoders need to have some sort of homing (e.g. a limit switch or another encoder head) in order to determine the absolute axis position. In addition the control system will generally integrate the pulses coming from the encoder to determine the absolute axis position. Noise which causes pulses to be missed or add will gradually deteriorate the measured position and cause inaccuracies. There are also more options available for incremental encoders compared to absolute, including magnetic and inductive forms.

Physical Effects — Friction and Balance

Friction causes the tracking mount to lose its pointing angle during vehicle motion, so the motors must apply torque to overcome the friction. High friction within the motor and bearings result in the motors having to use more power to overcome the friction. Having some friction in the bearings/motors however does alleviate power consumption as the motors needed to compensate for any out of balance effects and friction will tend to hold the mount still.

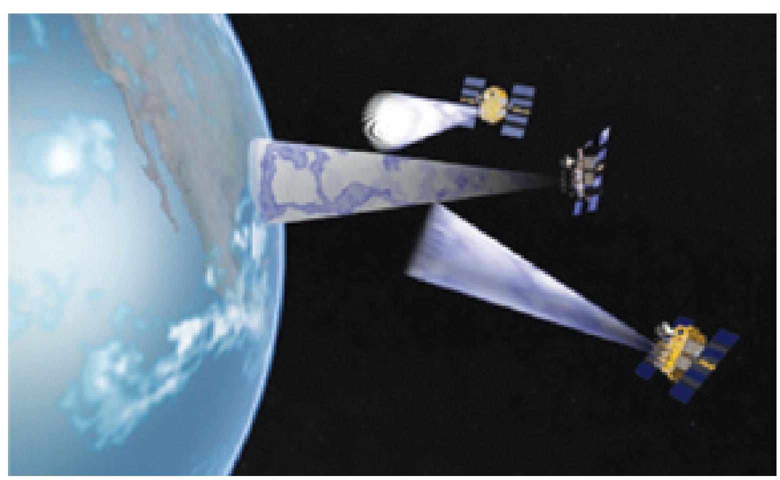
Balance is a critical factor in tracking mount design, as having a balanced system (ie the axes sit on the centers of mass) may aid in reducing power consumption and increase system performance. In an unbalanced mount linear acceleration of the vehicle will translate into rotational motion about axes, so the motors must consume power in order to maintain the desired pointing angle. The more balanced the mount the less this effect occurs.

Keyhole Effect

A problem within satellite tracking mounts is keyhole effect, which occurs when the mount is required to track a satellite at an elevation angles approaching 90 degrees from its base (referred to as looking up). This results in a blind region where the antenna is unable to see the satellite. In this region the tracking system needs to rely on non-closed-loop tracking (e.g. gyros and navigation system) to achieve an optimal position when the antenna is once again able to track the satellite. This blind region may also result in a large movement of the azimuth axis during the reaquisition process.

For example, an ***Azimuth and Elevation*** (**Az-El)** type tracking mount will be the worst case when looking at 90 degrees elevation (straight up). Pointing errors can be considered to have two components: magnitude and direction. When the Az-El tracking mount is facing straight up, the magnitude will be the amount the elevation axis needs to move, and the direction is how much the base will have to move. At high elevation angles where key-hole effects occur, the azimuth axis may need to track to a direction which could be anything in a +/- 180 degree range.

In a purely mechanical tracking platform, the most straight forward way to prevent the keyhole effect is to increase the vertical profile of the antenna mount to allow it to face straight up. However in some applications this extra vertical height may be unacceptable. In these applications there are more complicated approaches which include: additional axis; or some mechanical deflection of the beam will need to be considered.



A possible method for countering this effect is to add another axis to the system which is mounted at 90 degrees to the primary elevation axis. This axis may only need limited angular movement to reduce load on the azimuth axis when the mount is pointing at high elevation angles. The two elevation axes track out pointing errors, while the base is able to move to an optimal position. Tracking control loops will need sufficient bandwidth on the azimuth axis so it is able to move to a new optimal position before the angle limit on the elevation axes are reached. Adding a second elevation axis will increase the cost and height of the terminal as more mechanical and control system design is required, however it may result in power savings and less wear on the azimuth axis.

Need For Closed-Loop

Ka-band SOTM operation imposes quite stringent constraints on pointing-error control. These constraints are due to a combination of regulatory and link-budget considerations. While the actual pointing-error requirement for a SOTM terminal will depend on a number of parameters, it is likely to be of the order of hundreds of milli-degrees.

Achieving this pointing accuracy would be very difficult with an open-loop tracking system that relies solely on inertial measurement systems to steer the antenna. Therefore, it is sensible to consider using a closed-loop tracking system that employs some means of directly measuring the pointing-error.

There are many well known methods for estimating pointing-error. These include:

- *Mechanical scanning*
- *Monopulse*
- *Phased array (scanning and multi-beam)*

All of these approaches would normally rely on the use of a beacon on the satellite.

Mechanical Scan

A conventional reflector antenna can be mechanically scanned to estimate the pointing-error. Examples of this approach are conical scan and step-track. Mechanical scanning has two main disadvantages: it requires introducing a deliberate pointing-error, which can reduce the link budget; and it requires rapid mechanical motion so that pointing-error can be tracked during motion of the vehicle.

Monopulse

Monopulse systems are able to estimate the pointing-error without any mechanical scanning and without needing to deliberately miss-point. Monopulse antennas generally have two feeds: one feed has a normal antenna pattern, while the other has a pattern with a sharp notch along bore-sight. By comparing the signals from the two feeds, the magnitude and direction of the pointing-error can be determined. While the monopulse is an attractive solution to the problem of determining the pointing-error, it still has a number of disadvantages. Monopulse feeds are generally mechanically complex and so tend to be physically large, making it difficult to integrate one into a SOTM terminal. They also require at least two phase matched downconversion chains.

Phased Arrays

Phased arrays have many features that would be beneficial for SOTM. For example, the beam could be steered rapidly (the so called “inertia-less beam”), which would enable use of a high speed scan to estimate the pointing-error. Alternatively, a multi-beam phased array could be configured to operate in a monopulse mode.

Unfortunately, phased array operation at Ka-band presents many technical difficulties. In particular, it is very difficult to share the physical aperture between transmit and receive because of the large frequency separation between the bands. This means the phased array antenna must be nearly twice the size of a conventional reflector, if it is to achieve the same gain.

Other challenges are also introduced by use of a phased array. For example: ensuring that transmit and receive beams point in the same direction; and proving that regulatory requirements, such as antenna sidelobes, are satisfied for all possible pointing angles.The technical challenges of phase array operation at K-band make the conventional reflector antenna a more attractive solution.

Noise And Pointing-Error Estimation

Thermal noise from the antenna and LNA will cause noise on the estimated pointing-error, no matter which of the pointing-error estimations techniques are adopted. Noise on the pointing-error estimate will induce real pointing-errors. The antenna control loops treat the noise as a real pointing-error and will try to track it out, thus inducing a real pointing-error. The antenna control loops can only track the noise at frequencies up to their loop bandwidths. Therefore, they are effectively a low-pass-filter on the noise.

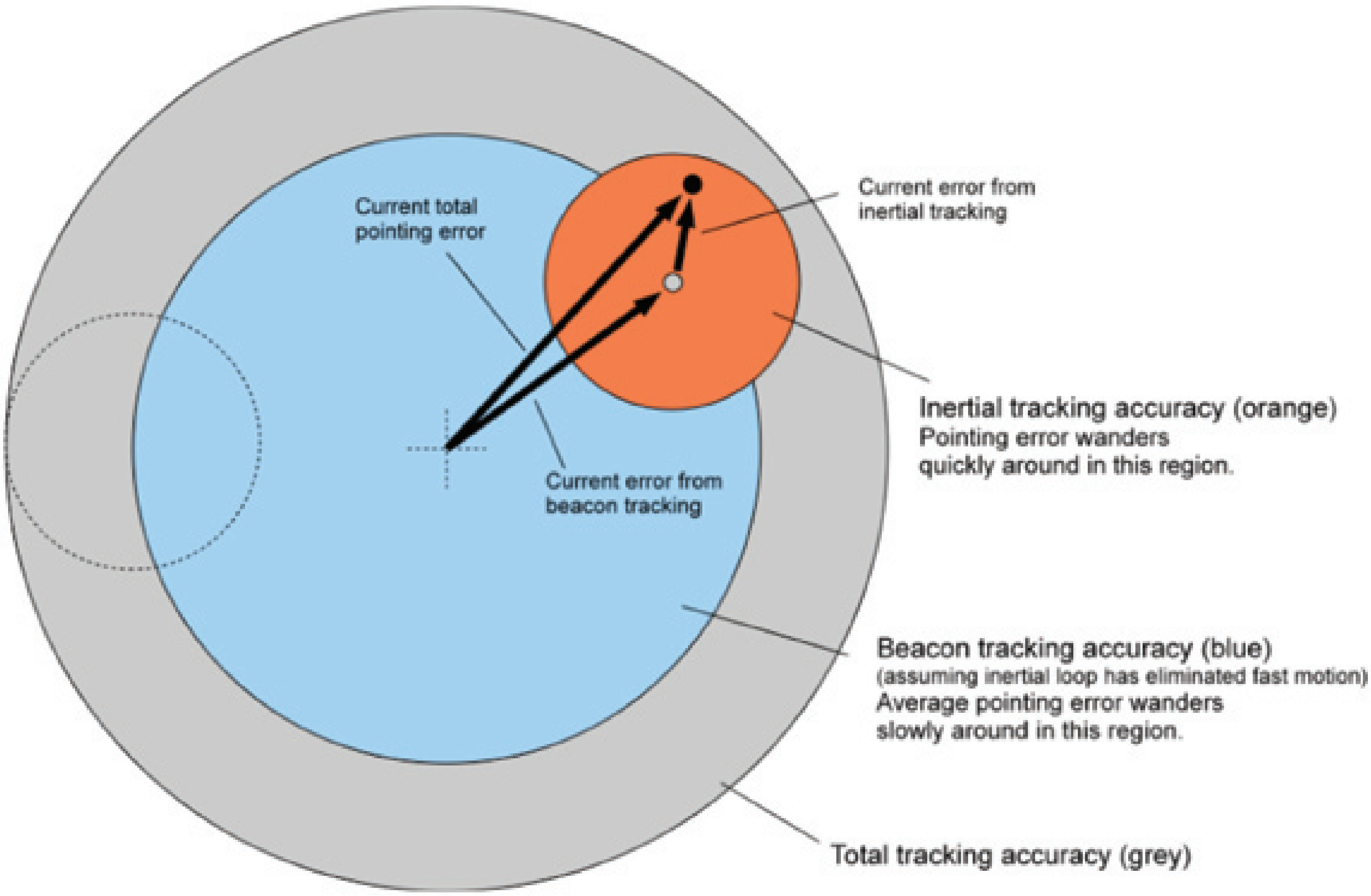
Filtering of the beacon signal is still normally required because; in general there will be a carrier-to-noise threshold at which pointing-error estimation will fail completely. Choosing the filter's bandwidth is a compromise. It must be narrow enough to reduce noise to a tolerable level, yet it must not be so narrow that it upsets the stability of the antenna control loop. The actual bandwidth required is a function of many system parameters, but values are likely to range from hundreds of Hertz to a few kilo-Hertz.

Actual pointing error induced by noise on the output of the beacon signal processing is only one part of the total pointing error budget. Control systems generally also use gyros to correct for higher frequency motion.

The following diagram illustrates how beacon noise, and gyro inaccuracies are combined to result in the total pointing error.

Doppler Shift And Frequency Offsets

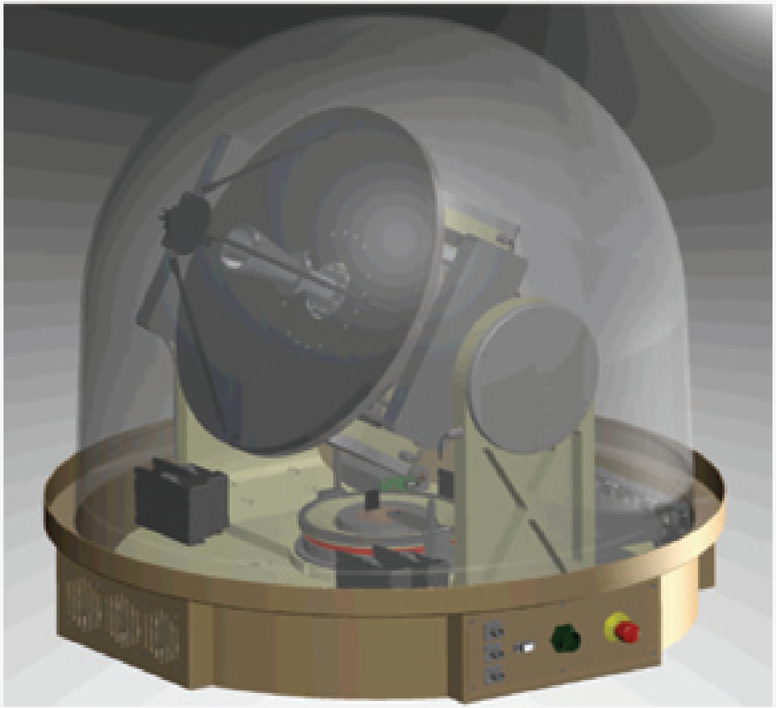
Uncertainty in the beacon frequency is quite large. This is due to drift in the satellite's LOs and Doppler shifts caused by vehicle motion. The frequency offset can be several hundred kilo-Hertz, and the Doppler shift can change at a few kilo-Hertz per second as the vehicle maneuvers. These frequency offsets exceed the filter bandwidth typically required in pointing-error estimation. This means that some form of tracking filter is required.



A conventional ***Phase-Lock-Loop*** (**PLL**) based tracking filter could be used to follow the wandering beacon signal. However, a ***Fast Fourier Transform*** (**FFT**) based approach is possible if the pointing-error calculation algorithm is relatively tolerant to small frequency offsets. With either approach, a balance must be reached between the speed, and accuracy of the filter's frequency tracking.

Summary

This article has covered some of the more challenging aspects of designing for ***Ka-band On-The-Move Satellite Communications Systems*** considered by **EM Solutions** within its CTD Project. At the completion of the CTD Project the **Australian Defence Force** expects to be better informed about potential performance and applications, and technical risks associated with possible future implementation of Ka-band OTM terminals.



The Ka-band On-The-Move Satellite Communications Antenna Terminal being developed for the ADF by EM Solutions

About EM Solutions

EM Solutions is a technology provider to commercial and military customers in the telecommunications sector. EM Solutions is a market leader in the supply of Ka-band products to defence and enterprise customers. Their products include LNBs, BUCs and SSPAs, and Fixed Point-to-Multipoint radios based on the WiMAX IEEE 802.16d standard.

Image credits
Page 8 — Satellite Tracking of People LLC
All other images courtesy of EM Solutions

WE'VE COME A LONG WAY TO GET TO PCMA

A principal objective of recent U.S. Department of Defense telecommunication transmission policy is to simplify its integrated wireless networks. To reach that objective, DoD policy includes a reduction in the number of available wireless waveforms and corresponding network hardware.

The objective is to field fewer types of wireless network devices, while providing improved network interoperability to accommodate the emergence of Internet Protocol (IP) as a connectivity standard.

At the same time, the Department of Defense wants to continue to encourage innovation. Interoperability does not mean that SATCOM users should be faced with only a plain vanilla set of choices for their networking, rather that those choices should meet an underlying ability to interoperate with other similar network devices.

A number of features and choices remain when considering wireless networking equipment like the satellite communications modems that form the backbone of many wireless networks. There is no “one size fits all” modem, as many networks require features that may be advantageous to one operating environment, but are inefficient or detrimental to another. However within common networks, interoperability with efficiency is the goal.

MIL-STD-188-165B

A new element of ***DoD Frequency Division Multiple Access*** (**FDMA**) modem policy is the creation of **MIL-STD-188-165B**, which includes new, more-efficient operating modes. Though this new standard is often thought of as catching the military up to commercial standards and technology, the new -165B standard is actually enhanced beyond pure commercial technology.

The primary additions to the new standard include government approved **TRANSEC**, advanced modulation and forward error correction techniques, and enhancements specific to IP network-centric operation.

The MD-1366 EBEM

To implement this new standard for high-speed, high-performance, flexibility, and interoperability, the U.S. Department of Defense and its coalition defense partners have selected the **ViaSat *MD-1366 EBEM***, the only modem certified to the MIL-STD-188-165B standard. This *Single Channel Per Carrier* (**SCPC**) SATCOM modem incorporates the latest technology in advanced modulation and coding, while providing backwards interoperability with the majority of SCPC modems in the government inventory. The U.S. and coalition partners

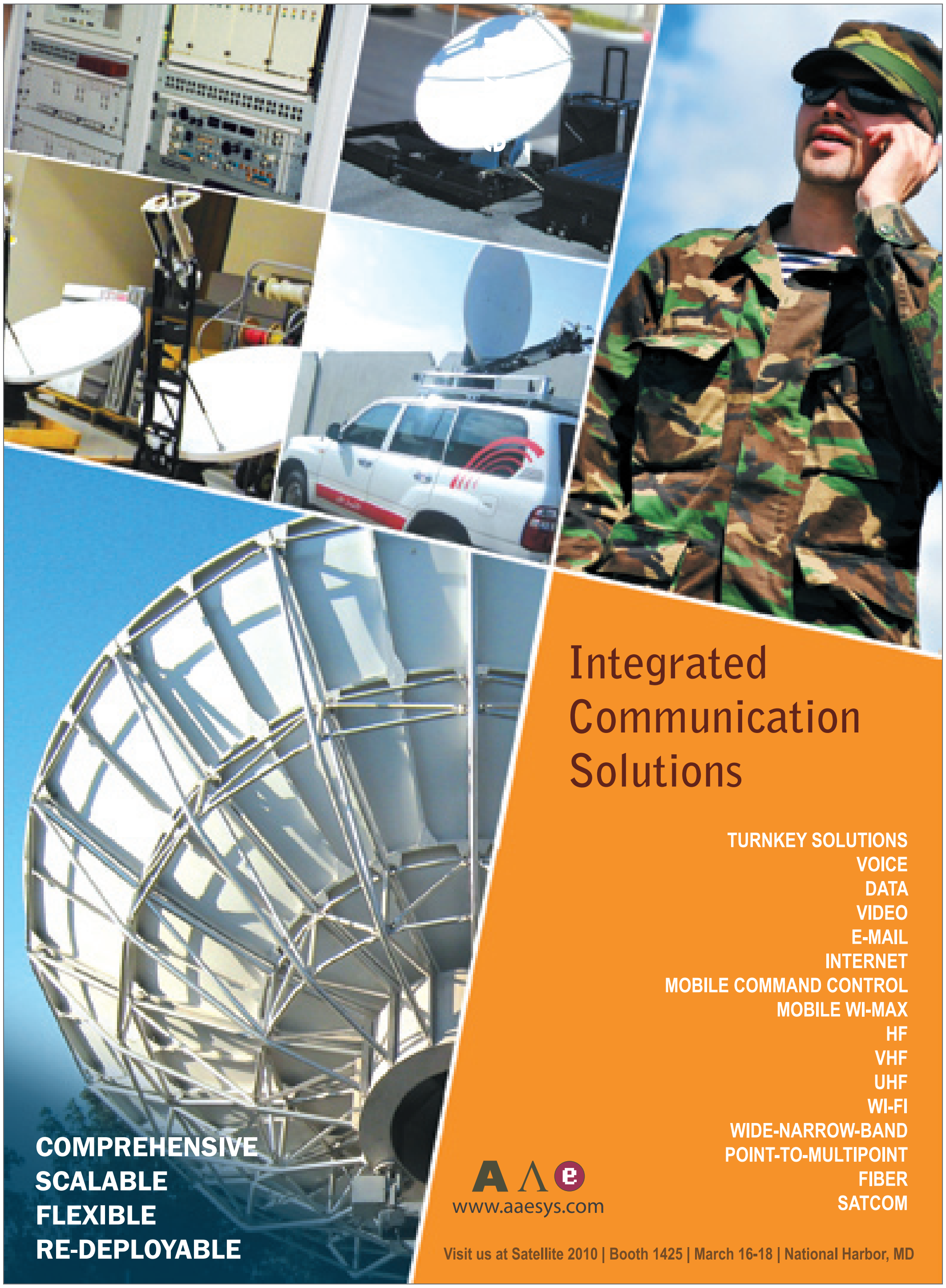
The ViaSat MD-1366 EBEM, the only modem certified to the MIL-STD-188-165B standard

adoption of the -165B standard waveform has made the MD-1366 EBEM the most widely used FDMA modem for government applications and networks since the OM-73.

The bottom line advantage of the MD-1366 efficiency is that more carriers can be placed on a single satellite transponder and those carriers can be better utilized, enabling more warfighters to gain access to more data when and where they need it. A few key improvements over MIL-STD-188-165A modems create this additional efficiency:

- ***Increased symbol rates to 60 Msps providing single carrier data rates up to 155 Mbps.***
- ***Open-standard interoperable Turbo codes***
- ***Advanced modulation techniques including 8-PSK and 16-APSK***
- ***Information Throughput Adaptation***
- **Radio Aware Routing**

The main advantage of turbo coding is that it reduces the Eb/No needed to close a link at a given code rate. Known turbo codes at reasonable block size and complexity can come quite close to the Shannon channel capacity limit (within about 1 to 2 dB).



