

Worldwide Satellite Magazine

July/August 2011

SatMagazine

**Imagery
+
Earth Observation**

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NASA
SSTL**

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SatMagazine
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Richard Dutchik, Contributing Editor
Alan Gottlieb, Contributing Editor
Dan Makinster, Technical Advisor

Authors

Michael Carlowicz
Chris Forrester
Hadass Geyfman
Rani Hellerman
Jos Heyman
David Hodgson
Eugene Keane
Mark Lambert
Hartley Lesser
Pattie Waldt

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Satnews Publishers
800 Siesta Way
Sonoma, CA 95476 USA
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Cover photo: Qatar, Dohar, “The Pearl” — courtesy of DigitalGlobe

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Funding Facilitation **The European Commission has signed an agreement confirming the transfer of funds to ESA...**



◆ **Jean-Jacques Dordain (left), Director General of ESA, and Heinz Zourek, Director General of the European Commission's DG Enterprise and Industry, signed in Paris an agreement confirming the transfer of funds to ESA for the initial operations of the space component for the GMES program.**

This funding is for the initial operations of the space component for the Global Monitoring for Environment and Security program. The agreement, which secures 104 million euros, was signed at ESA Headquarters in Paris by Heinz Zourek, Director General of the European Commission's DG Enterprise and Industry, and Jean-Jacques Dordain, Director General

of ESA. This agreement follows on from the EU Regulation that was adopted in October 2010 for the Global Monitoring for Environment and Security (GMES) program. The additional funding demonstrates that the existing agreement has been

working well and cements the trust the European Union has in ESA to execute its role in realizing the GMES program. GMES is a unique endeavour that will provide decision-makers with access to accurate and timely information services to manage the environment, understand and mitigate the effects of climate change, and ensure civil security.

Since the success of GMES hinges largely on the provision of robust

satellite data, ESA is tasked with coordinating the program's space component. This includes developing, launching and operating five families of Sentinel satellites, and making the data from these dedicated missions and from other space agencies available for GMES services. This transfer of funds to ESA, which has been appropriated from the EC's Seventh Framework Program and GMES Initial Operations Program, will bridge the gap until the next Multi-annual Financial Framework comes into play in 2014.

The first three Sentinel missions are designed to orbit in pairs, thereby offering maximum coverage of Earth's surface. This latest injection of funds will cover the costs for operating the first satellites until the new operational EU funds become available. It will also provide initial funds that will allow the preparation of contracts for the launch of the second satellites that make up the Sentinel pairs.



◆ **Sentinel-1, the first Earth observation satellite to be built for Europe's Global Monitoring for Environment and Security programme. Credits: ESA-P. Carril**

Providing Key Space Weather Data

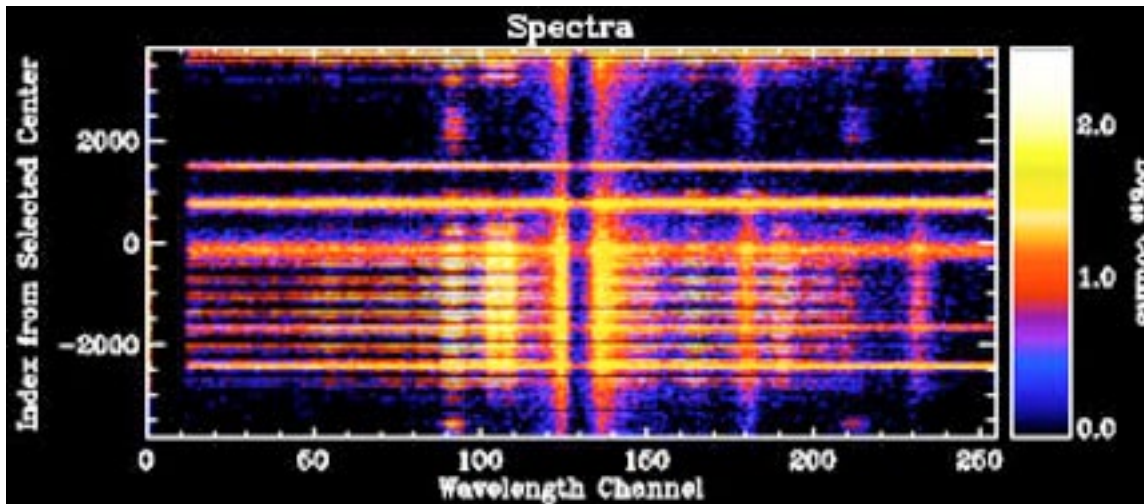
Data products from the Special Sensor Ultraviolet Limb Imager (SSULI) developed by the Naval Research Laboratory's Spacecraft Engineering Department and Space Science Division were officially transitioned for use in operational systems at the Air Force Weather Agency (AFWA) on June 9, 2011.

InfoBeam

After extensive validation of the SSULI sensor software and derived atmospheric specification, the **Air Force Weather Agency** received

Airglow/Aurora Spectroscopy (HIRAAS) experiment flown aboard the **Department of Defense (DoD) Space Test Program (STP) Advanced**

“The SSULI team is very excited to see data from the mission transition into operations, the result of a large team of extremely dedicated NRL scientists and engineers,” said **Andrew Nicholas**, SSULI principal investigator, **NRL Space Science Division**.



Example scan from the SSULI instrument, x-axis represents wavelength, y-axis is altitude and the color represents accumulated counts in one orbit (101 minutes).

Source: Naval Research Laboratory

a formal letter from the **Defense Weather Systems Directorate (DWSD)** at the **Air Force Space and Missile Systems Center (SMC)** recommending that they begin using the **SSULI** data as inputs into Space Weather models and also as standalone data products.

“These datasets now in use at the Air Force Weather Agency provide key understanding of the atmosphere for both Department of Defense and civilian users,” said **Sean Lynch**, program manager, **NRL Spacecraft Engineering Department**.

SSULI measures vertical profiles of the natural airglow radiation from atoms, molecules, and ions in the upper atmosphere and ionosphere from low Earth orbit aboard the DMSP satellite. It builds on the successes of the *NRL High Resolution*

Research and Global Observations Satellite (ARGOS). SSULI makes measurements from the *extreme ultraviolet (EUV)* to the *far ultraviolet (FUV)* over the wavelength range of 80 to 170 nanometers (nm) with a 1.8 nm resolution. SSULI also measures the electron density and neutral density profiles of the emitting atmospheric constituents.

SSULI uses a spectrograph with a mirror capable of scanning below the satellite horizon from 10 to 27 degrees every 90 seconds. These observations represent a vertical slice of the Earth’s atmosphere from 750 to 50 kilometers (km) in depth. Use of these data enables the development of new techniques for global ionospheric remote sensing and new models of global electron density variation.

The DoD **Defense Meteorological Satellite Program (DMSP)** is managed by the Space and Missile Systems Center (SMC), Los Angeles Air Force Base, California, and command and control is provided by a joint-operational team at the **National Oceanic and Atmospheric Administration (NOAA)**, Suitland, Maryland. The DMSP mission is to generate terrestrial and space weather data for operational forces worldwide. The Air Force is the Department of Defense’s executive agent for this program. The data from this program is also furnished to the civilian community through the Department of Commerce.

The mission of the **Air Force Weather Agency (AFWA)** is to maximize America’s power by enabling decision makers to exploit timely, accurate, and relevant weather information every time, everywhere. AFWA is a field operating agency, reporting to **Headquarters, United States Air Force Director of Weather, Deputy Chief of Staff, Air, Space and Information Operations, Plans and Requirements (HQ USAF/A3O-W)**.

Elliot Holokauahi Pulham, CEO, Space Foundation

On May 18, I had the privilege of testifying before the *United States Senate Committee on Commerce, Science and Transportation* as a third-party, unbiased expert on the *Contributions of Space to National Imperatives*. I was joined by *Frank Slazer*, vice president of space systems for the *Aerospace Industries Association*, *Dr. Christopher F. Chyba*, professor of astrophysics and international affairs and director of the *Program on Science and Global Security* at Princeton University, and former NASA astronaut *Capt. Frank L. Culbertson, Jr.*, USN (Retired).



With the future of the U.S. space program in the hands of politicians — some of whom really understand the benefits and, unfortunately, many who do not — this was an excellent opportunity to remind them — and America — why we need to invest wisely in robust and wide-reaching exploration of space and development of space assets — including rebuilding our human spaceflight programs.

Let me share a bit of what I told them — in hopes that you can help the **Space Foundation** with our crusade to bring some sense back to how the United States, views, funds and pursues space. The data I cite here is primarily from the Space Foundation's flagship publication — and the industry's top resource on space information — *The Space Report; The Authoritative Guide to Global Space Activity*.

Over the past six years, the global space economy grew a whopping 48 percent — from \$164 billion in 2004 to \$276 billion in 2010 — and the average annual industry growth rate increased from about 5 percent to nearly 8 percent last year.