For instance, an R=1/3 turbo code can achieve a BER of about 1 in 10-7 at an Eb/No = 1 dB with a block size of less than 2000 bits. Reducing the code rate to R=1/4 would reduce the Eb/No required to about 0.7 dB. Providing an open standard for this enhanced forward error correction technique means that efficiency and interoperability can finally coexist.

Demonstrations of the modem have shown the value of the new modulation and coding choices. In one, the MD-1366 EBEM, (operating at 16-APSK R=7/8), achieved 205 Mbps total capacity on a single XTAR transponder, the highest capacity ever achieved on a 72 MHz X-band transponder. EBEM also operates on C-, Ku-, and Ka-band transponders, including certification for the new WGS satellites.

ESEM = True Modem Pair Compatibility

When it comes to satellite modem interoperability, it takes more than waveform commonality to ensure modem pair compatibility. Using different modems that have an open-standard waveform, but proprietary baseband interfaces is just as ineffective as using two different proprietary modems.

The presence of an Ethernet interface to deliver IP data over a wireless network also does not necessarily mean that heterogeneous modems are compatible. The manner in which a satellite modem converts digital data to analog signals for delivery over the air and then retranslates that data back to a digital format must be the same on each side of a satellite link.

To create true Ethernet compatibility between virtually any modem pair, the government created an open-standard option for the MD-1366, the *Ethernet Service Expansion Module* (**ESEM**). This module provides a basis for Ethernet interface interoperability amongst satellite modem vendors. Within the MD-1366 EBEM, it extends FDMA modem capability far beyond traditional fixed-channel operation.

Information Throughput Adaptation

What's the number one bandwidth-killing aspect of most SCPC modem links? It's link margin, thrown away in the name of contingency for harsh operating environments. *Information Throughput Adaptation* (**ITA**) is a way to keep that built-in safety margin, but use it for enhanced data throughput when that margin is not needed.

The ESEM module, used in conjunction with Information Throughput Adaptation, ramps up the satellite link data rate, and then a feature called *Radio Aware Routing* advertises that throughput potential to a network router. Together, the features maximize overall network throughput across the satellite link when little or no margin is needed.

If downlink power decreases, ITA then automatically and dynamically decreases the link data rate using more robust waveforms to maintain the link connection. During a demonstration, the EBEM has shown its seamless, error-free adaptation to data rates from 28 to over 155 Mbps without operator intervention.

These features allow users to make use of the many dBs of FDMA link margin that typically go unutilized in a fixed-channel rate environment. In traditional fixed-channel military satellite communication environments, where a 3-4 dB link margin is typical, these features can provide more than a 100 percent improvement in data throughput. The ESEM plug-in interface also enables the concurrent transmission of Internet Protocol (*IPv4 or IPv6*) Ethernet baseband traffic as well as non-IP data flows for maximum interoperability.

The EBEM with ESEM is certified for use over ***Defense Satellite Communication System*** and ***WGS*** satellites. Already, U.S. Army, Navy, Marine, and Air Force customers have recently ordered large quantities of MD-1366 modems equipped with the ESEM interface.

Beyond The MIL-STD

In the **CENTCOM AOR**s, soldiers are short more than 500 MHz of bandwidth, as compared to what they need for the most basic of communications. This type of shortage provides an ideal opportunity for the ability of the MD-1366 EBEM to close this gap. But while the MD-1366 EBEM performance gains and cost savings are impressive to be sure, the "bandwidth problem" that the military faces — as well as the constantly growing need for more of it — requires further innovation, consistent with the DoD desire to encourage performance beyond MIL-STD operation.

Bandwidth Re-Use — PCMA

Combining the uplink and downlink transmissions into the same bandwidth is another way to boost the capacity of satellite transponders. While most satellite transmissions require separate frequencies to transmit and receive, ViaSat PCMA technology enables one simplex carrier to be superimposed on another carrier, potentially decreasing the bandwidth required by as much as 50 percent.

The technology uses an adaptive self-interference cancellation technique to subtract the transmitted signal and recover the desired signal. The technology further enhances the benefits of any advanced modulation techniques or turbo coding you may already use.

However, it's important to keep in mind that frequency re-use techniques are icing on the bandwidth efficiency cake. They are appropriate only when certain conditions apply:

Link requirements

- ***Must use full-duplex circuits (symmetric or asymmetric)***
- ***Must be able to receive your own uplink signal (doesn't work with on-board processed, cross-strapped, cross-banded, or otherwise non-loopback transponders)***

Implementation considerations

- ***More power is required with the dual simplex frequency pair approach (~3dB total composite transponder power)***
- ***An implementation power loss exists (0.15 t0.5 dB depending on near/far ratio)***
- ***May need to change existing coding rates and modulation to take advantage of bandwidth reduction***

PCMA is best used to overcome *Power Equivalent Bandwidth* imbalances. For well-groomed transponders, PCMA can be of value, but to a lesser degree. Link budget analysis can determine feasibility, link configuration, and the possible overall savings of power and bandwidth with PCMA. Where PCMA does provide value, it's the closest thing to a free lunch in satellite communications today.

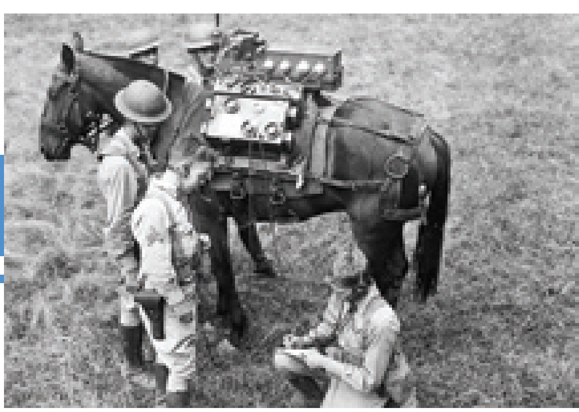
More Efficiency + Control

DoD efforts to simplify networking hardware and operation are not intended to be limiting to the overall capabilities of the network. Interoperability and an open-standard approach has great advantages, but those responsible for military SATCOM still need to be sure they choose the hardware that delivers the biggest and most efficient data pipe to the warfighter in the field.

The **MD-1366 EBEM/ESEM** with *Information Throughput Adaptation* and *Radio Aware Routing* features, as well as **PCMA** bandwidth re-use technologies, moves networks and users beyond the traditional "fixed channel data rate" environment of FDMA communications. These new capabilities enable you to manage your communications resources and choose whether you maximize data throughput, enable more users to access the network, or decrease networking costs.

About ViaSat

ViaSat produces satellite and digital communication products for fast, secure, and efficient communications to any location — satellite networks, antenna systems, wireless datalinks and terminals for combat situational awareness, information security for military networking, mobile IP networking for soldiers, communication microprocessor chipsets, application and communication acceleration, satellite network system design, communication simulation and training systems, and consumer satellite broadband services.



Amplification — Meeting Those Demanding Ka-band Requirements...

Stephen Turner

Historically there have existed far fewer choices for Ka-band amplifier products than their lower frequency counterparts. Factor in military grade Ka-band amplifiers and the selection becomes even more scarce. Paradise Datacom has released a new family of Ka-band LNAs and SSPAs that build upon their tradition of highly reliable SatCom amplifier products. These products are suitable for deployment in demanding military applications such as Wideband Gapfiller Satellite (WGS) terminals.

Ka-band LNAs

Paradise Datacom's Ka-band LNAs are optimized for best noise temperature performance in various subands. Currently available models cover the 18.3-20.2GHz and 20.0-21.0GHz bands. These LNAs are available with a low loss isolator to mask ripple in the noise temperature due to antenna feed and filter VSWR effects. Noise temperatures with an isolator are in the 140o to 160oK range. Noise temperatures without the front end isolator are in the 110oK to 130oK range. The Ka-band LNAs are fully equipped with transient and regulator protection as well as alarm circuitry.

The alarm circuitry allows the LNAs to be used in automatic switchover redundancy systems when used with the **RCP2-1100 Redundant Controller**. All of the Ka-band LNAs have 55dB minimum gain which buffers out any further noise degradation by the other components in the receive path. Third order intercepts are in excess of +16dBm allowing for superior dynamic range over the large fade range that exists in Ka-band satellite links.

Figure 1 — Paradise Datacom RF18/RF20 Series LNA

Ka-band SSPAs

Complementing Paradise Datacom's family of *Solid State Power Amplifiers* (**SSPAs**) are the new HPAKa series of Ka-band amplifiers.

The **HPAKa040AC** is a 40W saturated output power amplifier that covers the 30.0-31.0GHz band and produces a linear output power of 20-25W across the full WGS band. The amplifier is packaged in Paradise Datacom's *Compact Outdoor* amplifier chassis. The Compact Outdoor is one of the industry's most recognizable packages as it has been in production for over 10 years.

An industry standard, the Compact Outdoor amplifier is known for its ruggedness and high reliability as well as its ease of field maintenance. It is one of the industries only SSPAs that has been independent test lab certified to 50g shock and vibration making it a natural for transportable VSAT terminals.

The Compact Outdoor amplifier is available in a wide variety of frequency bands and power levels and has been fielded in stringent environments ranging from desert heat to
; cold climates. The amplifier
a unique and efficient thermal
uses forced air convection
movable fan tray on the bottom
rface of the amplifier can be
asily removed to clean out
excessive debris from the
internal heat sink. No tools
are required for the fan tray
moval making this maintenance
xtremely easy to perform in
field. The Compact Outdoor
fier was specifically designed

to fit most standard antenna mounts. The familiar package and moderate weight make the Compact Outdoor a perfect fit for VSAT terminals. The package envelope is 19.9 x 10.0 x 6.50 inches with a weight of 36 lbs. A high power isolator is integrated into the package making the amplifier completely tolerate of any level of load mismatch. A picture of the 40W Ka-band SSPA is shown in *Figure 2*.

Figure 2 — Paradise Datacom's Ka Band (40W) Compact Outdoor Solid State Power Amplifier (SSPA)

Monitor + Control

The **Paradise Datacom Compact Outdoor SSPA** incorporates the most comprehensive monitor and control of any Satcom amplifier. Among the standard interfaces include: Ethernet, RS485/422/232, and parallel I/O, in the form C alarms and opto isolated discrete signals. The Ethernet interface can be integrated into higher level monitor and control systems by SNMP or UDP programming. For simplicity, there is also a built-in web browser that enables a very easy monitor and control with a computer running a web brower application. *Figure 4* shows a computer screen shot of the built-in web browser.

There are also rack mount (1RU) remote control panels and a Fiber Optic interface link that work seamlessly with the Compact Outdoor amplifier. Alternatively, when an amplifier includes an integrated L-band to Ka-band *block up converter* (**BUC**,) the amplifier can be controlled via the FSK control signal multiplexed on the IFL by an L-band modem. There is also a weatherized, tri-color, LED visual display on the monitor and control panel for local visual fault status monitoring. As shown in *Figure 3* there is also a switch and link port that is standard on the amplifier. These ports enable the amplifier to be placed in automatic switch-over redundant systems without the need for a separate controller.

The built-in redundant controller capability saves cost and greatly simplifies 1:1 redundant system configurations. The monitor and control of redundant system functionality is obtained through the remote control just as single thread operations. Paradise Datacom has a Windows™ based monitor and control program that can be downloaded from the company website: www.paradisedata.com. The Universal M&C program is a convenient means of performing all remote monitor and control of the Compact Outdoor amplifier.

Figure 3 — Compact Outdoor Monitor and Control Panel

State-Of-The-Art Microwave Design

Extremely efficient microwave combining techniques are utilized in the **HPAKa040AC Ka-band SSPA**. The latest 3D Electromagnetic (EM) odeling techniques are used ı spatial waveguide combining ıat are optimized to achieve ssible insertion loss the band allows the effective power merous devices to achieve er levels.

Microwave devices in the Ka-band region have strong nonlinearities that distinguish them from their lower frequency counterparts. This requires that the amplifier designer employ linearization techniques in order to achieve usable linear output power for satellite communication systems. Paradise Datacom uses both traditional predistortion linearization and feed-forward techniques to achieve outstanding linear performance from otherwise nonlinear amplifiers.

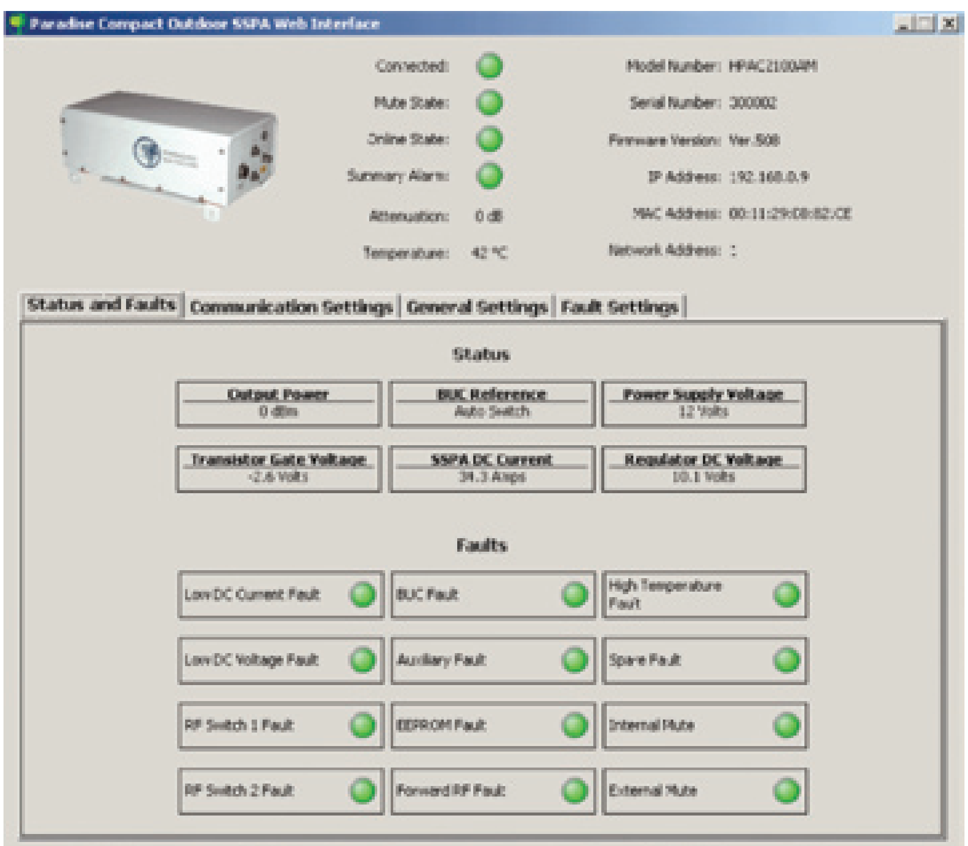


Figure 4 — Web Browser Monitor + Display

Extensive cosimulation between finite difference time domain (FDTD) and behavioral modeling enables Paradise Datacom engineers to optimize the performance of Ka-band amplifier

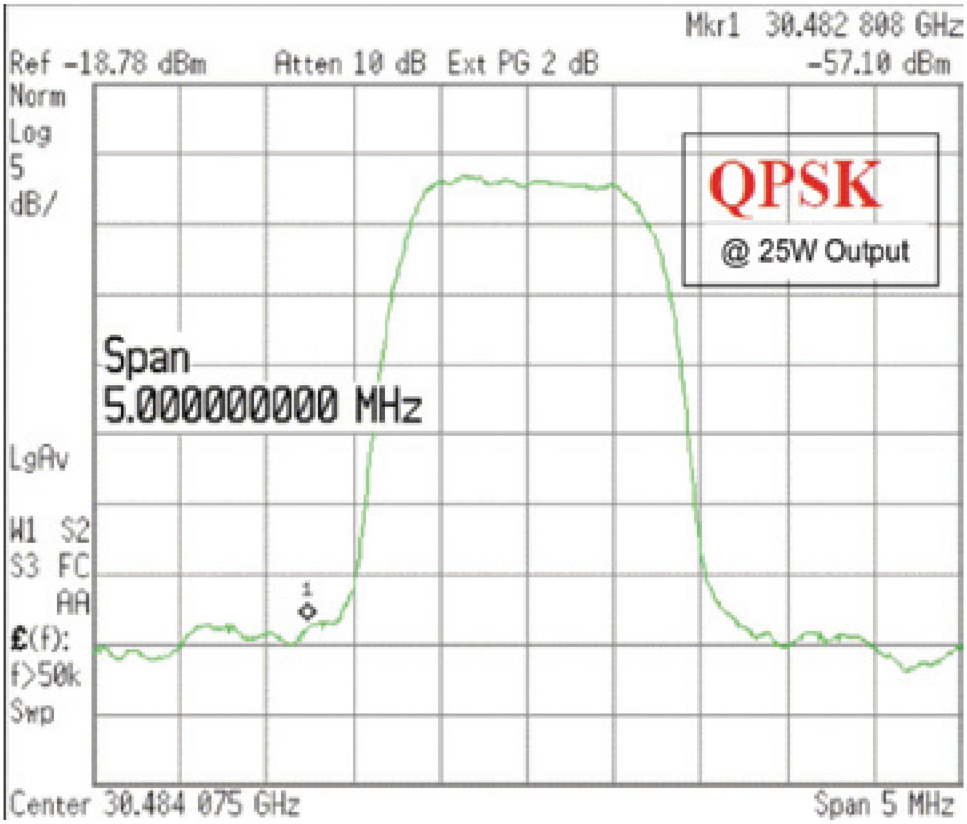


Figure 5 — QPSK Response:
-32dBc @1x Symbol Rate @25W Output

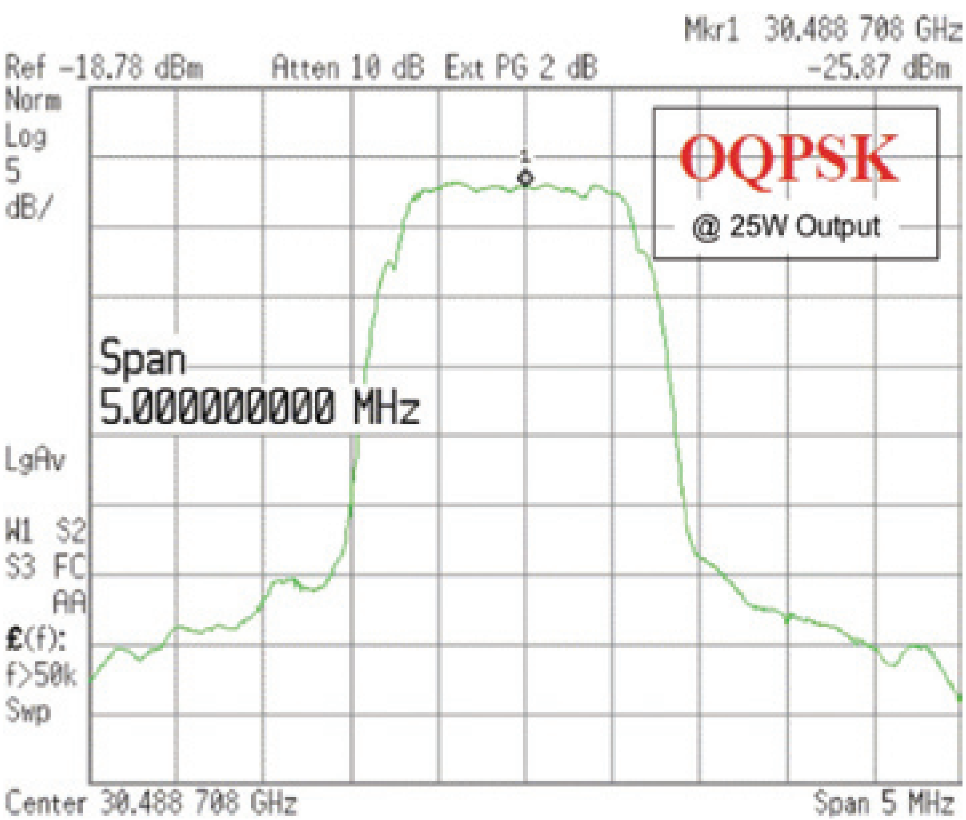


Figure 6 — OQPSK Response:
-30dBc @1x Symbol Rate @25W Output

designs. Adaptive bias techniques are utilized to maintain the highest possible AC prime input power to linear output power efficiency. Figures 5 and 6 show the single carrier OPSK and QPSK spectral regrowth at 25W output power.

The two tone peformance is slightly worse that the single carrier spectral regrowth due to the higher crest factor. Two tone intermod levels are typically characterized by evaluating the amplitude separation between the third order intermod product and the single tone power in dBc. This is characterized over a wide range of output power to obtain a characteristic as shown in *Figure 7*.

The gain of the amplifier is temperature compensated to keep the gain within a 1dB window from -40oC to +60oC ambient temperatures. The gain is also adjustable from 55dB to 65dB in 0.1dB steps. Prime power consumption is less than 500VA making it one of the most efficient Ka-band SSPAs in the industry.

As is standard on all Compact Outdoor SSPAs, integrated output power detection is included along with a -40dBc sample port. Paradise Datacom's Ka-band **ZBUC** can be integrated in the Compact Outdoor SSPA so that L-band operation is accommodated.

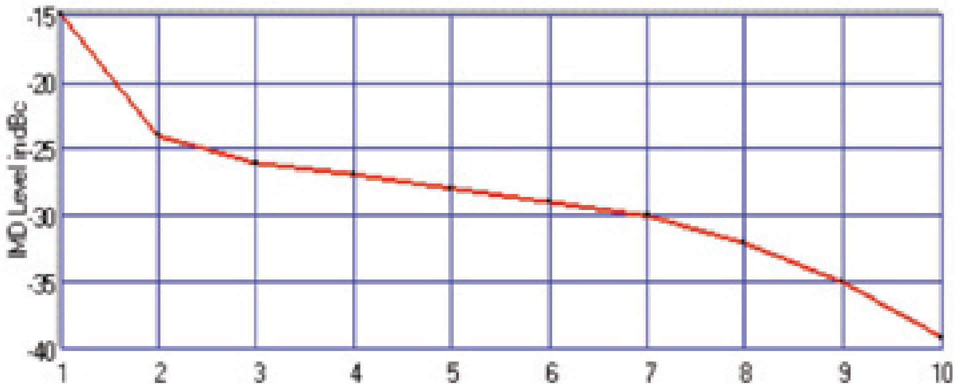


Figure 7 — Two Tone Intermod Product Level vs Back-Off from Psat

The Ka-band **ZBUC** has an efficient and low phase noise local oscillator that is phase locked to a stable reference source. A high stability reference is included in the block up converter. Internal reference stability is of the order +1.10-9. ZBUC technology provides for auto-detection and switchover to an externally applied reference. This is an extremely useful feature to be able to switch the block up converter to an external reference without requiring any factory modifications.

In addition, the ZBUC is capable of automatically phase locking to a variety of external reference frequencies including: 5, 10, 20, 25, and 50MHz without hardware modification.The ZBUC is characterized by its signature outstanding spurious and phase noise performance.

Summary

Paradise Datacom manufactures a variety microwave components that are ideally suited for Ka-band satellite ground terminals. Their electrical performance is well within the operating parameters established by MIL-STD-188-164 and used in ***Wideband Gapfiller Satellite*** (**WGS**) applications.

Low Noise Amplifiers are available with noise temperatures ranging from 100o to 160o K. Solid State Power Amplifiers are available in saturated output power levels of 12W, 20W, 40W, and 80W. Built upon the legacy of the Compact Outdoor robust design, Paradise Datacom Ka-band SSPAs offer superior reliability and performance.

About Paradise Datacom

An Intelek company, Paradise Datacom is focused on the design, manufacturing and sale of satellite modems, solid state power amplifiers (SSPA), low noise amplifiers (LNA), block up converters (BUC) and associated redundancy subsystems. Paradise Datacom has delivered products and subsystems for use in satellite communications systems to an extensive list of customers located around the world. The managers and engineers of Paradise Datacom have unparalleled experience in the production, sale and distribution of satellite communications products. Senior members of the Paradise Datacom engineering and management team received their training and experience from the companies that pioneered the satcom industry including Scientific Atlanta, VertexRSI, Radyne/Comstream, Comtech/EF Data, EEV and ViaSat. Engineering excellence and management's commitment to our customer's requirements are the core values that Paradise Datacom has been built on, and to which we constantly reaffirm with every new customer.

SATCOM Uplink HPAs — Linear Power... What It Means...

All satellite communications links are subject to uncertainties and variations in equipment, environmental and atmospheric effects, and random variables that make satellite communications link design as much art as science. While tools are available for developing link budgets, the decisions and assumptions that really determine link performance come from careful consideration of all aspects of the link itself.

Among the critical decisions link designers make are the items that contribute to EIRP: antenna gain and amplifier power. Whole treatises exist on antenna gain possible for a given diameter, but here we focus on the RF power into the antenna. In the past, this power has been specified in every way you can imagine, with link budgets often showing rated high power amplifier (HPA) output power and then a back-off value in dB assumed sufficient to meet interference requirements. These back-off assumptions vary widely, are frequently untested, and are even occasionally missing. New satcom systems using millimeter-wave bands and more complex waveforms may mean that the old assumptions don't always hold. The current trend is toward specifying linear power required at the amplifier output flange. This provides a concrete value for the link budget, and a straightforward method for comparing candidate power amplifiers while enabling optimization of prime power efficiency by evaluating the biggest power consumer in its likely operating condition.

Painting by Jean-Sébastien Baye

HPA Power Rating

The many ways of describing the power available from an HPA can be confusing for system engineers not specializing in the satcom link's RF components. To better understand linear power, it is helpful to understand terms commonly used to describe HPAs such as rated power (Prated), saturated power (Psat), 1 dB-compressed power (P1dB), and linear power (Plinear). The power saturation curve of a typical HPA (*Figure 1 on the next page*) shows that output power increases dB for dB with input power in the "linear region". As input power increases further, amplifier gain begins to "compress" so that output power increases <1dB for each dB of input power increase. In the saturated region, output power has reached its maximum (Psat), so increasing input power no longer increases output power, and amplifiers respond in highly non-linear fashion in both gain and phase, causing problems in communication systems where maintaining the modulated signals' gain and phase are critical to successful transmission.

Another commonly used parameter in describing HPAs is P1dB, which may be ~1dB below the Psat … or not. An amplifier's P1dB is defined as the point on the saturation curve where its gain is compressed by 1dB. This is found by determining the amplifier's linear gain, subtracting 1dB, and locating the corresponding point on the curve *(Figure 2 on the next page).*

Two general categories of HPAs are used on satcom uplinks: vacuum tube-based amplifiers and solid-state amplifiers. For vacuum-tube amplifiers, including both travelling wave tube amplifiers (TWTAs) and klystron-tube power amplifiers (KPAs), the industry practice is to use the tube's saturated output power as the HPA's rated power. The TWTA's rated flange power is typically 0.5dB to 0.7dB lower due to component losses in the amplifier's output section; i.e., the "750W" Ku-band TWTA provides 650W RF power at the flange. Solid-state power amplifiers (SSPAs) always use flange power, yet the industry nomenclature has greater variation because some suppliers use Psat and others use P1dB. Satcom system designers must take careful note of these differences.

Linear Power

What matters most in the link is linear power, generally defined as the output power at which the amplifier operates without interfering with transmission of in-band or out-of-band signals transmitted over the satellite. Many specific definitions of linear power exist, but the most common Plinear definitions are based on the following parameters:

- *Spectral regrowth (SR)*
- *Intermodulation products (IMD)*
- *Noise Power Ratio (NPR)*

Requirements for spurious and amplitude-to-phase modulation conversion (AM/PM) performance often also apply, but the driving requirement in setting linear power for single-carrier systems tends to be SR and for multi-carrier systems tends to be IMD or NPR.

Spectral regrowth is the energy from the modulated signal that spreads into adjacent channels due to the amplifier's inherent

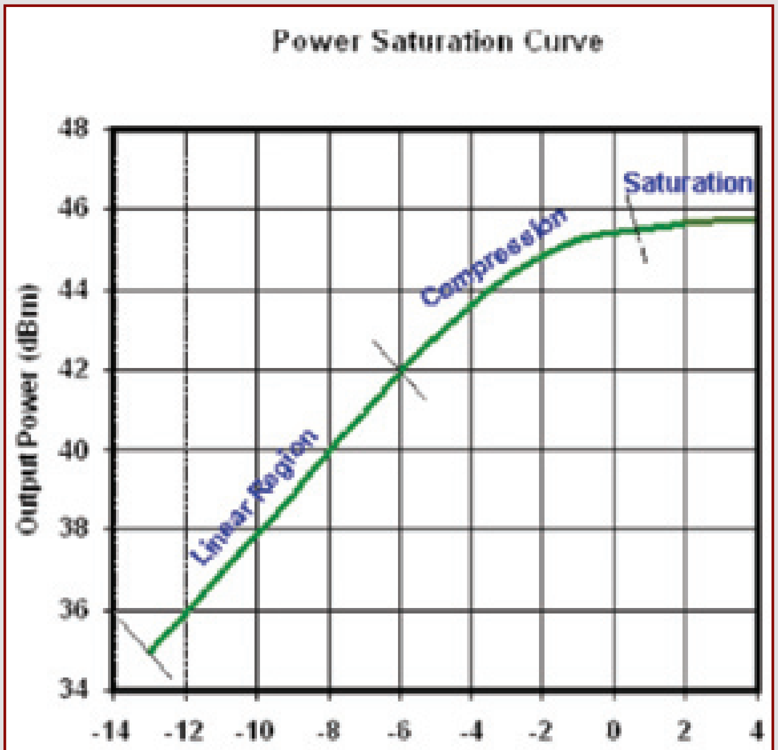


Figure 1 — Power saturation curve showing linear, compressed, and saturated regions

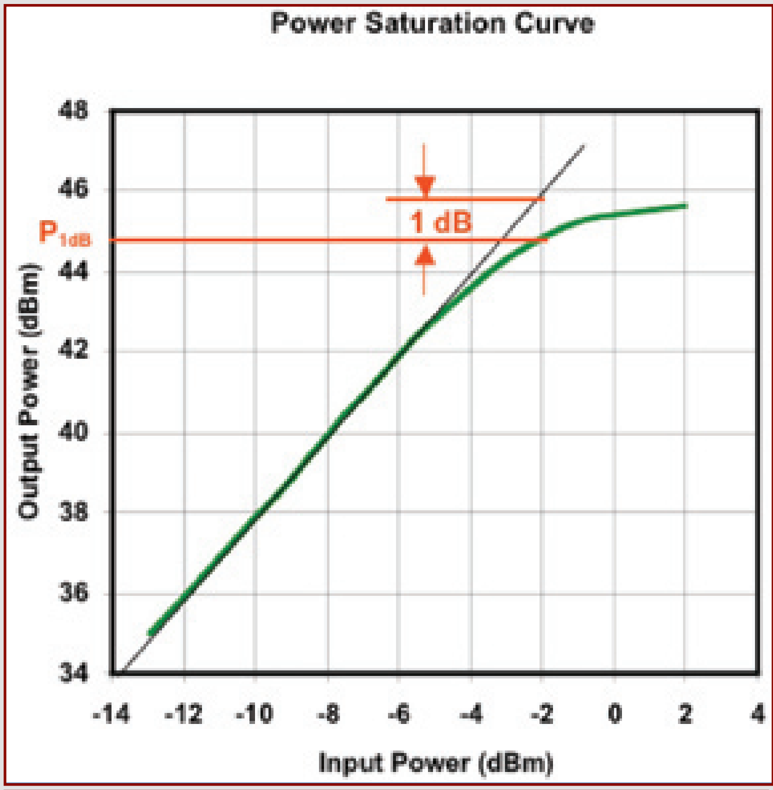


Figure 2 — 1-dB compressed power (P1dB)

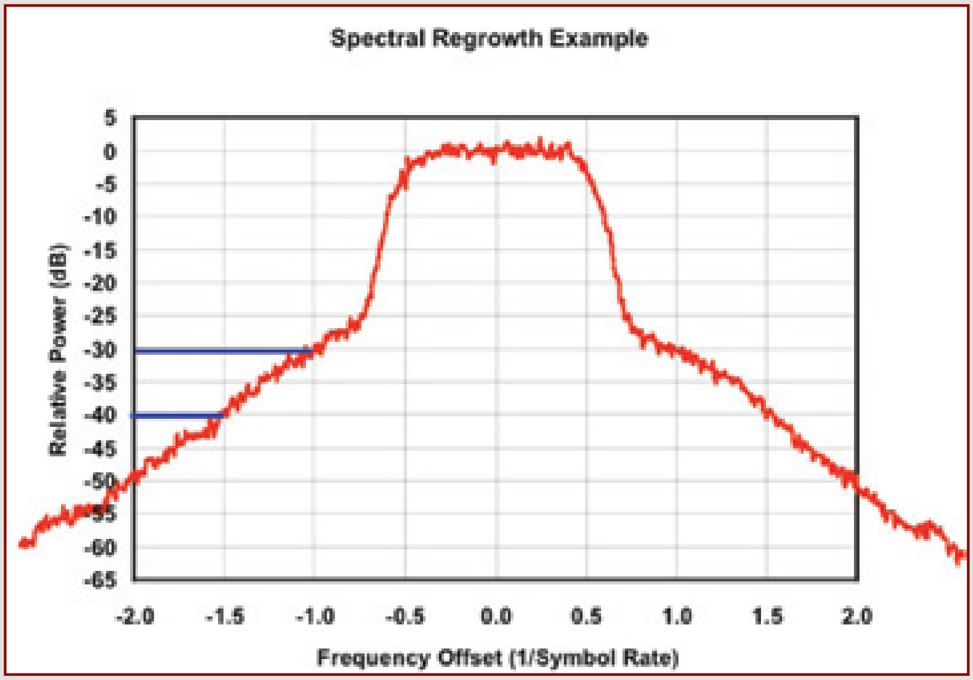


Figure 3 — Spectral regrowth for single OQPSK-modulated carrier

non-linearities. SR is highly subject to signal conditions (modulation format, symbol rate, and filtering). Most commercial SATCOM currently uses quadrature-phase shift keying (QPSK) or offset QPSK (OQPSK); these are frequently used when specifying SR performance. Typical specifications require SR be -30 dBc at an offset frequency from the carrier equal to the modulated signal's symbol rate, or sometimes 1.5 times the symbol rate. These points are identified in *Figure 3* on an SR plot for an OPSK modulated signal, where the amplifier meets a -30dBc SR at 1x symbol rate offset from center frequency, and -40 dBc at 1.5x symbol rate offset. The output power at which this data is taken is therefore the amplifier's single-carrier linear power.

Intermodulation products, or intermods, are spurious signals occurring in-band when more than one carrier is transmitted simultaneously through a single non-linear device. These undesired tones fall in band for closely spaced carriers and interfere with communications in nearby channels if too large. This most commonly used linearity requirement for satcom

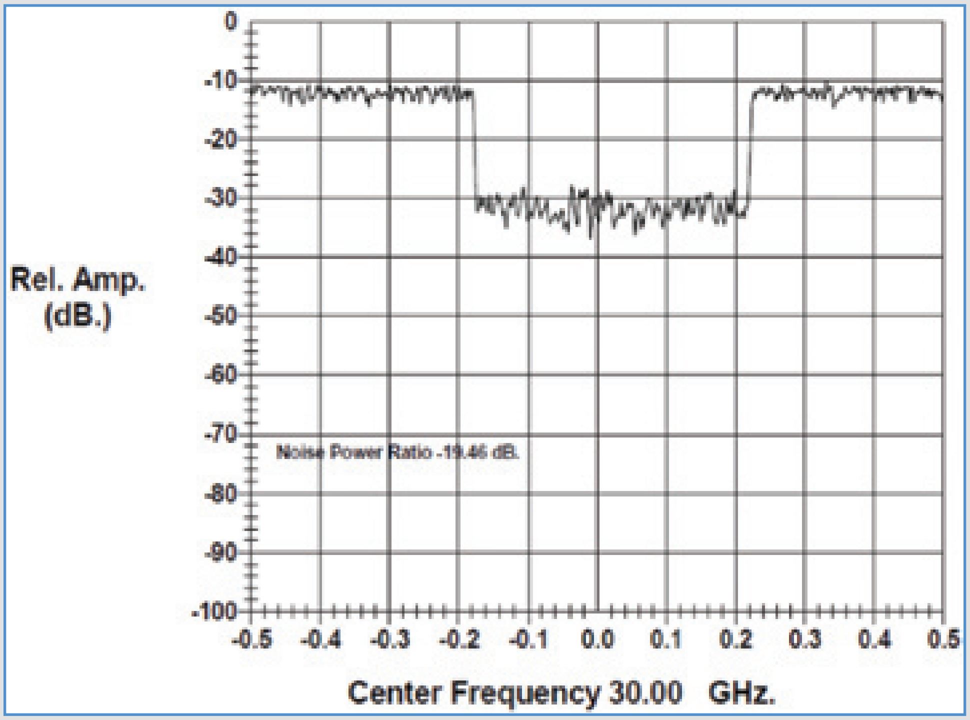


Figure 4 — Two-tone intermodulation products

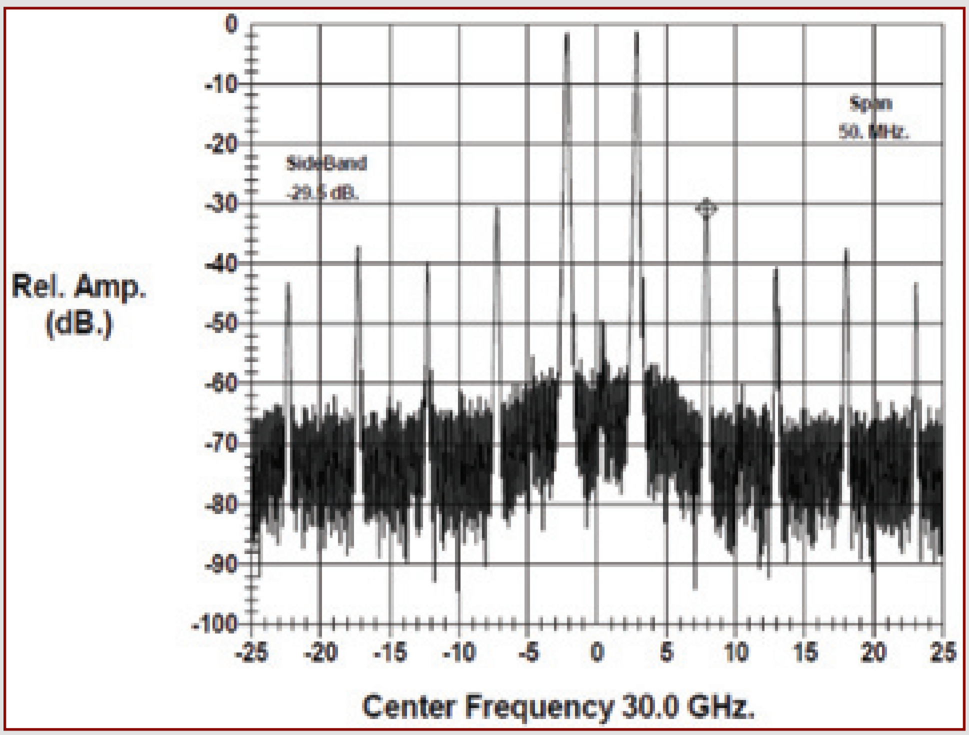


Figure 5 — Noise power ratio

amplifiers is often specified in the range of -24 or -25dB below the individual carrier power used for the test so that the IMD has negligible impact on signal-to-noise ratios in adjacent bands. Figure 4 shows two equal carriers and the resulting intermods for a typical amplifier, taken at a specified linear power level; the highest power IMD in this case is the -29.5 dBc third-order intermod.

Noise Power Ratio

For uplink transmitters carrying many signals on individual carriers, the most appropriate linear power definition is noise power ratio (NPR), or the level of "noise" created in the channel from multi-order intermodulation products among the many modulated carriers being transmitted. To measure NPR, an input signal that looks like noise (many uncorrelated modulated carriers at similar power levels) is passed through a filter that notches out a narrow portion of input noise power. These narrow notches (<10% of input signal bandwidth) have 40+ dB of rejection. Distortion from non-linear interaction of these input signals shows up as a noise floor in the notch. The NPR is the average power level of noise in the notch compared with the power level of the rest of the output signal (*see Figure 5*).