Now, while government space activities continue to play a major role, the space economy is today predominantly commercial. Commercial satellite services and commercial satellite infrastructure together account for some \$189 billion in 2010 — nearly 70 percent of total space activity.

Space is also very international. Of the 25 largest satellite communication companies in the world, only one is headquartered in the United States. Roughly three quarters of all commercial satellites are manufactured outside the U.S.

Global space employment has been stable over the past couple of years, with job increases in Japan, India, Germany and other nations offsetting job losses in the United States. The United States remains by far the largest government player, but, while government space spending around the world increased to \$87.12 billion in 2010, the U.S. government space budget was flat at \$64.63 billion. It doesn't take too much thinking to conclude that our lead is eroding.

In 2010, as the global economy continued to battle back from recession, the space industry actually gathered momentum. The commercial sector flourished, adding billions of dollars to the economy, and it's now expanding due to new government policies that encourage greater reliance on commercial providers, affecting both traditional aerospace companies and newer space actors seeking to develop technological capabilities.

Additionally, more countries are becoming involved in space or are revitalizing dormant space programs, with Australia, South Africa and Iran as recent examples. In many cases, these nations are also incorporating a deliberate commercial element that targets economic development and technology creation.

The role of civil space is evolving. The emergence of lower cost smallsats and cubesats is reducing barriers to entry, creating new avenues and opportunities for science and commercial applications. Commercial human spaceflight lets people experience space on a personal level and furthers public interest in space even for those who do not leave the ground. The growing engagement of society in space pursuits stirs our imagination and brings us closer together — researchers, scientists, business professionals and government officials — to explore the practically limitless opportunities that space promises.

Space products and services are an integral part of daily life, expanding each year into new areas of human activity. In one dramatic example, space technology and expertise helped rescue a group of Chilean miners trapped underground. This was but a single instance of how knowledge gained from human activity in the challenging environment of space can be applied to life on Earth.

In more commonplace situations, space applications help people communicate with each other and access entertainment as they travel by ground, sea or air. Satellite-enabled Internet connections are becoming commonplace as airlines outfit their fleets with the latest equipment. Navigation applications for cell phones can combine input from built-in cameras and GPS chips, enabling users to view directions as an overlay on an image of their surroundings. GPS tracking systems installed on racecars allow people to participate in virtual competitions against professional drivers during real racing events.

Whether during work or leisure hours, most people reap the benefits of space systems and technology as an integral part of their daily lives — often without even knowing space is involved.

The commercial sector continues to use space technology in manufacturing processes and products. Glass manufacturers incorporate techniques used in the analysis of data from the *Hubble Space Telescope*. Consumers can purchase clothing made from textiles originally developed for astronauts or style their hair with tools using nano-ceramic technology developed by NASA.

On a more global scale, satellites offer a unique perspective that helps explain the human relationship with the environment. From enabling forestry managers to track the spread of tree-destroying

Rocky Mountain pine beetles to helping coordinate cleanup efforts after the Gulf of Mexico oil spill to monitoring the effects of the earthquake in Japan, satellite data is critical to managing natural resources and responding to manmade disasters.

Many governments, realizing that space technology is both a tool for carrying out their responsibilities and for generating economic growth, play an important role in developing new technologies by financing commercial companies, transferring government technology to the commercial sector and/or creating a supportive regulatory climate.

Canada, Germany, Israel, Japan and India are expanding space programs. The U.S. government is not. This is sad because today's robust commercial space industry has its origins in government space investment. **DirecTV**, **Sirius/XM** radio, **ESPN** and countless other satellite services are the grandchildren of America's **Telstar** program. *Google Earth*, satellite weather and commercial space imagery are descendants of the **Corona** spy satellite program. The U.S. aerospace industry, which by some estimates accounted for 50 percent of the new wealth generated in America between 1962 and 2002, built its muscle on government space programs such as **Mercury**, **Gemini**, **Apollo**, the **X-24A**, the **Space Shuttle** and the **International Space Station**.



The Apollo 11 mission's success

Space investment has spawned new technologies and new industries that could not even have been imagined when the investments were made. Doing things (to quote JFK when he set our goal for the Moon in 1962) “not because they are easy, but because they are hard” leads to the creation of new capabilities that, in turn, lead to entirely new industries.

Take, for example, the cordless tool industry. The industry was content to continue manufacturing longer and longer extension cords. But, NASA’s unique need for tools on the Moon gave birth to a solution that no one had imagined; NASA contractor **Martin Marietta** hired **Black & Decker** and the rest is history. Today cordless power tools are manufactured in Maryland, North Carolina, South Carolina, Georgia, Mississippi, Tennessee, Arkansas and Texas — and increasingly in Japan, China and Europe.

This is the way that invention and discovery works, and this is why America’s past investment in space programs has yielded such stupendous returns:

- Because spacecraft needed a renewable source of energy on orbit, we have a solar power (photovoltaics) industry.
- Because NASA needed to accurately dock and undock spacecraft, we have precision guidance technology that enables LASIK eye surgery.
- Because the Air Force required a precise global positioning system, GPS has become the fundamental underlying architecture for commerce, finance, logistics, inventory management, law enforcement, emergency services and personal navigation around the world.
- Because NASA needed to power the Space Shuttle main engines, we have life-saving heart pump technologies.

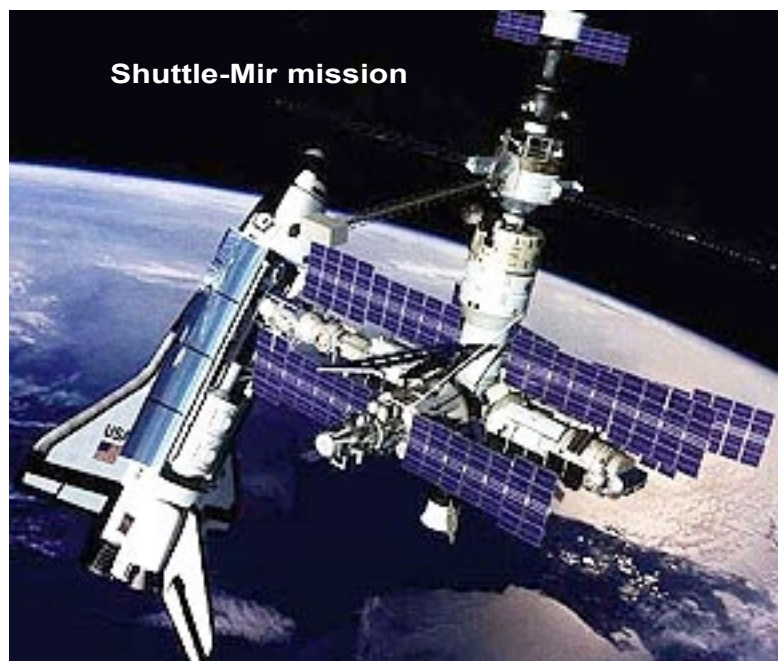
None of these outcomes were expected. But, more than 40,000 new products are the result of our previous national investments in space.

Funding national space programs has also brought tremendous benefit to U.S. foreign policy and national security, both directly, and indirectly.

Leadership in space has been a leading contributor to American “soft power” since the dawn of the space age. Our entry into the space race is often seen only as a reaction to the Soviet Union’s launch of *Sputnik*, but the doctrine behind it is worth remembering. JFK’s Moon speech is often quoted for its inspirational and humanistic value. Less often quoted are the political and national security realities that America was coming to grips with: “The exploration of space will go ahead, whether we join in it or not . . . and no nation which expects to be the leader of other nations can expect to stay behind in this race for space. . . the vows of this nation can only be fulfilled if we in this nation are first, and, therefore, we intend to be first.”

The mastery of space has always carried with it the not-so-subtle message to friend and foe: This is what we are capable of. You want to work with us. You want to be our friend. You want to follow our lead. You do not want to challenge us.

Whether our objective is to win the Cold War (*Apollo*), extend a hand in friendship (*Apollo-Soyuz*), motivate collaboration (*Shuttle-Mir*) or build a broad-based international community (*ISS*), the soft power of space programs is often one of our best foreign relations and national security tools.



Certainly, space programs have also been inextricably linked with “hard” power. The ability to observe other nations, share intelligence instantly around the world and, when necessary, to strike, depend upon space investments. All Americans know about the successful mission to get Osama Bin Laden. We may never know just how many space assets were used in the operation.

While much of it remains secret, it may have involved such things as:

- Satellite imaging of the compound
- Satellite signal intelligence gathering
- Stereoscopic satellite imaging to gather data for constructing mock-ups of the compound
- GPS-powered precision navigation and timing
- Secure satellite theater-level communications
- Secure satellite strategic communications
- Satellite weather forecasts and real-time data

Our national intellectual capacity — the brain power we can bring to bear on any problem, issue or challenge — is directly affected by our investment in national space programs. For example, as the Apollo program gained momentum, enrollment in graduate studies in science and engineering also grew. Since that time, it has waned.