Back-Offs + Pre-Distortion

Power amplifiers require a "back-off" in output power from their maximum level to meet specified linearity and not interfere with other signals' transmission. For TWTAs to meet linearity requirements noted above, typical back-off is 6-7 dB below rated output power. For SSPAs, typical back-off to meet linearity is 2-4 dB below rated P1dB. Predistortion can increase the amount of linear power

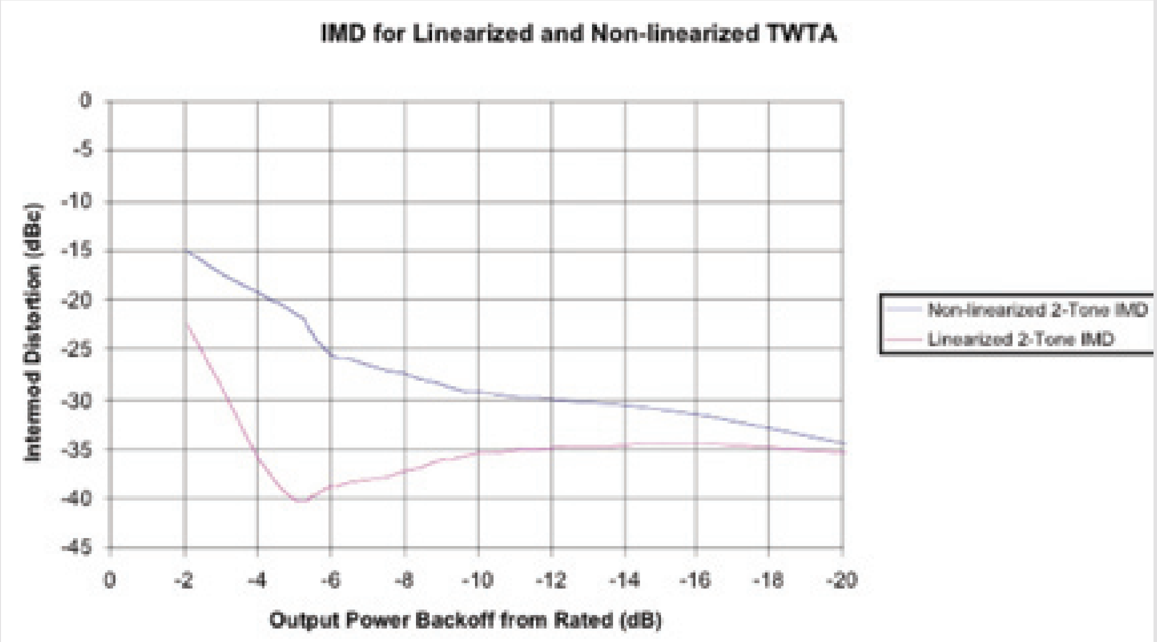


Figure 7 — Intermodulation of linearized vs non-linearized TWTA

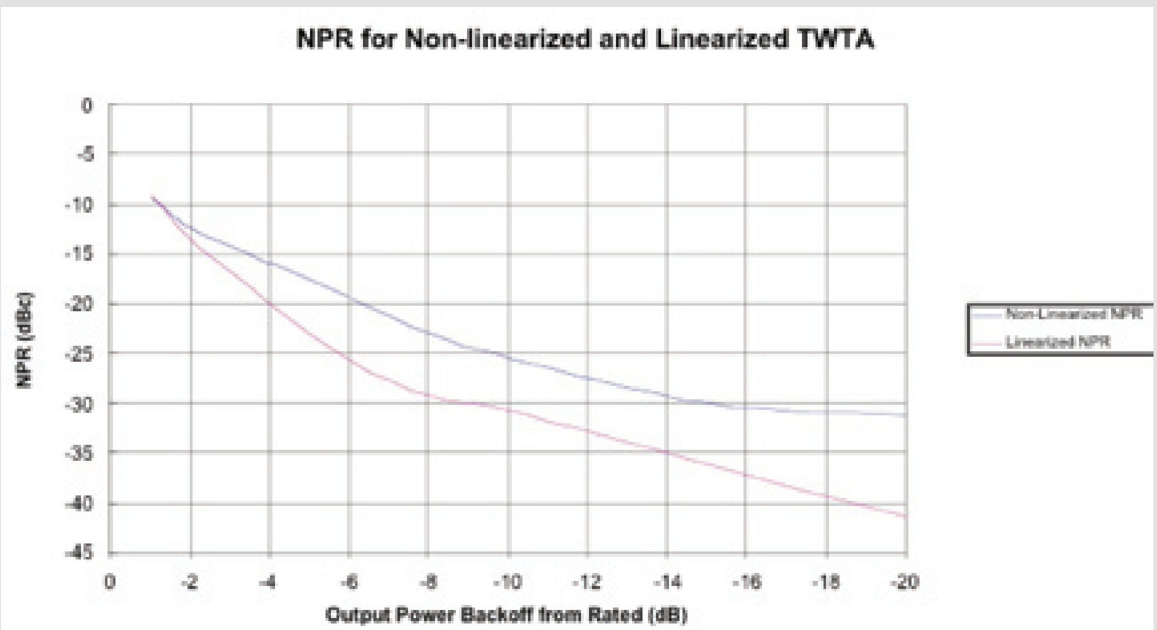


Figure 8 — Noise Power Ratio of linearized vs non-linearized TWTA

for both TWTAs and SSPAs, although the benefit is much greater with TWTAs. For most SSPAs, the small improvement gained from a linearizer doesn't justify the additional cost, although this is not the case at Ka-band where solid-state devices exhibit poor linearity characteristics compared with lower frequencies. For TWTAs, predistortion linearizers typically improve linear power by at least 3 dB. Linear operating power levels depend on the parameter specified, but linearized TWTAs generally require only 2-4 dB back-off to meet requirements.

To see the full benefit of the linearizer, we can examine its effect on each of three linearity parameters defined. *Figure 6* shows spectral regrowth performance of a TWTA with and without a linearizer.

For a -30 dBc requirement, the linear power level improves from ~5.5 dB below rated power to ~2 dB below rated. This 3.5 dB improvement can be critical in enabling use of a much lower rated power amplifier, and consequently reducing prime power draw significantly.

For intermodulation products, linearization can provide a similar increase in linear power level (*Figure 7*). For -25 dBc IMD

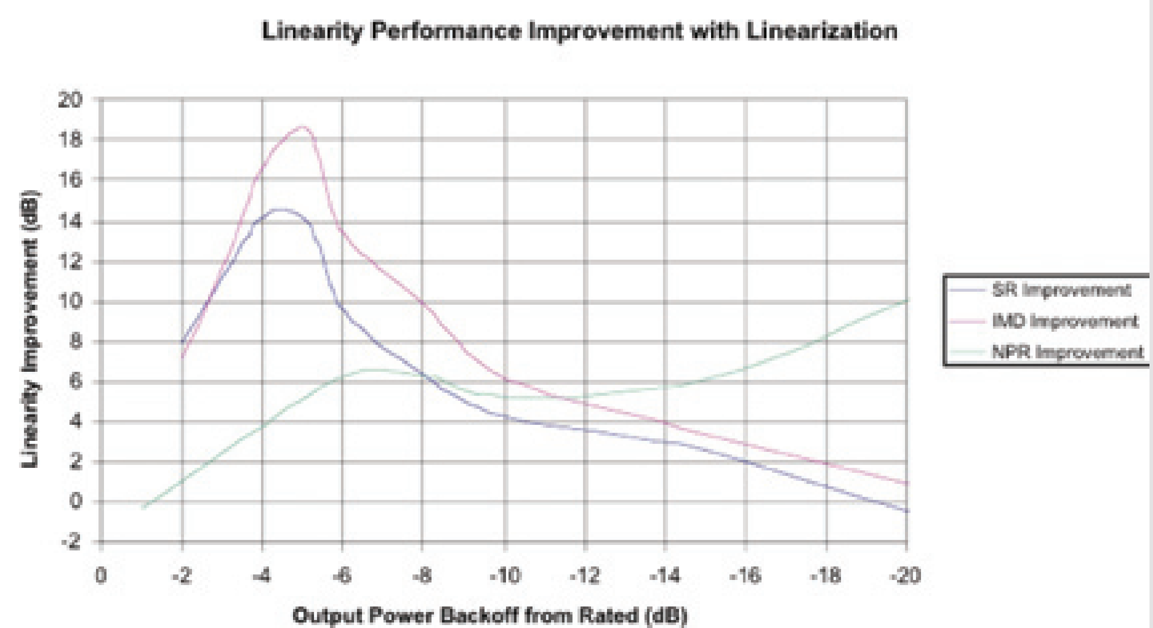


Figure 9 — Linearity improvement due to TWTA linearization

Clearly, the task of understanding system requirements and selecting an appropriate HPA is not an easy one, but hopefully with solid understanding of the linearity required in the system and how best to specify the amplifier, link budgets just got a little less cloudy.

requirements, linear power increased from 5.7 dB below rated power to 2.4 dB below. This 3.3 dB improvement provides system benefits in lower HPA cost, power draw, size and weight. In addition, Figures 6 and 7 also demonstrate the large performance advantage maintained throughout the likely operating region from 2dB backed-off down to 10-15 dB backed-off.

NPR specifications are often the most challenging, but *Figure 8* shows an example of NPR performance with and without linearizer. Linear power for a typical -19 dBc NPR spec goes up from 6 dB below Prated to just 3.8 dB below — a 2.2 dB improvement. In the case of NPR, the linearizer improvement continues increasing well below the Plinear all the way down to 20 dB below rated.

To summarize linearizer benefits, improvements in all three distortion parameters were plotted on a single graph (Figure 9). In typical operational ranges of 3db to 15dB below rated power, the linearizer provides at least 3dB improvement and often much more for each parameter.

About Comtech Xicom Technology

This Company was founded as Xicom Technology in 1991and has grown to be a leading SATCOM amplifier supplier. Regarded as an industry leader across the board, Xicom provides rugged, highly efficient and reliable Traveling Wave Tube Amplifiers (TWTAs), Klystron Power Amplifiers (KPAs), Solid State Power Amplifiers (SSPAs), and Block Upconverters (BUCs) for commercial and military broadcast and broadband applications around the world. These Xicom High Power Amplifiers (HPAs) are in use in critical communications links on the ground, in the air and on the sea; they support fixed traditional and direct-to-home broadcast, mobile news gathering, transportable and flyaway systems, secure high data rate communications, and broadband access over SATCOM. Website: http://www.xicomtech.com/

Illustration courtesy of ART.NET

BGAN SOFTWARE DEFINED RADIO (SDR) BREAKTHRU

Claus Krohn Vesterholdt

A complete SDR-based BGAN radio was successfully demonstrated at the SDR Forum Conference and Exhibition 2009 in Washington D.C. in December. The demo revealed the result of the joint SDR program completed by GateHouse, Inmarsat, and Spectrum Signal Processing by Vecima (Spectrum) and gave evidence that BGAN SDR-based satellite communication (SATCOM) is an opportunity readily at hand for manufacturers of military radios.

The demonstration of BGAN SDR radio in Washington D.C. is implemented using generic components. All BGAN functionality is realized in software: **GateHouse's BGAN waveform**.

The **BGAN Class 10** active tracking antenna supplied by **SpaceCom** and the L-band front-end are for L-band usage only —– however, although these components are calibrated to be compliant with the BGAN specifications, they would be able to run other L-band waveforms as well. Alternatively, the **SDR-4021** radio platform from **Spectrum** would be able to run other waveforms in other frequency bands using other front ends.

The BGAN SDR radio obtained **Inmarsat** approval for on-air usage prior to the ***SDR Forum Conference and Exhibition*** and on-air demonstrations were given in the exhibition area with a 50 meter cable connecting to the antenna, which was placed outside the exhibition hall.

Several gigabytes of data were exchanged with the BGAN network via the air interface during the four days of the exhibition. The GateHouse team demonstrated the following applications, all on a standard laptop connected to the BGAN SDR radio with an Ethernet/IP cable:

- *FTP transfers of binary files of 2, 5 and 10 MB size. The average transfer rates on the downloads was as high as 450 kbits/s and on the uploads 320 kbits/s which is close to the maximum theoretical BGAN transfer rates*

- *Live video streaming from a web cam placed at Times Square New York supplied a stable stream of 250 kbis/s*

- *Emailing using the web access interface to the GateHouse exchange server. Emails were sent to visitors' PDAs and typically received over the BGAN network connected to GSM/GPRS/3G networks in a few seconds*

- *General web browsing on company web pages as well as news and weather pages*

The demonstrations marked a technological breakthrough for BGAN SDR — moreover that the technology has matured to a point enabling integration in viable solutions.

Software Defined Radio

Over the last 30 years, radios have changed from being purely hardware-based to containing more and more software. The term 'Software Defined Radio' is not new but has been around for quite some time representing a vision of a single wireless multi-purpose device that seamlessly integrates multiple communication channels, including SATCOM.

Driven mainly by the military market and DoD/MoD's need for interoperability, flexibility in choice of communication means, reduced total cost of ownership as well as rapid functionality upgrades and repair, the SDR technology has experienced great advances and focus during the last decade.

Increasing globalization, *i.e.*, participation of many countries in international conflict resolution and peace keeping missions, has significantly increased the need for communication and interoperability in remote areas of the world.

SDR is an operational alternative to current practice with dedicated hardware/software for each communication mean, *e.g.*, one radio for SATCOM and one for VHF, UHF etc. This is space demanding and sets a practical limit to the number of communication means that can be fitted into vehicles and which soldiers in the field can carry and use. With SDR, the number of communication means is only limited by the channels available on the radio.

SDR does not only provide benefits for the end-users but also for the manufacturers of military radios. It provides each manufacturer with the opportunity of customizing their offerings to changing customer demands incurring only limited extra costs and time to market. With SDR, the manufacturers can produce the SDR radio hardware and postpone equipping it with software waveforms until customer requirements are clearly defined. This significantly saves development time and waveform porting costs. In other words, with SDR, manufacturers are capable of delivering greater customer value at lower cost.

SDR technology has been encouraged by the rapid technological developments over recent years in integrated circuits, where size and power consumption has decreased and performance has increased, enabling very high performance generic hardware platforms.

The U.S. DoD has invested in SDR via the ***Joint Tactical Radio System*** (**JTRS**) program which has produced a number of SDR radios and waveforms. JTRS has also developed the ***Software Communication Architecture*** (**SCA**) which specifies how radio platforms and waveforms must be designed and implemented to ensure interoperability.

Inmarsat BGAN

Inmarsat is a recognized pioneer and market leader in the field of global *Mobile Satellite Services* (**MSS**), and the IP-based **BGAN** (the acronym for ***Broadband Global Area Network***) service is the most advanced of the company's current offerings. The system offers standard and streaming IP data services as well as a voice and text service (*see the fact box below*...).

BGAN Fact Box

Data — Standard IP (TCP)
- *Variable bit rate service*
- *Up to 492 kbps (send & receive)*

Streaming — Guaranteed bit rate service
- *Available on demand*
- *8, 16, 32, 64, 128, 256, 384 kbps (send & receive)*
- *UDP support*
- *ISDN support*

Voice — 4 kbps circuit-switch service
- *Voicemail*
- *Enhanced services: call waiting, forwarding, barring holding*
- *Broadcast quality voice 3.1kHz*

Text — Send and receive text messages via your laptop
- *160 characters SMS*

Source: Inmarsat

The BGAN service is provided globally via 3 satellites placed in geostationary Earth orbit. System specifications define terminals operating from ground vehicles, ships and airplanes.

While the Inmarsat BGAN system is a commercial system, it has been adopted by military forces for *beyond-line-of-sight* (**BLOS**) communication, primarily because it is easy to set up and use and provides an on-demand 492 kbps data service on the surface of the Earth with exception of the Polar Regions.

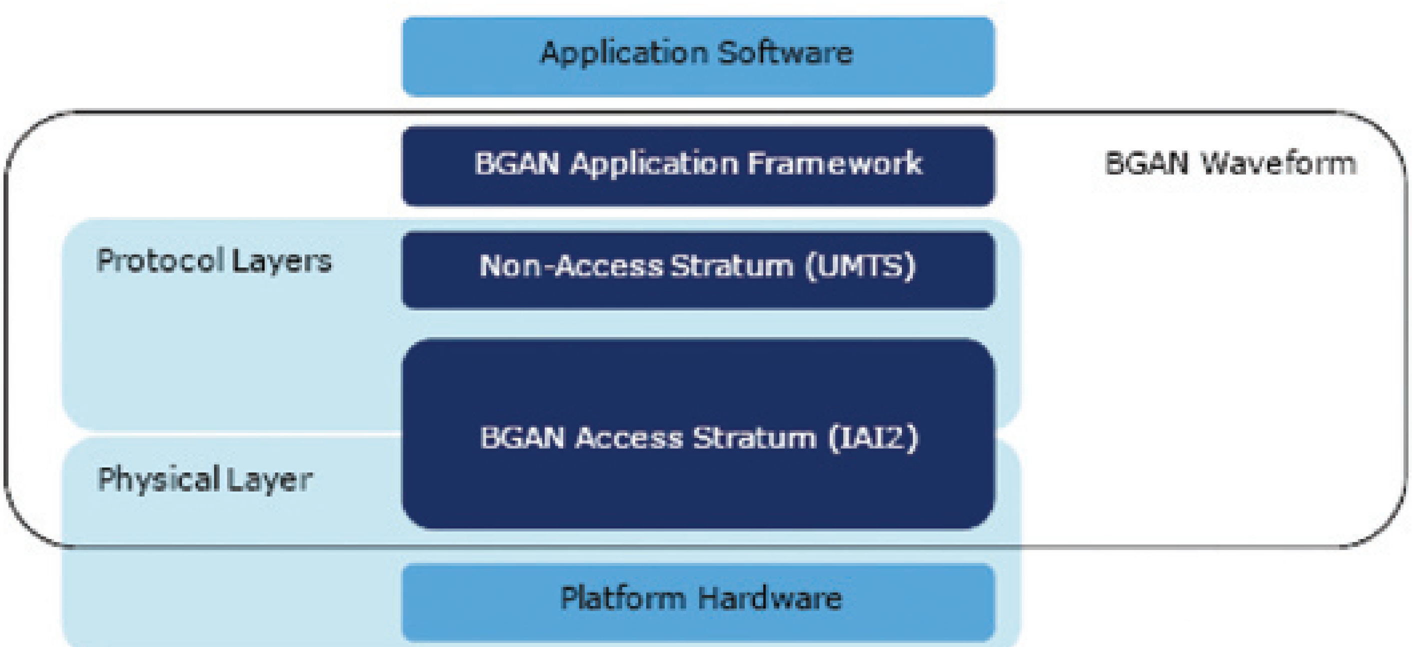
In 2008, the government sector (civil and defense) contributed 55 percent to the overall Inmarsat BGAN revenue . The airtime is generated from an installed terminal base provided by manufacturers of commercial equipment for government aircrafts, ground vehicles and ships. The shift to SDRs is expected to enable BGAN on tactical radios, as it provides an opportunity for an instant BLOS capability, at limited extra cost.

GateHouse BGAN SDR Waveform

The **GateHouse BGAN SDR Waveform** contains all the functionality required to build a BGAN radio with on-demand, BLOS communication capability. The waveform is integrated on an *SCA version 2.2.2* compliant platform and can run as the only waveform on the radio or as one of several waveforms on a multimode radio. Development efforts to port the waveform from one radio to another is considerably less than for a conventional radio design, where the software typically interfaces with custom designed hardware.

The traditional approach has been to develop rather inflexible purpose-specific hardware plat-forms for BGAN radios which effectively limit the solutions to one radio/one application. The SDR approach implements the complete functionality (waveform) in software and leaves the underlying hardware generic and fit for other purposes as well.

In addition to the advantage of reusing radio hardware platforms and allowing coexistence of multiple waveforms on a single radio, the SDR approach also enables considerably



The BGAN Waveform is comprised of an Inmarsat proprietary access stratum (IAI-2), a 3GPP UMTS non-access stratum release 4 and an application framework easier up-grade procedures of the BGAN terminals as the BGAN standard evolves (*e.g.*, support of higher data rates).The GateHouse BGAN SDR Waveform is structured internally according to the Inmarsat BGAN specifications and contains multiple layers of functionality and is comprised of an Inmarsat proprietary access stratum (IAI-2), a 3GPP UMTS non-access stratum release 4 and an application framework

The demonstrations in Washington in December marked a breakthrough for BGAN SDR and a milestone for GateHouse, which for a decade has been the leading independent provider of the complete embedded software package for Inmarsat BGAN terminals.

Advantages Of The SDR-based BGAN Solution

Today a wide variety of commercial BGAN terminals are available. While these terminals are reasonably inexpensive they do not readily provide the levels of flexibility, security or robustness which are required for military use.

One solution to this problem is to combine a commercial terminal with a military radio, and use the built-in security features of the radio to provide secure end-to-end communications over BGAN. Another solution is to use military-grade BGAN terminals and combine the advantages of secure communications platforms with the rugged construction that's needed to operate the equipment in the field for extended periods of time. The development of the GateHouse BGAN SDR waveform was sparked by the realization that an SDR based solution is able to provide all the advantages of the existing solutions, while at the same time reducing the amount of hardware needed.

A BGAN SDR waveform can be integrated with any military-grade Software Defined Radio capable of transmitting and receiving in the BGAN L-band frequency range (1.5GHz-1.6 GHz). This means that units can now be deployed with a single multifunctional radio that can be BGAN-enabled almost as easily as changing a channel or another preset.

About the author

Claus Vesterholdt is the Technical Program Manager for the Satellite Communication activities in the Danish software company GateHouse A/S. He has a Master degree in Electrical Engineering from Aalborg University and has taken various positions in the wireless communication industry over the last 16 years. He has been leading a number of programs and projects on the development of communication software for wireless communication systems, mainly GSM/GPRS terminals and Inmarsat BGAN terminals.Claus has experience in developing and testing communication software for terrestrial systems and satellite systems. Currently, Claus is responsible for all technical activities in the satellite communication area of GateHouse and is leading the engineering team.

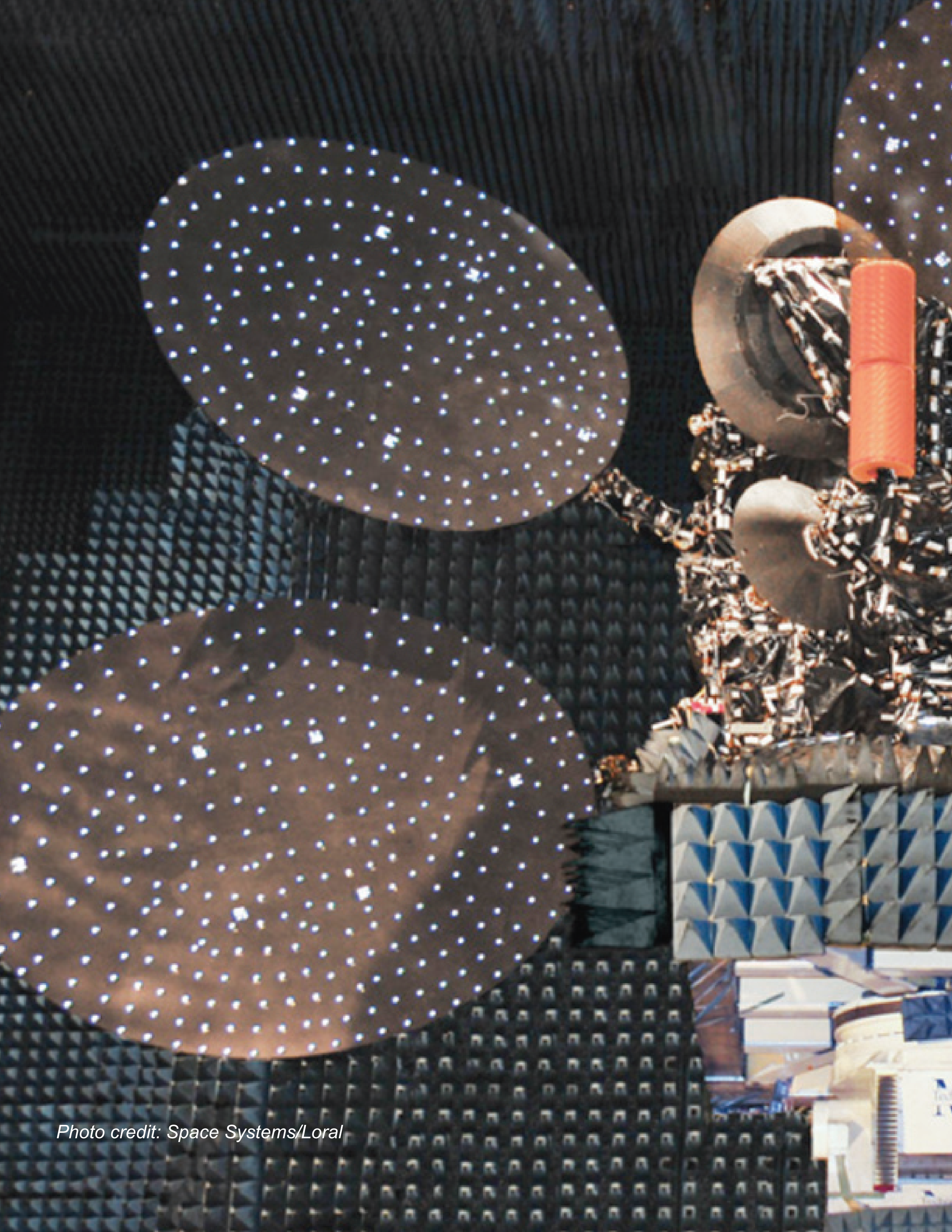
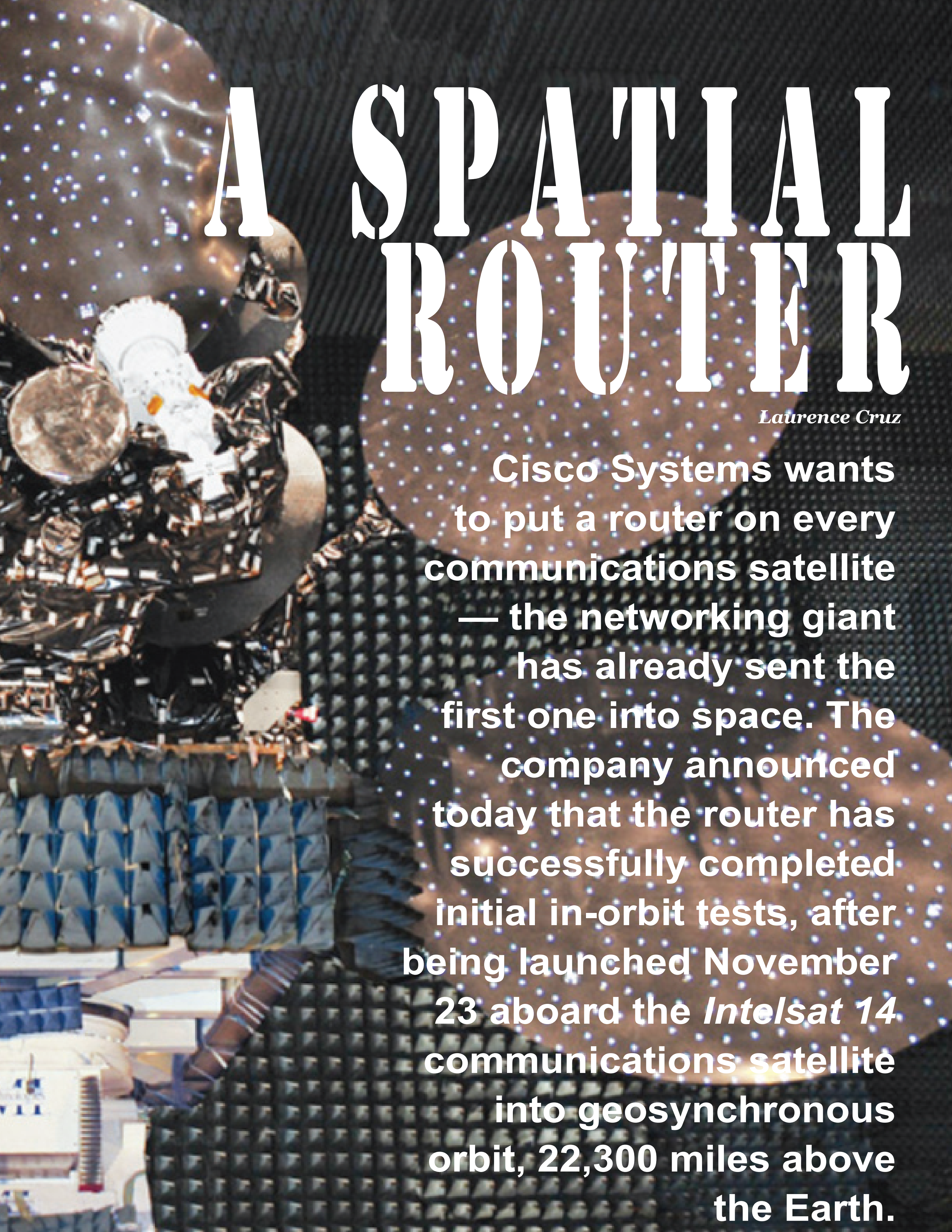


Photo credit: Space Systems/Loral



A SPATIAL ROUTER

Laurence Cruz

Cisco Systems wants to put a router on every communications satellite — the networking giant has already sent the first one into space. The company announced today that the router has successfully completed initial in-orbit tests, after being launched November 23 aboard the *Intelsat 14* communications satellite into geosynchronous orbit, 22,300 miles above the Earth.

initiative dubbed ***Internet Routing in Space*** (**IRIS**), which company executives say extends the same Internet protocol-based (IP) technology used to build the World Wide Web into the heavens. The long-term goal, they say, is to route voice, data and video traffic between satellites over a single IP network in ways that are more efficient, flexible and cost effective than is possible over today's fragmented satellite communications networks.

It's an exercise that's sparking intense interest in the satellite industry as well as in the U.S. military, telecommunications companies, and other businesses that stand to benefit from the technology.

Don Brown of **Intelsat General**, the world's largest operator of commercial communications satellites, says ***IRIS*** is to the future of satellite-based communications what Internet forerunner **ARPANET** was to the creation of the World Wide Web in the 1960s.

"There is a very strong potential for IRIS to revolutionize communications satellite architecture," says *Brown*, who is vice president of hosted payloads at the Maryland-based satellite operator. "IP changes everything."

Brainier Satellites

"Communications satellites are a type of satellite stationed in space for the purpose of telecommunications, including mobile communications to ships, vehicles and handheld devices. They are also used for TV and radio broadcasting where wires and cables do not reach or are not practical.

History Behind Cisco's Routers in Space

Cisco Systems first began evaluating satellite communications networks as candidates for an Internet protocol (IP) makeover several years ago, company executives say. The networking giant took the idea to Maryland-based Intelsat General, the world's largest operator of commercial communications satellites, executives say.

Later, the companies approached the U.S. Department of Defense as an obvious beneficiary of such technology, says Intelsat's Don Brown. You can read more regarding the history at http://newsroom.cisco.com/dlls/2010/hd_011910.html

Later, the companies approached the U.S. Department of Defense as an obvious beneficiary of such technology," says Intelsat's *Don Brown*.

Read More

"Historically, the brains of satellite communications networks have resided largely in ground-based hardware, with the satellite itself passively reflecting the data beamed up to it. But IRIS shifts much more of the intelligence to the orbiting router — with potentially dramatic benefits," says Cisco's IRIS project manager *Greg Pelton*.

"For starters, a space-based router can intelligently allocate bandwidth, prioritizing more important traffic and allowing telecommunications companies to respond to changing demand," *Pelton* says. Hence, if one customer no longer needs bandwidth — a broadcaster covering a just-canceled political event, for example — that bandwidth can be assigned to another customer —such as a government agency dealing with a sudden natural disaster.

"Space-based routers would also make it practical for telecommunications companies to offer high-bandwidth, on-demand services such as ***Cisco TelePresence***," *Pelton* says. "That's not an option with existing satellite networks because customers must reserve bandwidth in advance and pay for it whether they use it or not," he says.

Eliminating The "Double Hop"

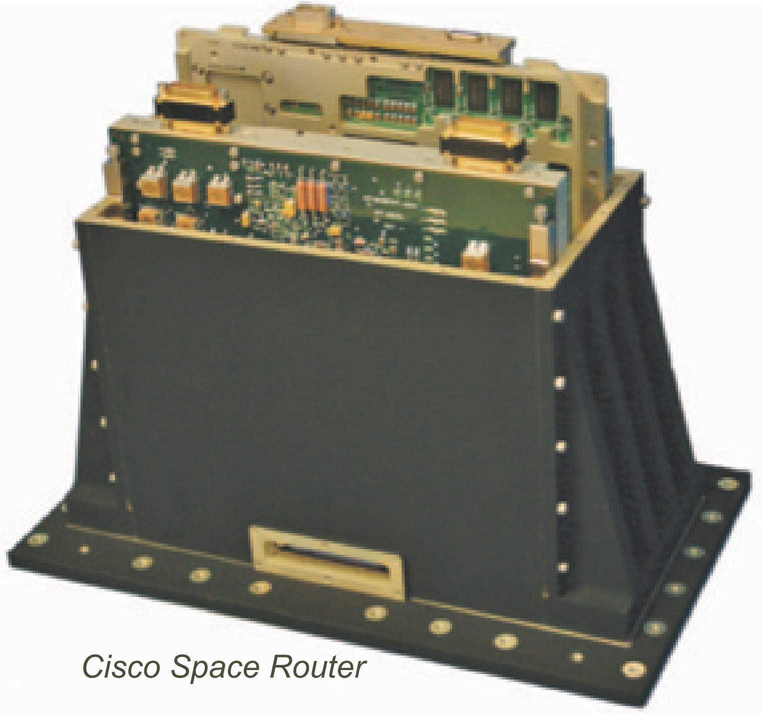
"Other benefits include a better user experience with time-sensitive services such as voice and video," *Pelton* says. "Currently, voice calls or video transmissions routed between two satellite users suffer from delays that hinder interaction; think of those interviews between TV news anchors and reporters in the field that are punctuated with dead silences.

“These delays often occur because the data between anchor and reporter must bounce first from one satellite and back, then travel along the ground before bouncing off a second satellite. These two round trips into space, or ‘hops,’ total nearly 90,000 miles and add a half-second delay to the signal,” Pelton says. “IRIS will cut the delay in half by routing the signal directly between the two users and thus eliminating the so-called “double hop,” he says.

“IRIS also aims to provide ‘any time, any place’ broadband services and to reduce operating expenses for telecommunications companies by merging their terrestrial and space networks, which are currently managed separately,” Pelton says. In fact, he says,

“The opportunity to transform an entire industry doesn’t come along very often. And the fact that our product isn’t delivered on a truck but on a rocket with over a million pounds of thrust is pretty cool, too.”

— Greg Pelton, Cisco’s IRIS project manager



Cisco Space Router

“in addition to offering a multitude of services now lying dormant in the router’s operating system software, known as Cisco IOS, IRIS may enable the creation of entirely new capabilities.

“That will be the prize in the Crackerjack box we’re going to find over the next year,” Pelton says.

Changing The Status Quo

The potential opportunity for Cisco in putting a router on every communications satellite is huge. *Pelton* shared that "about 100 communications satellites are launched every year, and that the overall satellite market in 2009 was worth $125 billion. Satellite industry executives say it will take years for the company to realize this vision, however, and that IRIS will likely face its share of growing pains along the way.

"Some of the challenges, they say, will be technological, such as matching customers' applications with the IRIS system; and some will be economic, such as achieving the economies of scale needed to push down prices for customers. But perhaps the greatest challenge will come from changing the status quo," *Pelton* says.

"The satellite industry has been doing things the same way for decades," he says. "Introducing an architectural change and business change can cause a lot of discomfort for our customers and our partners."

Analyst *John Mazur* with international technology consultancy **Ovum** says IRIS represents the first time Internet technology has been made available from a space-based platform.

"It takes IP ubiquity to a whole new level," *Mazur* says. "With a few more IRIS birds, IP will be available anywhere, anytime on the planet, although bandwidth may be limited." *Peter Clarke*, another Ovum analyst, links IRIS to the surging technology trend of cloud computing. He says companies that have not caught the cloud-computing vision will be baffled by IRIS, while those that have embraced the cloud will readily see the potential of IRIS, which will in turn spur competition.

"It's another pipeline from the cloud down to the user," *Clarke* says. "It's going to sharpen up the market. It's going to improve services across the board."

Next Steps

"Technically, the IRIS router is not the first Cisco has sent into space. In 2003, the company launched an off-the-shelf, commercial router aboard a low Earth orbit satellite, but that experimental effort was never intended to offer services to users," *Pelton* says.

Not so the IRIS router, which has been modified to withstand the rigors of space. Now that it has completed initial testing, the router will begin two new phases of testing, Cisco says. Starting in February, the U.S. government will evaluate IRIS for three months.

"It's a very cost-effective way for the government to improve its communications capabilities," says *Arnold Friedman* of Palo Alto, California-based **Space Systems/Loral**, which built the satellite hosting IRIS. "Especially at this time where budgets are tight, this is a really interesting alternative."

"Next, Cisco will spend a year evaluating IRIS for business customers," *Pelton* says. "In doing so, the company hopes to give the satellite industry a chance to get used to IRIS and understand how it can improve their business," he says.

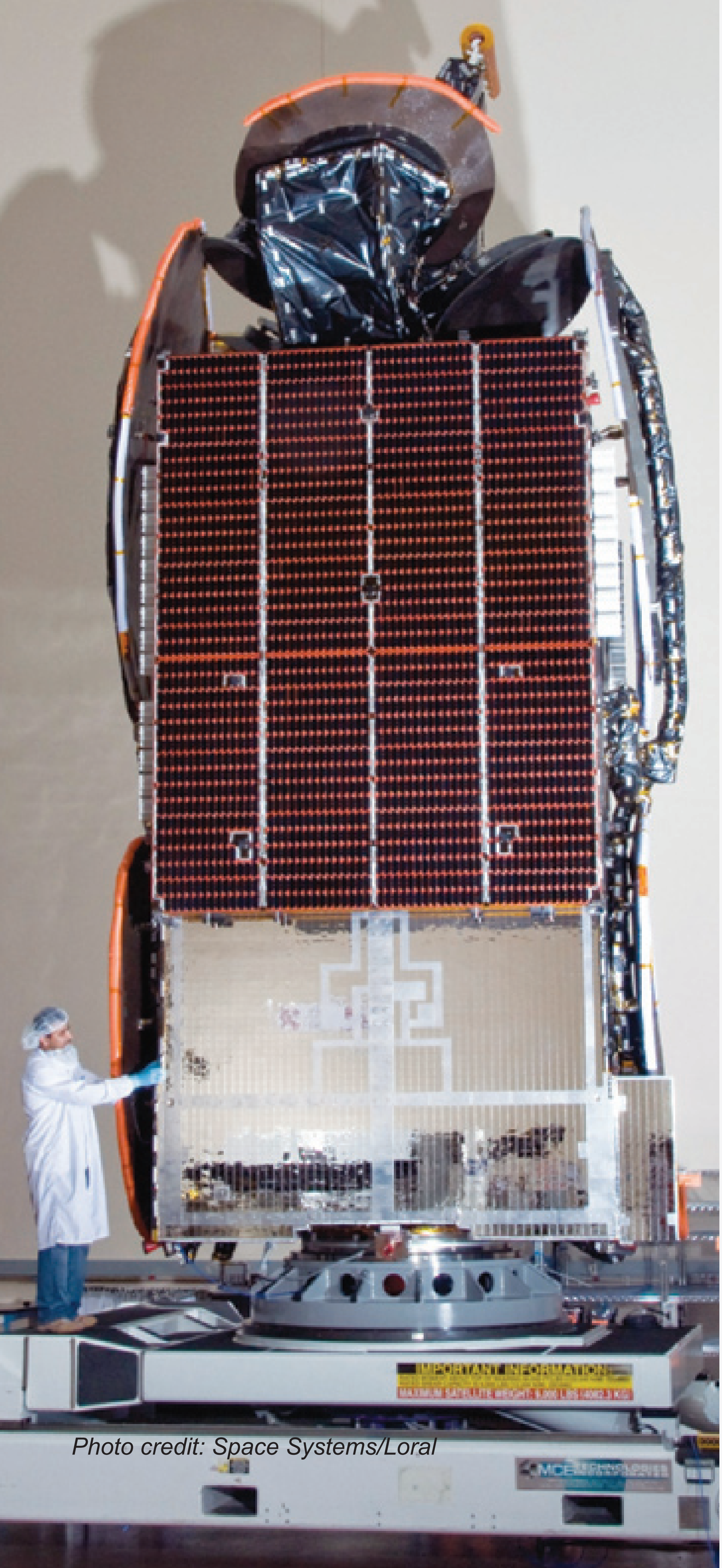
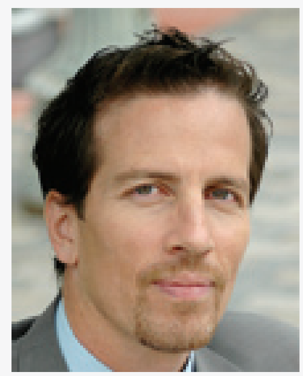


Photo credit: Space Systems/Loral

"The opportunity to transform an entire industry doesn't come along very often," Pelton says. "And the fact that our product isn't delivered on a truck but on a rocket with over a million pounds of thrust is pretty cool, too."

About the author

Laurence Cruz is a freelance writer based in Los Angeles. A UK transplant, he has worked as a reporter with The Associated Press in Seattle and as an environmental reporter for The Statesman Journal in Salem, Oregon. He has a BA in English from Oxford and an MA in Communications from Washington State University.



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MILITARY SA

The "Spirit of Iridum" poster by Robert T. McCall

TELLITE WANS

Gordon Dorworth

HOW TO OPTIMIZE, ACCELERATE AND PROVIDE INTEROPERABILITY

There are many operational and environmental conditions which adversely affect military satellite communications, impairing network performance and consuming valuable bandwidth. While satellite communications enable mobility and communications in remote locations, satellite-based Internet connectivity suffers due to adverse weather, interference, high-latency and transport and application protocol inefficiencies.

Many of these factors degrade throughput, while others limit the amount of traffic that can run over a satellite link. Additionally, interoperability among disparate military networks can jeopardize mission-critical communications.

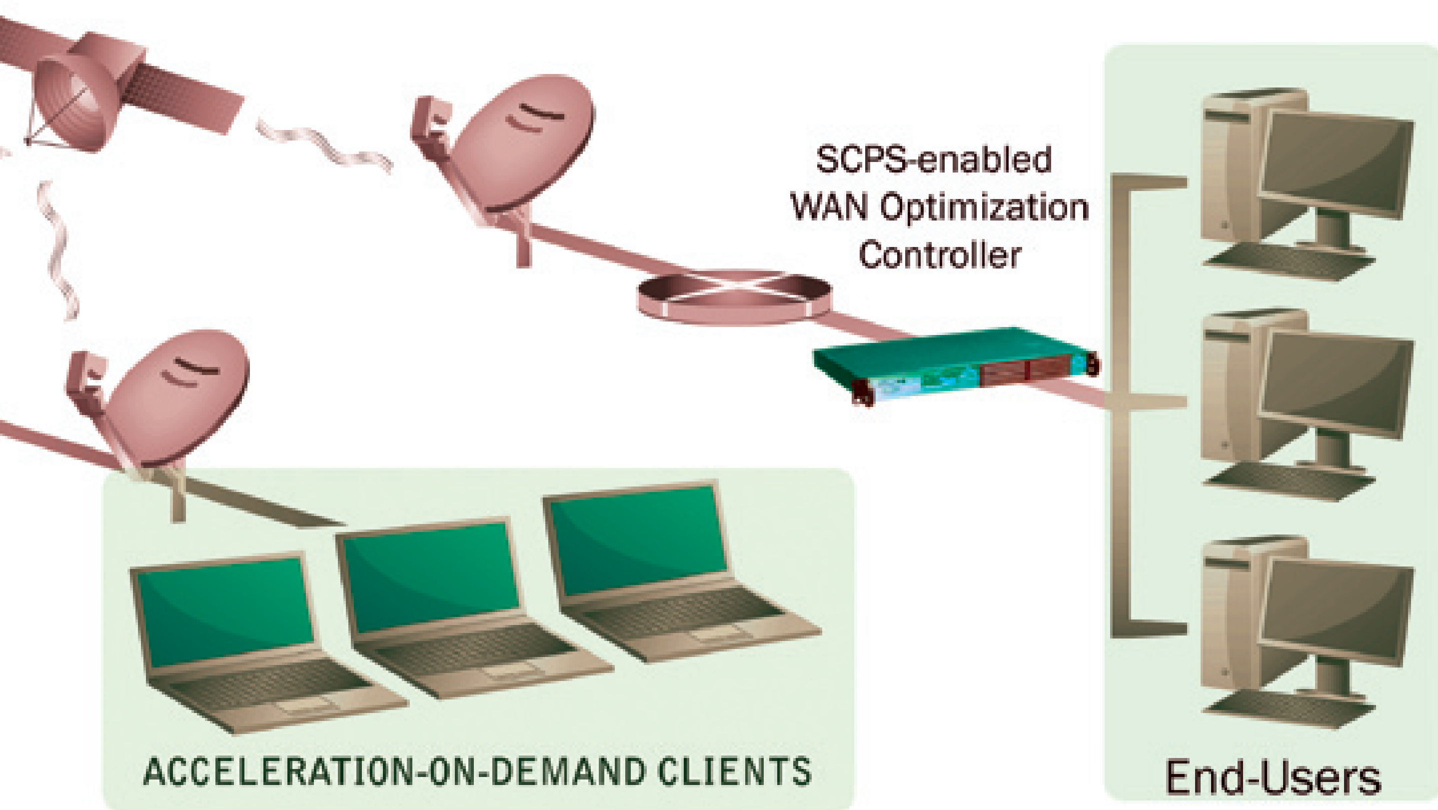
To combat this, **NASA** and the **Department of Defense** (DoD) jointly created the ***Space Communications Protocol Standards*** (**SCPS**) protocol suite that has been deployed throughout the U.S. military. They rely on SCPS-TP to overcome transport protocol interoperability, and enable satellite WAN links to have a greater amount of traffic flow. This helps deliver more reliable satellite links in support of military missions, regardless of the operating conditions.