Doing the hard things requires our best and brightest minds. Developing this intellectual capacity requires inspiring, challenging and exciting work to do. When America has made that investment, we have never failed to achieve our capacity for greatness.



Focus On EO + Imagery

A Conversation With Jack Hild, V.P., DigitalGlobe



Manhattan, New York, courtesy of DigitalGlobe

Focus On EO + Imagery

SatMagazine (SM)

What are you hearing as customers' top priorities today — have those priorities evolved in recent years?

Jack Hild

They've absolutely changed. If you look back at the evolution of commercial imagery, for years we were satisfied with **LANDSAT**. The prolific use of LANDSAT opened a market for better resolution. And a little more than a decade ago, Space Imaging and DigitalGlobe's **QuickBird** hit the one-meter threshold. As the next generation of commercial satellites pushed the resolution to a half meter, technology improvements — driven in part by GPS devices — made accuracy the next imperative.

This new generation of half meter class vehicles is demonstrating that it is up to the task. What's the next demand? Speed. It's no longer good enough to have a high resolution image that is accurately positioned. Our customers expect the image to be delivered inside their decision space. Look at what has happened in Japan and the Middle East and North Africa recently. There's a growing demand that imagery collection and dissemination move at the pace of world events. We're taking the steps to make that a reality.

SM

With those customer priorities in mind, what are DigitalGlobe's top technology strategies for the next three to five years?

Jack Hild

We will continue to focus on maintaining the highest quality and accuracy possible. That's a given. From there we are focused on speed...making that high quality image available to a user at speeds unheard of just a few years ago. Our new Antarctic ground station is operational and we will be deploying additional mid-latitude ground stations within the next 18 months. That ground infrastructure plus the agility and capacity of the constellation gives DigitalGlobe unprecedented access and the ability to meet the time-sensitive missions of our customers. We continue to invest in High Performance Computing, again, as a way to improve our timeliness.

Finally, we are delighted with the performance of **WorldView-2's** eight spectral sensors, which are narrowly focused and provide complete coverage of the visual spectrum, along with two near-infrared bands. This technology is exclusive to DigitalGlobe and gives scientists a more detailed view of Earth and the ability to analyze information in completely new ways. We, along with our partners and customers, are continuing to explore its capabilities.

SM

Looking further out, what are the biggest changes you see coming for the industry?

Jack Hild

Growth will continue, fueled by robust high quality imagery collection. We will see the pixel market slowly but steadily expand as much more current imagery becomes available and as cloud services offer easier and more rapid access. Evolutionary changes, like increased integration with other data sources and devices, will continue, driven by a requirement for higher fidelity information for situational awareness.

Viewing and navigation devices play an important role in industry growth, and I see tablet devices also making a big difference. They are small enough to be highly portable and offer a much larger field of view than a smartphone.

Advances in multi-spectral imagery processing and signature development, especially for advanced MSI sensors will continue to yield new understanding of the global environment. Our **8-Band Challenge** yielded more than 550 entries. With that kind of interest from analysts and scientists around the world, I know we will see some exciting discoveries from WorldView-2 imagery.

SM

What are you presently doing, or planning to do, to make that vision a reality?

Focus On EO + Imagery

Jack Hild

Building out our constellation and ground infrastructure is key. That gives us a high volume of current, accurate imagery and the delivery speed to be relevant to our most demanding customers. Next is access. A constantly refreshing picture of the world is within reach. Imagine all of our collection, every day, being processed to the highest quality and accuracy standards and then being exposed in any of the common viewing platforms. It will spatially enable more users from a broad array of industries and ultimately form **THE** common foundation for most location-based applications.

Finally, it's all about improving what you have — utilization and development of our 8-Band sensor will improve our content in ways that we haven't even imagined yet.

SM

A recent initiative from DigitalGlobe encompasses 8-Band multi-spectral commercial imagery. Would you please explain why this technology is so important to DigitalGlobe, its importance to current and potential customers, and how such imagery is gathered?

Jack Hild

Imaging across the electromagnetic spectrum allows you to focus on certain spectral signatures that let you see some features

better than the human eye. In our case, we designed our new 8-Band sensor to be particularly adept at two functions.

First, the sensor and processing can be tuned for better insight into vegetation. Analysts can assess crop health and identify some species to a degree unequaled by traditional 4-Band sensors. Second is maritime situational awareness. Our 8-Band sensor is showing improvement over older technology in deriving bathymetric data, and, combined with its agricultural capabilities, is a useful sensor for evaluating wetland vegetation and coral reef health.