In addition, the U.S. DoD operates in areas of the world where bandwidth is extremely scarce and expensive. The military is very mobile, and communications can be extremely time sensitive. Providing a comprehensive solution for reliable and fast military communications has become an ever-increasing challenge — balancing security, speed of delivery and bandwidth consumption.

There is an emerging need to combine SCPS-TP and robust WAN optimization and application acceleration features into a single, small footprint solution for military satellite communications. WAN optimization and application acceleration capabilities not only substantially reduce the amount of unnecessary traffic going over a satellite WAN, they also increase the throughput beyond traditional SCPS-TP solutions.

This article details the obstacles faced by military satellite communications, and how solutions that integrate SCPS-TP and WAN optimization are able to provide military and government organizations with greater use

WAN Optimization and Application Acceleration



of bandwidth, and speedy, secure access to mission-critical information needed to do their job, no matter where they are located.

Two essential requirements for improving reliability, performance and interoperability The first requirement is **transport protocol interoperability via SCPS-TP**. As mentioned above, the SCPS-TP protocol suite was jointly developed by NASA and the DoD. However, an SCPS-TP implementation that has become the “defacto standard” transport protocol is ***SkipWare*** from **Global Protocols**, a protocol engineering firm specializing in the development and integration of bandwidth efficient, error-tolerant protocol solutions based on SCPS-TP. SkipWare is the industry’s first commercial SCPS-TP implementation.

The second requirement is acceleration and optimization technologies from companies such as **Stampede Technologies** that provide considerable performance and bandwidth availability improvements for Internet-based satellite communications. Satellite WANs require acceleration and optimization technologies to improve bandwidth utilization, in order to squeeze greater amounts of traffic into a satellite link, and accelerate traffic going over the link to deliver the applications more quickly to the users.

The diagram above shows satellite communications using SPCS-enabled WAN optimization controllers at the head-end and an appliance at one remote site. Software is deployed at a second remote site.

Many of the WAN optimization solutions on the market are not SCPS-TP-compliant, and therefore, they lack the degree of interoperability required by military personnel, while standalone SCPS-TP implementations have limited acceleration capabilities.

However, there are solutions on the market specifically designed to accelerate, optimize and provide interoperability for military satellite communications. These solutions offer the best of both worlds — rich optimization and acceleration capabilities, and integrated SPCS-TP.

WAN optimization solutions with integrated SPCS-TP provide comprehensive optimization and acceleration technologies that work together to address network bandwidth constraints, high-latency, traffic volumes, transport and application protocol inefficiencies, excessive content/object transfers, and application contentions. These solutions can save as much as 75 percent or more of bandwidth capacity, while dramatically increasing the response times experienced by end-users.

The benefits that can be achieved:

- ***Obtain greater value from your bandwidth***
- ***Improve application delivery times***
- ***Improve WAN response times***
- ***Optimize connectivity with any SCPS-TP-based military network***
- ***Reduce the amount of data that is sent over the satellite link — allowing you to send more traffic***
- ***Reduce the number of round trips (for transport & applications) to complete a transaction***
- ***Offload tasks from clients and servers — allowing them to handle a greater amount of traffic***
- ***Secure data and transactions — end-to-end***

Primary Issues

High Latency — Latency reduces the amount of data that can be transmitted through a network link, regardless of how much bandwidth is available. On terrestrial-based WANs, latency can range from 0.1ms to 200ms. However, on a satellite link, latency can be as high as 1,000ms. Because of latency, even though you pay every month for a certain amount of bandwidth, in reality, you may not be getting the full value of the connection.

Latency has significant adverse affects on TCP and web-based applications that require extensive handshaking. For satellite communications, one major challenge with respect to the performance of Internet applications is the latency between two earth stations connected by a satellite. For GEO satellite communications systems, latency is at least 250ms. Beyond the issue of distance; framing, queuing,

and on-board switching can make end-to-end latency as high as 400ms.

Transport Protocol Limitations + Inefficiencies — *TCP has a maximum window size of 64 kilobytes. This requires that for each round trip, TCP only allows 64KB to be sent. For example, sending a 64MB file over a satellite WAN will require 1000 round trips in order to complete the transmission. TCP packets require an acknowledgement (Ack) that they were successfully received before additional packets can be sent. If the round trip time takes 100ms, then that transaction is going to take 100 seconds to complete — regardless of how much bandwidth the link is capable of supporting.*

Chatty Application Protocols — Applications have their own protocols with similar challenges to TCP, and can be even more inefficient. For example, Web pages are comprised of many separate objects, each of which is requested by the user (browser) and retrieved sequentially.

Similar to TCP, a browser will wait for a requested object to arrive before requesting the next one. Web applications can generate hundreds of round trips by themselves. These round trips are in addition to the round trips generated by TCP. Web applications can also have window sizes 15 to 20 percent smaller than TCP, requiring even more round trips.

Solutions

Bandwidth Optimization — *Satellite WAN links can be costly, especially in remote locations and foreign countries where network connectivity options are limited. Bandwidth optimization helps to squeeze more bandwidth into network links. However, as important as bandwidth optimization is, it is also vital to accelerate traffic throughput. Optimizing bandwidth doesn't necessarily help with throughput, particularly on high-latency links and chatty applications.*

TCP Acceleration — *To address the inefficiencies of TCP, WAN optimization solutions manage network connections in several ways to optimize the flow of data and reduce the impact on the network, application servers and end user devices. WAN optimization solutions can maintain a consistent pool of connections (multiplexing) between themselves and the Web application servers. The Web application servers are offloaded from managing the connections, and are isolated from inadvertent session disconnects.*

Using WAN optimization client technology, a persistent connection between the client and the WAN optimization appliance is always maintained, even when browsers close and reopen sessions. These sessions are also multiplexed across multiple connections, improving *throughput and response time. This persistent connection capability is extremely important for AJAX and Web 2.0 applications that constantly open and close sessions as they poll and access various Web services.*

***HTTP Acceleration** — HTTP acceleration enables HTTP browser traffic to be intermixed across multiple "pipelines". All browser activity is optimized, including the network-intensive polling associated with Web 2.0 and AJAX applications. A key advantage of using a WAN optimization client-side implementation is that communication resources can be shared across multiple applications, and all HTTP requests and responses from any application (including multiple browsers) that are intermixed simultaneously across multiple concurrent sessions. HTTP acceleration serves as a platform for the consolidation and aggregation of all web-based traffic from a given client.*

Much as physical "link aggregation" uses multiple Ethernet network cables/ports in parallel to increase network link speeds beyond the limits of any one single connection, HTTP acceleration logically aggregates multiple HTTP protocol streams across a few TCP sessions. Individual objects or pieces of objects can be split into any size and then multiplexed with other object data and reconstructed as needed, which makes HTTP acceleration ideal for converged networks and managed service networks that must deliver mixed payloads consisting of mission-critical applications and other network-intensive traffic.

***Caching** — Caching techniques are used to position frequently requested content and objects closer to the users requesting the data. Caching maintains copies of routinely accessed data to eliminate unnecessary requests to web servers.*

Cache differencing goes a step further and maintains identical copies of the browser's cache on the local WAN optimization device. Intelligent cache differencing understands what data has actually changed, and then transfers only the changed data. The result is less data transferred, improved network utilization, and increased user productivity. An important aspect of cache differencing to be aware of is the ability to perform differencing not only on HTML GET requests, but also on POST requests. This is significant because responses to posts are always marked non-cacheable, and most applications that are based on SOAP and XML (including most AJAX applications) issue SOAP requests via the HTML POST command.

Pre-Caching helps eliminate network bottlenecks, and improve end-user response times. Administrators can define content that is automatically distributed (Pre-Cached) to specific users at off peak hours. During a predefined time, the end-user devices will randomly pre-cache the content, enabling instant access to the information when the user needs it.

Compression ***— Compression eliminates non-essential information from data that is moved from one location to another. The data is then reassembled to its original form after the transfer is complete. Compressing data reduces network traffic and accelerates the delivery of time-sensitive information.***

GZIP Compression is a standard technique used to compress data that is sent to browsers. This is useful for reducing the text portions of pages. However, GZIP is not typically used for attachment compression, or for inbound compression from the browser. GZIP cannot be used to compress HTTP headers, cookies or image data. To accomplish these tasks, bi-directional compression is used to reduce the data size through extremely efficient and intelligent compression techniques.

When a WAN optimization solution is deployed in a two-sided environment (both at the head-end or NOC and the remote sites), bi-directional compression provides compression for HTTP headers, application cookies, text and data objects, JPEG files with image reduction, file attachments and file uploads and downloads.

Quality of Service (QoS) ***— QoS enables the network to use queuing functionality to provide preferential treatment to certain classes of traffic. Traffic Shaping ensures on-time delivery of time-critical information. Traffic shaping allows different TCP ports to be assigned to individual applications. Specific port assignments, priorities and policies can be assigned at the database-level, guaranteeing QoS for mission-critical applications.***

Summary

Military satellite communications are not only vital for mission-critical operations, they are also important for deployed military and government personnel to be able to communicate with family and colleagues back home. Today's satellites use Internet technology that is inherently hampered by TCP and application protocol inefficiencies, latency and adverse environmental conditions that can drastically impair network performance, reliability and bandwidth use. Additionally, open-source standards are critical for ensuring complete transport protocol interoperability among disparate military networks.

WAN optimization and application acceleration solutions that integrate SCPS-TP can substantially reduce the amount of unwanted and unnecessary traffic going over a satellite WAN, while increasing throughput. These solutions are able to provide military and government personnel with fast, reliable and secure access to mission-critical information — from anywhere in the world.

About the author

Gordon Dorworth is the President and CEO of Stampede Technologies, a leading provider of WAN optimization and application acceleration solutions for satellite and terrestrial-based networks.

NETWORK MANAGEMENT — THE NEXT STEP

Wally Martland

Most of the Network Management Systems (NMS) solutions on the market today evolved out of Monitor and Control (M&C) solutions. Operators at an Earth station relied on the M&C system to monitor and control one or more antennas' RF equipment without having to walk amongst the racks in order to determine if there was a failure on any piece of equipment. As network operators acquired or built out more infrastructure to meet the ever growing demand for bandwidth from their customers, M&C systems were forced to evolve into the NMS solutions on the market today.

The goal of the network management system was to provide operational efficiencies by allowing the operator at a Network Operations Center (NOC) to monitor and control all the equipment that comprised their transmission network, regardless of geographical location, from a single location or in some cases, a primary and a back up location.

Today, this goal has largely been realized as many network operators have the ability to manage all the equipment that comprises their network from a single Operations Center.

This is accomplished from a NMS graphical user interface which typically consists of a map-based overview with graphical icons depicting each of the sites that make up the operators' network. These icons are colored coded to represent the status or "health" of the equipment at the site. By drilling down into a site, the operator is presented with a block and level display for each of the antennas located at the site (*see figure 1, below*).

Operators are able to identify when any of the equipment fails through the use of pop-ups

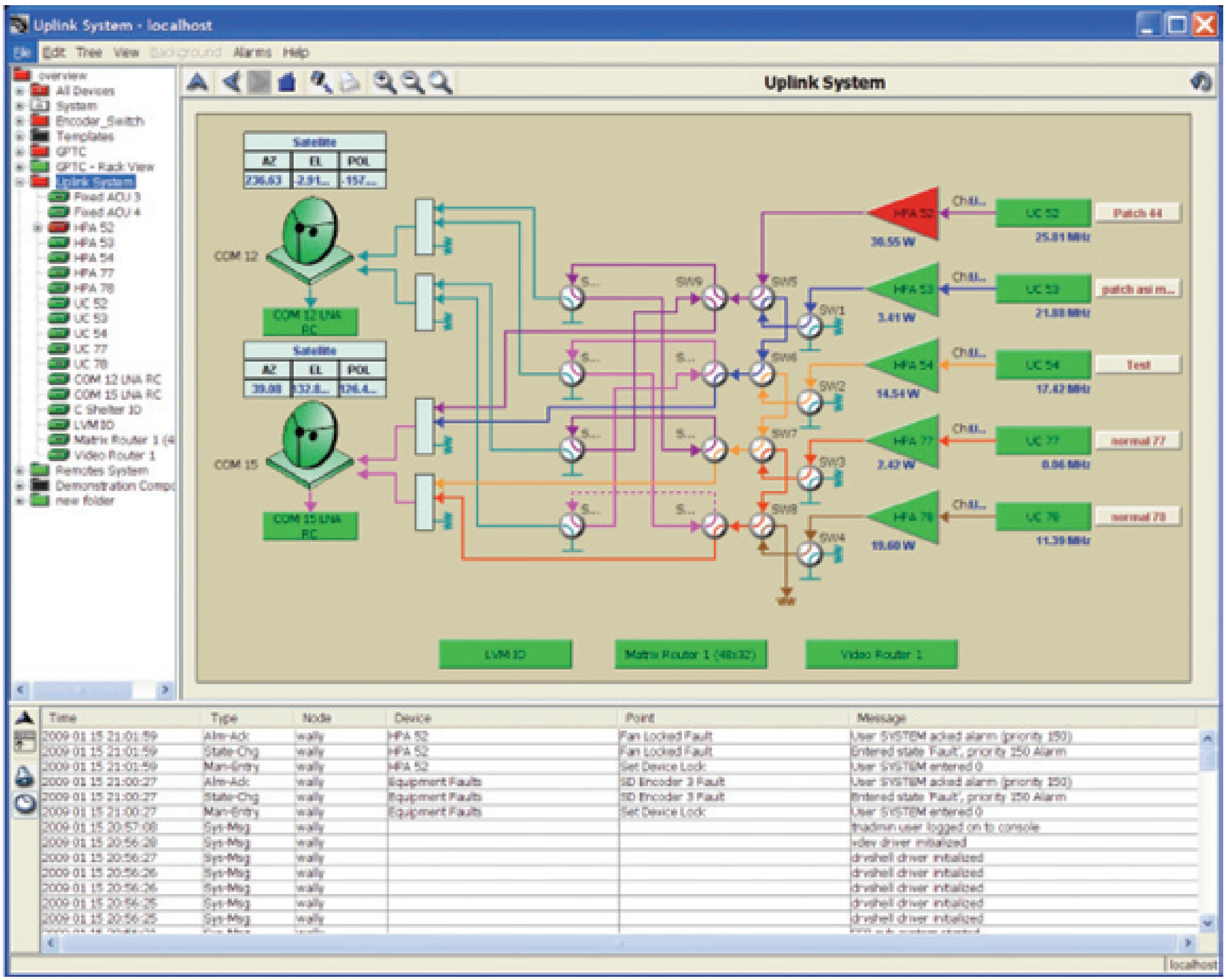


Figure 1 – Traditional NMS Block and Level Display

and changing icon colors that are displayed based upon equipment or site status. More importantly, they are able to recover from equipment failures via the NMS without having to dispatch a technician to site. In the event they cannot resolve the issue via the NMS, they can determine the most likely cause of the problem and dispatch a technician to the remote site equipped with the appropriate tools and parts to repair the issue. Not only does this make them more efficient in the operation and maintenance of the network, but it also saves significant costs in doing so.

But network operators today are faced with new challenges. Customers are demanding not only more capacity, but also higher reliability from their network providers through complex Service Level Agreements (SLAs).

Today, it is not uncommon to see reliability requirements of 99.995 percent or greater on the network. This is coupled with increased competition as more network operators enter the market. Although the NMS does allow operators to recognize and recover services by alerting them to equipment failures and allowing them to correct them from the console, the NMS does very little to communicate to the operator what the REAL impact is of these equipment failures. The basic problem is this — the NMS is still simply managing the equipment, while the network operators are trying to manage their services in an effort to maximize the network revenue based upon the SLAs they have established with their customers.

At **Newpoint Technologies Inc.**, a wholly owned subsidiary of Integral Systems Inc, we

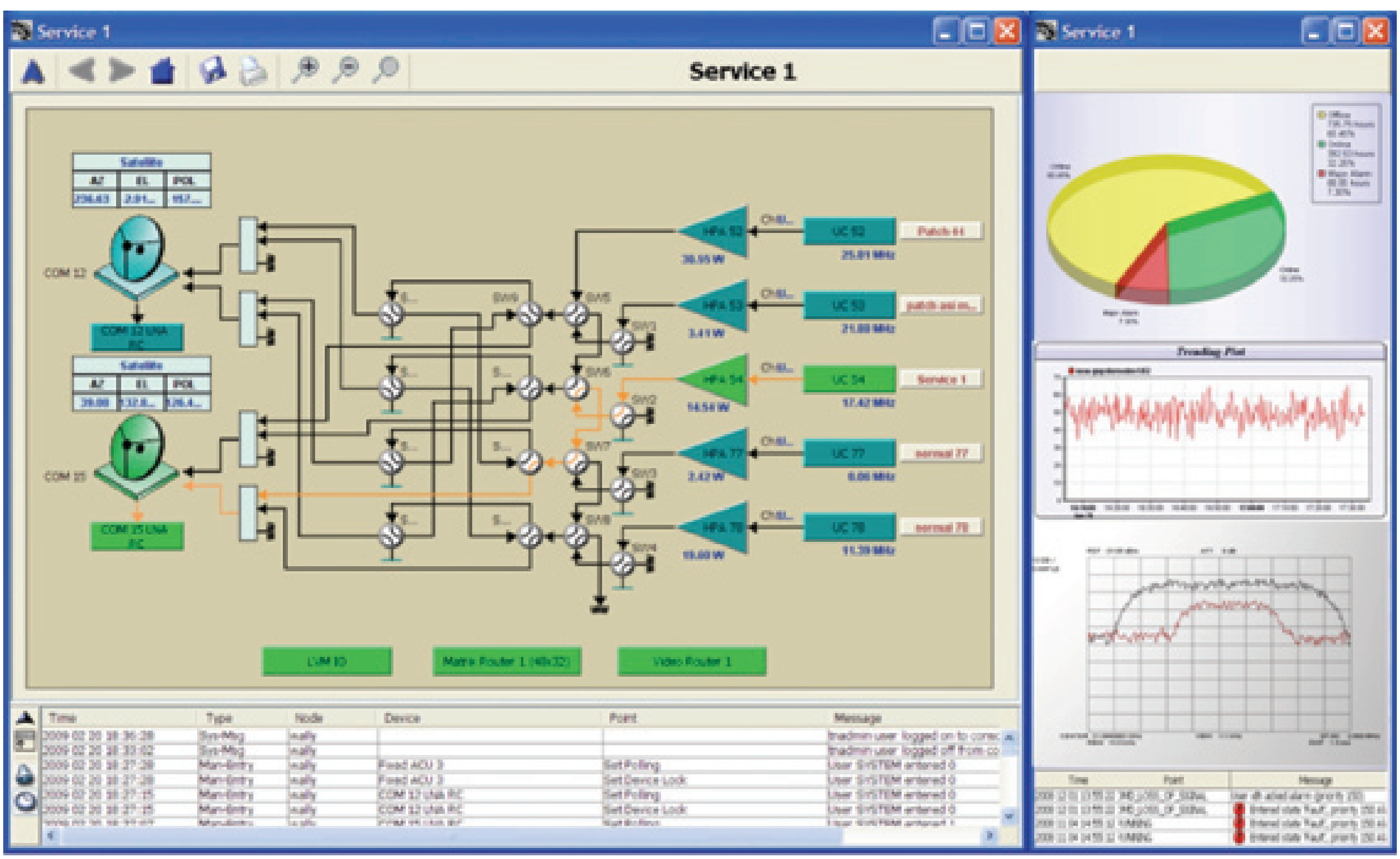


Figure 2 – Service Management Display

are working hard to close the gap between what the network operators require and what the current NMS solutions offer. Newpoint is introducing a new Service Management Module to our industry leading Compass/TrueNorth Network Management Solution. The TrueNorth Service Manager takes the NMS solution to the next level by allowing operators to not only continue to view the network as they do today using the traditional block and level displays (figure 1) but also provides them views for each of the services that are running on the network. These service views provide an origination to destination view of only the specific equipment associated with the transmission of the service (*see figure 2 on the previous page*).

As online units fail, and standby units are activated, the service displays are automatically updated to reflect the new transmission path for the service. When there is an alarm in the system because of an equipment failure, operators are alerted to not only the fact that a piece of equipment has failed, but also to what "downstream" services are affected by the equipment failure.

By allowing operators to assign priorities to the individual services based upon the established SLAs that they have setup with their customers, operators can quickly distinguish the high revenue generating services from the low revenue generating services and elect to recover the higher priority services first, and then work on the lower priority services. In the event that the equipment failure has left the network short on capacity to carry all the services, lower priority services can be replaced with the higher priority services until spare equipment can be put in place.

To assist operators in the activation and deactivation of services, or in moving services from one transmission chain to another, profiles can be stored for each of the services which contain the parameters needed to be set in the equipment to bring the service online. To bring a service up using profiles, the operator only has to select the equipment to be used for the service transmission, and the profile to be applied (a service could have more than one profile), and the software will execute the set up of the service by downloading the profile to the equipment and verifying the profile has taken. If an error occurs along the way, the operator is prompted and required to take action to resolve any issues.

Once the concept of services have been introduced into the NMS, the operators are provided with powerful reporting tools which can be used to provided feedback into the SLA Management or Billing Systems. This includes detailed information on when the service was activated and deactivated over any given time frame, what alarms occurred while the service was running, and how long the service was down or degraded while it was active, etc.

Managers can have this information rolled up to a system view and see network usage statistics. For example, on average how many services were running on the network at any given time, how many services were offline due to equipment problems when they should have been active, how much spare capacity is on the network at any given time, etc.

Network Management Systems can no longer afford to be focused on only equipment failures, but must provide more information and tools to allow them to do their job even more efficiently and effectively. Operators are required to manage the services on their networks and their NMS should assist them to do just that. By introducing service management concepts into the equipment focused NMS, operators can make important decisions which minimize the revenue impact of equipment failures. Furthermore, the NMS can provide key indicators on the performance of the network and identify short comings on the network which should be addressed. The service based NMS is an essential part of managing any network.

About the author

Wally Martland is the President of Newpoint Technologies, Inc., a wholly owned subsidiary of Integral Systems, which provides Satellite Command and Control, Network Management, and Carrier Management software solutions to the satellite communications and broadcast marketplaces. Wally has over 19 years experience in providing Network Management and Remote Site Monitoring Solutions to the Satellite, Microwave, Transmitter, & SCADA marketplaces.

ROBERT WRIGHT, JR.

SENIOR VICE PRESIDENT, INTEGRAL SYSTEMS

Robert Wright, Jr., (U.S. Air Force Colonel, retired) is the Senior Vice President of Integral Systems' Military and Intelligence Group. Before assuming his current role, Colonel Wright served as Commander of the Space Innovation & Development Center at Schriever AFB, Colorado. His long career in space and communications includes commanding two communications squadrons and a communications group, including a one-year deployed tour supporting Operation Southern Watch. He held several key staff positions, including Executive Officer to the Director, National Reconnaissance Office, as well as aide-de-camp and Executive Officer to the Commander, United States Central Command. Colonel Wright has earned numerous awards and decorations including the Legion of Merit, the Defense Meritorious Service Medal with one oak leaf cluster, and the Air Force Commendation Medal.

> ***"I think continued augmentation through commercially leased services is inevitable, but with caveats. Commercial providers will certainly augment bandwidth shortfalls, and they are in a good position to help. We will also see the emergence of commercially-based Internet protocol routing in space..."***

MilsatMagazine (MSM)

Colonel Wright, how did you initially become involved in space communications? Why was a career path in the U.S. Air Force in this space segment so appealing?

Colonel Robert Wright

I could not fly for medical reasons, so I opted to be involved in the United States Air Force (USAF) space program. My initial assignment after graduating from the USAF Academy was to Space Division's ***Launch Vehicle Directorate*** at **Los Angeles AFB**, where I learned the Department of Defense (DoD) acquisition process in space launch and upper stage acquisition programs (*i.e.*, ***Titan 34D***, Inertial Upper Stage).

After a few years, I transitioned to National Security Space programs, and became exposed to the critical operations of the worldwide ***AF Satellite Control Network*** (**AFSCN**) and certain communications relay platforms. The appeal was in the technology and, later, in seeing the growing reliance on military and commercial satellite communications during the first Gulf War — the vast potential for support to fielded forces was daunting.

I later moved to the Pentagon and worked at a variety of space-related jobs, including *Program Element Monitor* for national security space system protection initiatives, supporting space event conferences, supporting the **National Reconnaissance Office**'s first *Deputy Director for Military Support*, exposure to the ***Defense Reconnaissance Support Program*** and ***Air Force Tactical Exploitation of National Capabilities Program*** (**AF TENCAP**), and serving as executive officer to the *Director, National Reconnaissance Office*.

In particular, I credit two managers during those years for keeping me engaged in this business — Brigadier General *Don Walker* (former Commander, *AF Satellite Control Facility and Director*, *Office of Space Systems*, *Office of the Secretary of the Air Force*) and *Martin Faga* (*Assistant Secretary of the Air Force for Space*, and Director, National Reconnaissance Office).

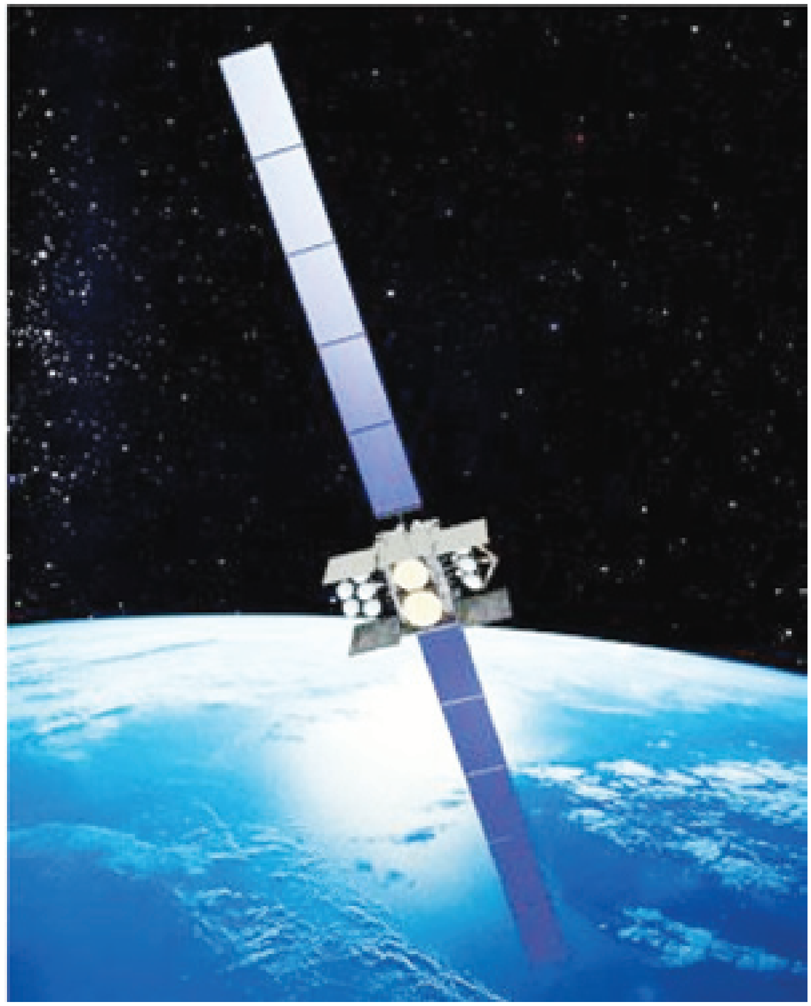
In 1994, I made a decision to transition from national security space programs to AF installation level, fixed based communications, and information technology systems, which still involved MILSATCOM fixed and mobile maintenance and operations. From there, I held a series of squadron and group-level command jobs that were the best jobs anyone could be privileged to have experienced.

I wouldn't have selected any other career path. Space communications technology is still appealing today, whether it's moving large amounts of data or incorporating and integrating COTS products.

For example, we've dramatically improved capacity and capability in fielding the new ***Wideband Global SATCOM*** (**WGS**) system. We've expanded from primarily X-band and UHF communications to Ka-band, incorporated phased array antennas, digital channelizers, and more steerable beams. These capabilities markedly improve support to fixed and mobile forces, while the Service acquisition community continues to speed up capability delivery dates to combatant commanders.

As exciting as the technology is, we've moved from a pure technology fascination to a better understanding of the importance of the data, of mission assurance, and threat analysis. Each day, we work, socialize, conduct commerce transactions, and go to school in the space and cyberspace domains. These domains are contested, so it really is about the data — data protection, data management, data exposure, data fusion, data dissemination.

My former boss, General *C. Robert Kehler*, Commander of **Air Force Space Command**, in partnership with *Scott Large*, former Director, National Reconnaissance Office, worked diligently to support the Space Protection Program, to address the importance of architecture and engineering solutions to existing and potential space and cyberspace threats and vulnerabilities — to ensure we are always postured to stay ahead of the threat.



WGS-3 satellite

I was very fortunate to be part of a team, under General *Kehler*'s vision that planned and executed the ***Schriever Space Wargame***. We leveraged observations and lessons from these wargames over the years to move the focus from technological capabilities of space systems to influencing development of National Space Policy and strategy, integrating commercial, interagency and Allied cooperative efforts, and influencing future investment decisions through the *Space Posture Review*, for example. The next Schriever wargame will focus on the intersection of space and cyber operations, continued policy and strategy examination and leveraging Allied and industry partnerships.

MSM

When you started your career, what was the major technology at that time as far as MILSATCOM was concerned? Looking back upon your Air Force command path, what was your most interesting assignment?

Colonel Robert Wright

The technology in those days seems rudimentary compared to today's capabilities. I recall the first ***Defense Satellite Communications System-III*** launch in 1982. **DSCS** was the DOD's primary long haul MILSATCOM program — *Super High Frequency* (**SHF**) capability. The ***DSCS-III*** had a 10-year design life then, with fixed and steerable antennas.

The U.S. Navy had ***UHF Fleet Satellite Communications*** programs. The first ***MILSTAR*** satellite, incorporating survivable and protected communications and cross linking capabilities, wasn't launched until 1994. MILSTAR featured low- and medium-data rate communications and antijam. From a ground perspective, I recall the decision to standup the *Consolidated Space Operations Center* (**CSOC**) at **Falcon AFB** (now **Schriever AFB**) east of Colorado Springs, for mission assurance reasons. In those days, vulnerability of the ground C2 segment to potential physical attack was a concern, so we built remote backup and mobile/transportable capabilities.

I've thoroughly enjoyed every assignment I've had, but my most interesting and challenging assignment was my year long squadron command tour at a remote location in Saudi Arabia. I worked alongside many dedicated, young, enlisted Airmen each day. These men and women were the experts in SATCOM systems operations and maintenance, as well as leading edge networking technologies.

We relied on satellite and troposcatter communications capabilities to link with Riyadh and other locations throughout the Middle East. It was my first of four command assignments, and my 250-person squadron was responsible for operations and maintenance of all military terrestrial and space communications in and out of the peninsula.

Additionally, we operated a network control center, cable television services, airfield precision approach radars, stood up a technical control center, operated a NORTEL telephone switch, a tactical telephone switch and imbedded all fiber backbone communications supporting the new housing complex of several thousand personnel.

MSM

You have witnessed many technological advances during your 30 year military career, giving you great insight into how our industry operates and grows. What do you see as the most important technological support for warfighters in the next few years? And how will such assets be protected from intrusion by those who would do us harm? How will your role at Integral Systems assist in this endeavor?

Colonel Robert Wright

We continue to look for game-changing technology applications, working with research labs, academia and industry to expose these potential technologies to manage, expose and deliver vast amounts of data. I believe we need to focus on the needs at the edge — the Soldier, Sailor, Airman and Marine, in the fight. We will move to deliver applications on ***iPhone***-like devices in the hands of individuals in the field, reducing the fog of war, enhancing situational awareness and enabling effective command and control.

DSCS

We're still in early innings of virtualization and cloud computing in military applications. There is a growing understanding of the importance of non-kinetic options in warfare. We need vastly improved operational-level situational awareness capabilities for integrated space and cyberspace operations. The need for modeling and simulation capabilities grows, especially in understanding the interrelationship between space and cyberspace. There will be a continued emphasis on robotics, unmanned air vehicles, autonomous operations, plug and play interfaces and *commercial off-the-shelf* (**COTS**) solutions featuring lower costs, rapid fielding and scalability.

We also understand our networks and data are constantly under some type of probing, intrusion, denial of service or attack, but we cannot realistically protect everything — not every node on the network. Our framework is to understand the critical infrastructure and information, develop proactive rather than reactive capabilities and policies to "fight through" and preserve operations.

At **Integral Systems** I will help deliver the innovative, scalable products and engineering solutions to both the military and commercial sectors to meet the needs discussed above. We are platform agnostic and listen to our customers' needs in order to offer tailored solutions. We're proven design, engineering and integration solution leaders and will expand our penetration into markets beyond satellite command and control.

MSM

How has your command experience as the Vice Commander of the 14th Air Force, as well as with communications squadrons and groups, prepared you for your role at Integral Systems? Will your past work in the Air Force assist you with your new civilian endeavors on behalf of your company with government and military procurement agencies?

Colonel Robert Wright

Certainly my experience in acquisition and operations will help in my new industry role. At **14th Air Force**, my timing there allowed me to support Lieutenant General *Shelton* (14AF/CC and the Commander, J*oint Functional Component Command*, *Space*) as we supported the *Joint Space Operations Center*, outlined fundamental space situation awareness and intelligence requirements at the operational level, articulated the need for a high accuracy catalogue, defined net-centric and data fusion opportunities, and worked a host of issues including integrated joint operations, space command and control relationships, satellite interference identification, detection and mitigation.

From a leadership and command perspective, I've been privileged to lead organizations implementing large scale fixed-base backbone network transitions from copper to fiber to *Voice over Internet Protocol* (**VoIP**) — both in CONUS and in combat zones overseas. I've led organizations responsible for operations and maintenance of fixed DSCS, AFSATCOM and MILSTAR ground terminals, as well as deployed with critical mobile command and control capabilities. My two assignments in the Pentagon on the SAF and HAF staffs, in HQ **Air Force Space Command**, in **Air Combat Command**, at HQ **US Central Command** and the **National**

Reconnaissance Office provided important insights as well. I've been fortunate to have been exposed to the rapid pace of information technology evolution at the circuit and application layer throughout my career — driven by *Moore's Law* — on the acquisition and operations side of the business. I understand the challenges that acquisition professionals have to quicken capability delivery to warfighters.

My most recent command tour at the **Space Innovation and Development Center**, with **AF TENCAP** as a direct reporting unit, gave me an even greater appreciation of the importance of integrating rapid, innovative, small dollar solutions with existing capabilities through architectures and concepts of operations and employment. Each of these experiences are building blocks to what I am doing now in industry, as we partner with various government and commercial customers to provide them the capabilities they need. I hope to be a part of the solution to these requirements and challenges. The move from military command to the civilian work force can be a tricky road to navigate — how did you manage such so successfully.

The jury's still out on my transition, but I firmly believe the leadership challenges are similar — building a sense of teamwork and a clear articulation of vision, strategy and goals remains paramount, as does creating a work environment where valued staff and technical professionals are challenged, recognized and rewarded for producing innovative solutions sets to meet our customer's needs on time and cost. As we have always done in the military, in the private sector we strive to recruit the best talent, nurture it, and emphasize responsive support to our government and commercial customers.

MSM

Can you give us an update on Integral Systems' Command and Control Systems – Consolidated (CCS-C) support of Wideband Global SATCOM?

Colonel Robert Wright

CCS-C's support to ***Wideband Global SATCOM*** (**WGS**) has been outstanding from the acquisition (***Space and Missile Systems Center — SMC***) and operations (***50 SW*** at **Schriever AFB**) perspectives. On June 15, 2009, we seamlessly cutover ***WGS Satellite Vehicle-2*** to CCS-C, our second WGS satellite. Going forward, our next opportunity for seamless cutover will be on February 25th for the recently launched ***WGS SV-3***.

Our continued focus to improve CCS-C's automation capability has and will enable the Air Force to recognize efficiencies in their manpower utilization. The successful transition of legacy and future MILSATCOM satellites onto CCS-C, including ***Defense Satellite Communication System*** (**DSCS**), ***MILSTAR***, ***Wideband Global SATCOM***, and the soon-to-be launched (2010) ***Advanced Extremely High Frequency*** (**AEHF**) satellites, in conjunction with ground breaking operational efficiencies gained, are a testament to the ongoing success of CCS-C and representative of an exceptional Air Force and Integral Systems partnership.

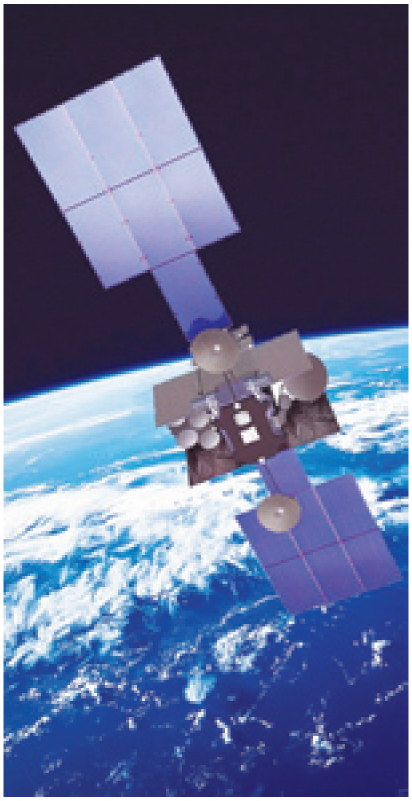
MSM
How are these new generation military communication satellites enhancing our warfighting efforts globally?

Colonel Robert Wright
The United States ability to conduct military operations worldwide is enabled by satellite communications. These next generation systems will enhance the ability of all levels of command, strategic to tactical, to communicate near real-time and with clarity, through both voice and video. Global SATCOM enables remote operations of intelligence, surveillance and reconnaissance platforms, integrated sensor-to-shooter capability, and delivery of real-time intelligence and situational awareness to all levels of command.

Regardless of theater, the worldwide capacity and throughput improvements by WGS and AEHF will be significant for all Services. One WGS satellite's capacity replaces the entire DSCS constellation. Once on orbit, three AEHF satellites in geosynchronous orbit will provide ten to one hundred times the capacity of the existing MILSTAR satellites. The terminal segment will be fixed and mobile, on ships and submarines, and on airborne platforms, and will include the ***Family of Advanced Beyond Line-of-Sight-Terminal*** (**FAB-T**), used by all of the Services and several international partners.

MSM
How are the current Defense Budget pressures affecting MilSATCOM procurements?

Colonel Robert Wright
Budget pressures are a reality for MILSATCOM and other mission areas — driving innovative, cost effective, scalable solutions for today's war, and tomorrow's. Industry, will lead in deriving viable solutions.



Having said that, we saw last year's cancellation of the ***Transformational Satellite*** (**T-SAT**) program, and the subsequent decision to procure additional AEHF satellites. **DISA** is restructuring the existing *DISA Defense Information Systems Network* (**DISN**) *Satellite Transmission Services-Global* (**DSTS-G**) contract to include more commercial suppliers.

MSM
Do you see the role of Commercial Satellite Communications expanding to augment growing Government communication needs?

Colonel Robert Wright
I believe continued augmentation through commercially leased services is inevitable, but with caveats. Commercial providers will certainly augment bandwidth shortfalls, and they are in a good position to help. We will also see the emergence of commercially-based Internet protocol routing in space, for example. But certain specific military

requirements for jam resistant, survivable and protected communications and so forth, commercial providers won't be the solution. The Air Force will buy more AEHFs for those specific needs, for example.

MSM

Are commercially hosted payloads a viable approach to augment communication needs?

Colonel Robert Wright

The Air Force has been investigating commercially hosted payloads for some time, and I believe a dual-use approach is not only viable, but in fact, working today. As I understand it, the Australian **Optus** and ***Defense C1*** satellite system has 24 Ku-band transponders for commercial use, which are revenue-generating for Optus. The system also hosts UHF, X-band and 6 Ka-band transponders which are not only available to, but are controlled by, the **Australian Defense Force** (**ADF**).

MSM

With such an increasing reliance on Commercial Satellite Communication links; What are your thoughts on how to protect these vital communication links or more appropriately, provide communication assurance for commercial satellites?

Colonel Robert Wright

Under the current DISA *Defense Information Systems Network* (**DISN**) *Satellite Transmission Services-Global* (**DSTS-G**) contract, mission assurance requirements were levied on each of the three companies providing commercial bandwidth services for DOD use. In the upcoming *Future COMSATCOM Services Acquisition* (**FCSA**), which replaces the DSTS-G, communications assurance requirements are planned to be dictated by *Service Level Agreements* (**SLA**).

As many vendors are likely to be involved, it will be challenging for DISA or STRATCOM to have a single, integrated picture of link quality, interference issues, or other integrated situational requirements. Likewise, it becomes even more difficult to validate that SLA requirements are being met. This is one of the many reasons that Integral Systems recently initiated a new group within the company, ***Integral Systems Service Solutions*** (**IS3**), to address these needs. Among its offerings, IS3 will provide an independent service for monitoring link performance across the vast commercial communications satellite constellation, and provide consolidated situational awareness and SLA validation capabilities to the agencies within the Government (DISA and USSTRATCOM) which are responsible for overall mission assurance.

EPOCH Suite

MSM

What role do ground segments provide in communication link management and communication assurance?

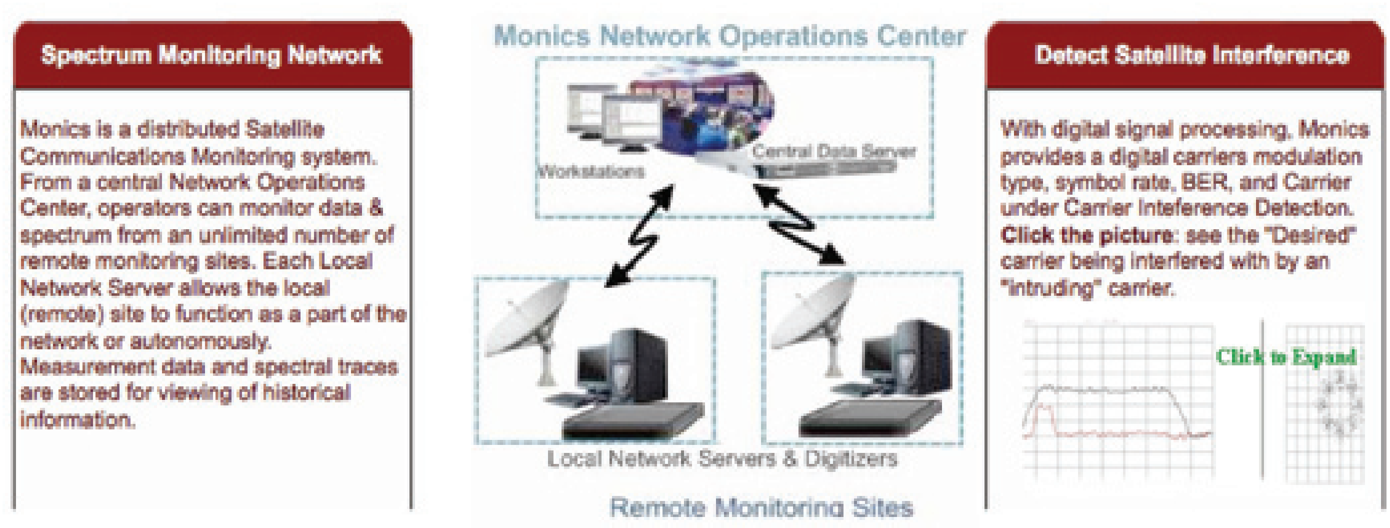
Colonel Robert Wright

There are many aspects of link management and communications assurance, from independent monitoring, to the correlation of independent monitoring information, to satellite payload health information that are derived from telemetry. Likewise, it becomes increasingly important to have real-time information about the ground terminal segment health so that link anomalies can be quickly resolved. Over the past few years, Integral Systems has more closely integrated our *SATCOM Network Operations* (**SATCOM NetOps**) products, and now services that provide this type of real-time management information to ease the challenge of correlating often dissimilar inputs into a single integrated picture. This is precisely the integrated situational awareness picture provided by IS3's subscription-based services offering.

Currently, our ***EPOCH*** Product Suite is being used to operate many of the commercial communications satellites and (via the CCS-C system) most of the nation's military communications satellites. Our ***SAT Monics*** interference detection software and our ***satID*** geolocation software lead the industry for satellite communications assurance.

Our leading-edge front ends, receivers, and digital communications products have become the industry standard for ground segment hardware. Our engineering business processes are tailored specifically to efficiently and effectively developing ground segment solutions.

Most important, our people: Integral Systems has consistently brought together some of the best talent in the ground segment industry — proven results-oriented professionals.



BO NORTON

VICE PRESIDENT, VIZADA

Bo Norton joined Vizada in 2003 and is responsible for all facets of service and support for Vizada's service providers, distributors and agents working with all US government agencies. At Vizada, Norton was responsible for developing a number of key industry firsts including the first L-band Aeronautical Leasing Program for the Closed User Group (CUG) in conjunction with Inmarsat and a key Service Provider partner. Now in its second year, this growing leasing program provides assured access for government customers all over the world and around the clock.

Before joining Vizada, Norton served as vice president of business development and operations for ADC International, a firm specializing in mobile satellite communications to the United States government. Prior to that, he was responsible for all new commercial and government business development for Military Advantage, Inc.

Norton is a former senior United States Naval Officer and Aviator. He has held a number of critical leadership and staff positions in the U.S. Armed Forces, including serving as a Air Wing Commander and Squadron Commander in addition to positions in a number of major Naval organizations in the U.S. and overseas. He has earned numerous personal and professional awards while serving in these positions.

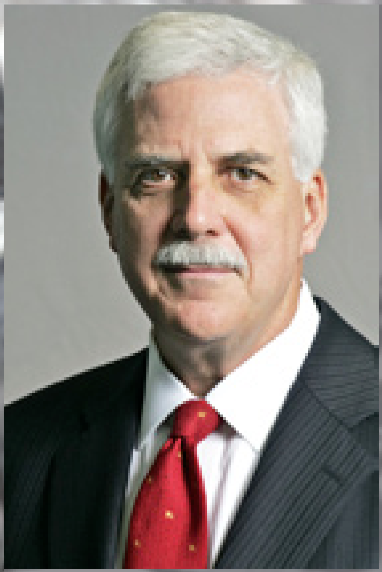
MSM

What is the correct mix of services for communications-on-the-move? Does this combination of technologies differ greatly, depending upon the service in question?

Bo Norton

While the trend in the commercial market in the past has been a gradual migration from L-band services (Inmarsat and Iridium) to Ku-band services, we are now seeing that the increasing throughput capabilities of the new 4th generation L-band services (Inmarsat and ThurayaIP) are causing customers to reconsider their options.

It has always been our position that in order to meet the breadth of our customer's global requirements, we have to be able to offer the full range of satellite services, whether it be L-, Ku- or C-band. Consequently, our challenge has been to stay out ahead of the requirements with regard to capacity so that as customers' satcom applications grow, we can meet them. To date, we have been successful as both commercial and



government markets have grown significantly.

Of the two most popular SATCOM technology bands, L- and Ku-, L-band is globally available (albeit on a contended basis) using standardized, lower cost, equipment and is more resilient to interference and atmospheric impairments. However, for higher bandwidth applications operating in specific theatres, Ku-band services can offer significantly better performance with much lower operating costs.

Unfortunately, there are still significant regional availability challenges for Ku-band services in some areas. For the government customer, it really comes down to selecting a provider with a wide variety of products and services whom they can trust to offer the correct solution in an unbiased manner. Through its extensive service provider network, Vizada offers the U.S. Government access to the right mix of products and service choices to meet their requirements.

MSM

How do you see COTM playing its role in both the ground and air (UAV/UAS) segment for our military services? Will COTM replace COTH over the next year or so, making hostile environments safer for folk with boots on the ground?

Bo Norton

The deployment of COTM solutions (over COTH) on the ground and in the air is limited only by the technology which is required to support it. COTM applications require small remote antenna equipment which can be mounted on a variety of moving platforms and transmission protocols which allow these smaller antennas to operate efficiently without introducing adjacent satellite interference. COTM as it exists today, is an evolution of several generations of SatCom technology. For example, the forgiveness of L-band, coupled with Inmarsat protocols and standardization has allowed for COTM deployments for many years. However, these applications have traditionally been limited in terms of data throughput.

To address larger throughput requirements, C-, Ku- and other forms of VSAT systems have been deployed. However, it is not until recently that advancements in communication protocols and antenna technology has allowed these systems to lock onto narrow VSAT signals as the vehicle is in motion. The need to “halt” obviously increases operator vulnerability and spurred the need for new technology to overcome this limitation. Today, the latest generation of Inmarsat equipment significantly increases data throughput performance while the latest generation of some VSAT technology addresses the need to stop the vehicle. As the technology has improved, so has the safety factor of the troops on the ground.

MSM

How can latency and capacity issues be resolved, especially in war fighter situations?

Bo Norton

The lion share of latency in any satellite communication network is dictated by physics, so network architectures which optimize communications for the war fighter generate the most interest. For example, the ability to deploy remote-remote communication (*e.g.,* single-hop or MESH) in lieu of the more traditional double-hop can cut latency in half.

Another way to minimize latency and jitter is to terminate the war fighter's traffic using the most direct path between the ground station and the target terrestrial network destination, using private, leased or other facilities which support prioritization of real time traffic and QoS. With respect to capacity, constraints are driven by network usage and satellite limitations.

The workarounds we offer our customers include access to multiple satellite network operators, assured access through leasing arrangements, prioritization and the use of our extensive network architecture.

However, in regions with limited satellite capacity and a large amount of commercial and government activity, congestion will continue to be a challenge for the war fighter.

MSM

Is COTM becoming more important for first responders and NGOs and how will such be used?

Bo Norton

In short, yes. We continually see the need for mobile satcom in crisis situations to provide the necessary flexibility for first responders to meet critical communication needs. Of note, first responders take a lot of cues from the military on technology, and they typically follow the military's lead when it comes to satcom usage. Over the last decade, both first responders and complimentary NGOs have become more aware of these capabilities through such situations like Hurricane Katrina and 9/11 where traditional mobile and landline communications networks were not available. Being able to offer a reliable emergency communication solution to form the critical link in their communication plans is absolutely key to many of the nation's premier first responders and support organizations such as The American Red Cross, The National Guard and Global Relief Technologies. At Vizada, we have invested a tremendous amount in training these groups on the applications and benefits of satcom solutions.

MSM

What is changing in regard to the military's use of commercial satellites and how do you see that continuing to evolve?

Bo Norton

In my opinion, the biggest change is the realization that the government cannot meet its own satcom bandwidth requirements through DoD satellites due to budgetary constraints and the lead time to design, fund, build and launch a military satellite system. As a result, the government is increasingly relying on commercial satellite operators to provide the necessary L-, Ku- and Ka-band capacity. Interestingly enough, the U.S. Defense Information Services Agency (DISA), which is charged with providing and leading the requirement for U.S. Department of Defense (DoD) communications, will tell you that 80 percent or more of the communications required by the U.S. DoD are covered through commercial satellites. At the same time, certain theatre commanders will tell you that that figure is actually higher in their AORs.

With the constant push for more bandwidth, usage flexibility, new and innovative solutions to help the U.S. government do its job, where does that leave Vizada? In short, a very enviable position as we have worked with our service providers and government customers to develop unique solutions to meet their requirements. These are embodied in our Vizada Solutions Certification Program and offered free of charge to them. It is my belief that we will see more of this type of public/private collaboration in the future as the need for rapid solutions accelerates. To that point, Vizada is in a prime position to provide this high level of service.

MSM

How do you ensure security in satellite communications for military usage? For the U.S. Navy, will COTM also play a role with communication buoys?

Bo Norton

Primarily through providing world class, highly reliable network integrity so that customers can run their own encryption devices with confidence. In addition, we can also provide the "last mile" connections to ensure end-to-end connectivity as required. With regard to Navy communication buoys, we work closely with our satellite network operators to ensure highly reliable connections are always available regardless of buoy location.

MSM

Having served your country as a naval officer and aviator, how did you manage the transition from the military environments to those of the commercial world? How did your Navy career prepare you for the business world?

Bo Norton

As with any leadership position, you take certain skill sets with you when you leave the military. In my case, these skills had to be melded with learning how to successfully operate in the commercial business sector. Luckily, I had mentors in both the military and commercial worlds who helped me do this and provided me with the opportunities to prove myself.

Here at Vizada, we have a team of professionals on the Government sales team with similar backgrounds so they fully understand how the government and business sectors operate. In my opinion, this has been the key to our success in meeting the customer's needs.

Frankly, I do not understand how any company can hope to be successful in the government market without such a knowledge base. You have got to know how things are done in the government and military and how to work around roadblocks in order to succeed.

MSM

Exactly what is the L-band Aeronautical Leasing Program for CUG and how did this arrangement come about with Inmarsat? Why is this product offering of importance to government agencies?

Bo Norton

The L-band leasing program for the Closed User Group came about because of the need to provide assured access to critical government aeronautical users in key regions of the world. Essentially, it provides dedicated L-band channels to select customers who have contracted for the service. The end result is a highly reliable service that can be shared and managed amongst a defined user pool. Needless to say, it has been quite successful from both the end user and service provider's perspective because it meets a highly critical need, is very efficient and cost effective.

MSM

What will Vizada offer in this new year for this ever-increasing market?

Bo Norton

We will continue to push our product groups and expand our portfolio to meet new requirements as they come along. You will see new Vizada Solutions in the areas such as IP Networking and Business Tools. Our team does a great job of delivering on our commitment to innovation. This year, we will continue expanding our infrastructure around the globe, along with expanding our offer of centralized control over business operations via The Source, which is our web-based management tool. We're in a new headquarters now for the Americas and are building out a state-of-the-art Vizada Technology Center where we will work closely with government customers to co-develop solutions, beta test and demonstrate new services designed to meet needs today and in the future.

TERRY MAGEE

EXECUTIVE VICE PRESIDENT, WAVESTREAM

Terry Magee is executive vice president in charge of Wavestream's business development, sales, marketing and product management. Terry's distinguished career is marked by 27 years of service in the U.S. Navy as a Naval aviator with extensive operational experience and tours on staffs and in the Pentagon. His four command tours included command of two Aviation Squadrons on the Duluth and the Kitty Hawk.

He subsequently served as president of Orincon, overseeing significant sales and market growth until the company's acquisition by Lockheed Martin. He has since served in senior operational and strategic positions with Lockheed Martin, including the development and execution of capture plans for numerous large programs and C4ISR/IT Maritime Strategies and campaigns.

Terry holds an MBA from the Naval Postgraduate School, and a BA in Biology from SUNY Brockport. He is active in several professional organizations, including AFCEA, San Diego Military Advisory Council and Tailhook, and community organizations, including Operation Home Front, United Through Reading, Palomar College Foundation and Achievement Rewards for College Students.

MilsatMagazine (MSM)

Terry, could you start off this interview with a company profile?

Terry Magee

In 2001, Wavestream's engineers recognized the potential solid state technology had in meeting the growing demand for smaller, lighter, more efficient high power amplifiers to support a broad range of satellite communications systems.

We made a significant investment in research and development to create a patented, next generation solid state technology using spatial power combining to address that demand and to provide an alternative to traditional TWTA solutions. The result is an extensive product offering that offers greater efficiency and higher output power in more compact, lighter weight packages.

Our company's first products were well suited to support military satellite communications systems. We developed a solid reputation for producing rugged, high output power amplifiers that could not only perform reliably in extreme environments, but were smaller and lighter to suit a variety of applications, including mobile operations and flyaway terminals.

Wavestream has since established itself as a premier provider of Ka- and Ku-band solid state power amplifiers for integration into military satellite communications systems. Our Ka and Ku-band products are field proven under the most extreme conditions, and have a track record for delivering the high output power required with greater efficiency and reliability. We have shipped more than 1,000 Ka-band and over 1,600 Ku-band amplifiers to support a variety of applications worldwide.

As we understand the challenges our customers face and have products that consistently exceed industry standards for reliability and efficiency, we've experienced significant company growth over the last two years. That growth has enabled us to extend our Ka- and Ku-band product lines to cover a broader range of military and commercial requirements, and has led to the introduction of new products to support C- and X-band systems.

We have expanded our international representative and distributor network to offer Wavestream products and support worldwide. We are entering the broadcast market to address the need for more efficient solid state amplifiers to replace aging TWTAs and looking at applications of the technology to other systems.

MSM

What makes your product offering different?

Terry Magee

We are able to achieve high output power in more compact, lighter packages through our patented spatial power combing technology. Wavestream's *Spatial Power Advantage* technology uses an array of active elements, with each element output feeding a radiating structure. Individual element outputs are spatially combined in a single step, into a coherent output beam.

The result is power combining efficiency independent of the number of elements, creating higher output power with greater efficiency, in smaller, lighter package footprints. We've leveraged this technology in every Ka-, Ku-, X- and C-band high power amplifier product we produce.

The flexibility provided by our technology allows us to be more responsive to changing system requirements and design products that accommodate different power levels, size restrictions or weight limitations.

As our products consume less energy, integrators can realize significant energy and maintenance cost savings over their system's lifecycle. For example, our latest product, the ***PowerStream 757C-i*** indoor C-band unit, has been designed as a form, fit, and function replacement for aging, energy-hungry, TWTA amplifiers currently used in the broadcast market. In addition to providing the proven benefits of solid state technology, our new PowerStream 757C-i product offers operators significant costs savings through reduced energy consumption, helping support the broadcast industry's efforts to "go green".

MSM

What challenges face the military in regard to MILSATCOM systems?

Terry Magee

Today's military faces the challenges of a new mission set, which runs the gamut of traditional warfare to antiterrorism, humanitarian assistance and disaster relief, peace keeping, and nation building. The military must leverage technology resources in new ways to adapt to circumstances that can change instantly and without warning. They are required to interact and communicate with many government and non-government agencies to complete their missions.

In this environment, we face the challenge of finding ways to rapidly design, build, launch and support military satellite communications systems that can adapt to constantly changing requirements. Highly reliable communication products must accommodate the vast amount of video, voice and data being generated to support the warfighter and enhance situational awareness across the battle space. Continual command and control connectivity is needed to support all types of operations and strategic and tactical forces anywhere in the world, and under any circumstance.

This means creating and supporting communications systems that are tending to be smaller, lighter, more mobile and man-portable or “backpack ready”. The military is also increasingly relying on unmanned platforms for communications and *Intelligence, Surveillance and Reconnaissance* (**ISR**) activities.

The trend we’re seeing is to off-load reliance on satellites and instead use unmanned systems to communicate real-time information to support military missions. Going forward, understanding the unique challenges of heat, vibration, humidity, weight, size and performance criteria to support communications systems in airborne, water and ground environments is critical.

The military’s mission set has also been redefined to support operations beyond the battle space. As we’ve seen with Hurricane Katrina and the Haiti earthquake, the military is called upon to act as first responders to support relief efforts, coordinate humanitarian aid, provide logistical support and establish infrastructure in times of catastrophic disasters. Establishing fast, reliable communications systems and networks is critical in getting relief and aid efforts underway. Again, the challenge is to create satellite communication systems that are adaptable to changing requirements and can be quickly deployed to support instant, reliable communications when established networks are destroyed.

MSM

How are you positioned for the future to support military SATCOM applications and requirements?

Terry Magee

Wavestream continues to work closely with our system integrator customers to better understand and define the military’s SATCOM requirements, and anticipate needs going forward. We have established relationships and continue to provide field-proven products for integration into a variety of satellite communications systems developed by companies including **General Dynamics**, **TeleCommunications Systems**, **Tampa Microwave** and **Globecomm**, to support critical programs such as ***WIN-T***, ***SNAP*** and several others. We are well positioned to expand our product and service offerings to meet the military’s evolving mission set to include support for non-warfare missions such as rapid deployment for disaster relief and humanitarian aid worldwide.

MSM

What are some of your Company’s goals for the next year?

Wavestream Solid State Power Amplifiers

Terry Magee

We'll continue to drive toward more flexible solutions with the goal of always remaining responsive to customer and market demands. For our military customers in particular, this means further evaluating the technology to offer products that meet the on-going demand for smaller, lighter, higher power amplifiers that fulfill a broader range of application requirements, including mobile antenna systems, line-of-site and beyond line-of-sight systems, and radar and countermeasures.

We also anticipate developing our technology to better address the expanding use of unmanned systems for communications and ISR activities. We will work to make investments in R&D and expand our technology resources to launch additional products and improve efficiency and power performance.

We're launching our first indoor C-band product to support the Broadcast industry and will continue to expand our product offerings to address satellite news gathering, teleport and mobile broadcast communications systems. In addition, we have several new product launches anticipated this year, which will continue to expand our Ka, Ku, C and X-band lines. It's an exciting time to be with Wavestream as we rapidly expand to meet our customers' needs and to support the end user, the war fighter.

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That Stacks Up...
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RBC-series Indoor Rack-Mount
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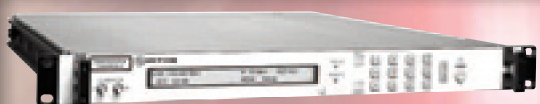

9900- SERIES FREQENCY CONVERTER

- Supports expandable NSU 1:N Switchover Series
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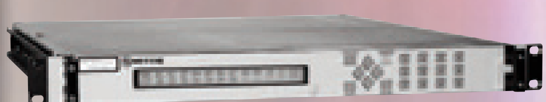

1:1, 1:2 and 1:N REDUNDANT SWITCHOVER SYSTEMS NSU- SERIES

The MITEQ Redundant Switchover Unit (NSU) Series is designed to improve reliability and increase the availability of satellite links and is available in three configurations:

- The NSU1 emulates the operation of the older RSU- series, but also has the ability to communicate settings between the online unit and backup unit. This allows the backup path to be used for low priority traffic. This is an optional feature, and can be accessed via a front panel key command.

- The NSU2 is a fully integrated 1:2 system, with a four-port transfer switch matrix located on the rear panel.

- The NSUN consists of up to 12 Redundant Switch Modules (RSM) with one controller. Each switch module is located in the rear panel of each converter.

SATCOM EQUIPMENT

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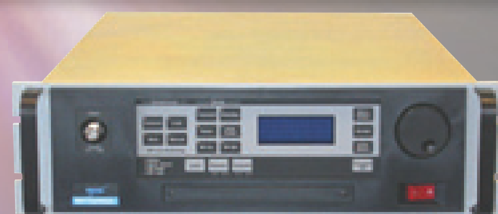

MT3200A

RACK MOUNT MEDIUM POWER TRAVELING WAVE TUBE AMPLIFIER

C-BAND: 400W
X-BAND: 400W
Ku-BAND: 400W
DBS-BAND: 270W
DUAL C-/Ku-BAND: 325W, 400W

MT2300/MT2500

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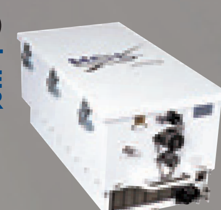
X-BAND: 200W
Ku-BAND: 125W
200W
Ka-BAND: 175W PK

MT3300/MT3600

ANTENNA MOUNT TRAVELING WAVE TUBE POWER AMPLIFIER



Ka-BAND: 175W
250W CW
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