More work is needed in these disciplines, but we remain excited about the potential.



Western forest fires. The Station Fire in California was one of the largest in the modern history of Los Angeles, California. The image was collected on August 31, 2010, and is courtesy of DigitalGlobe.

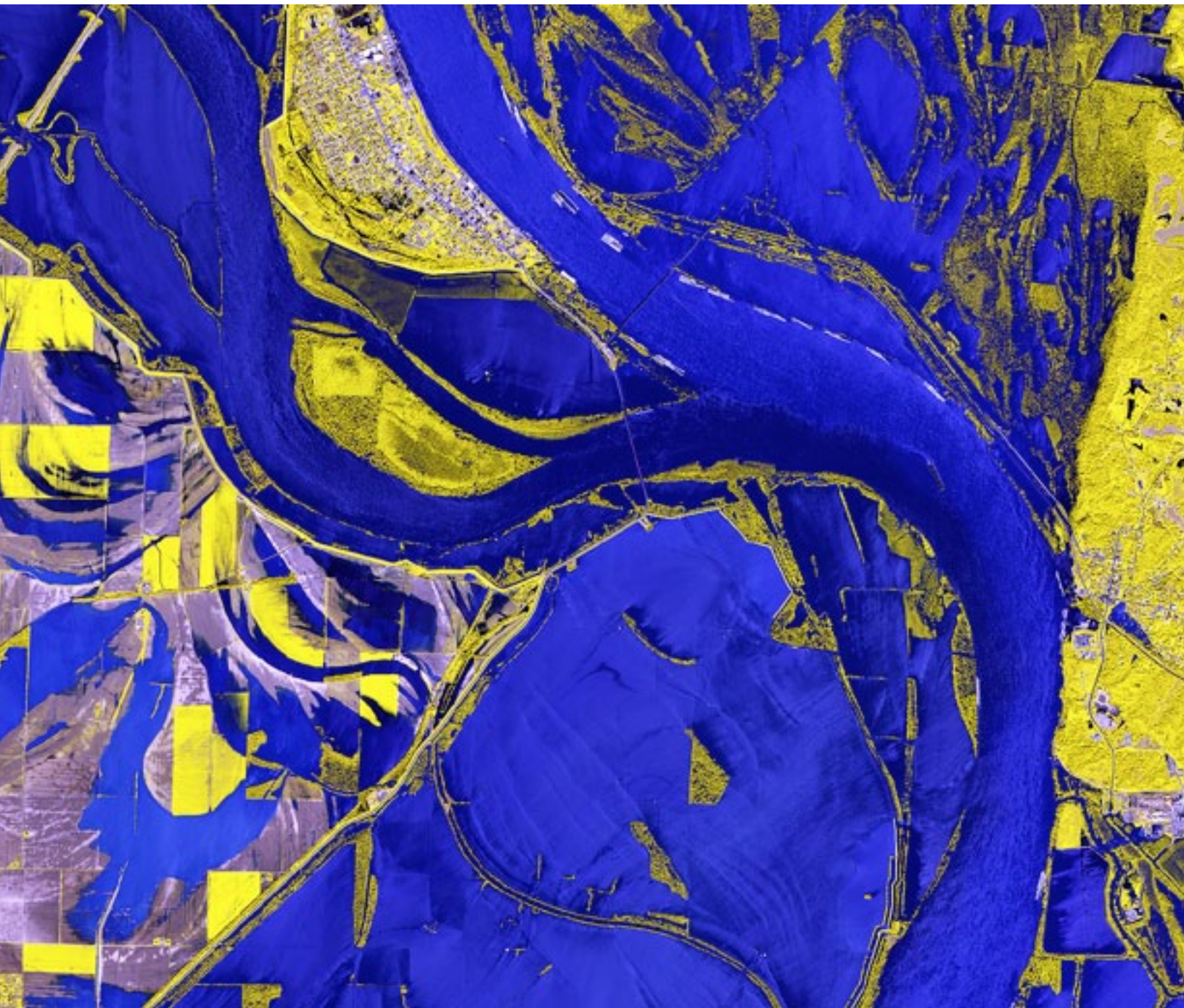
Focus On EO + Imagery

SM

Would you discuss your three, on-orbit EO satellites and the roles they play in your company's business and marketing plans? What are DigitalGlobe's future plans regarding additional satellites to satisfy increasing imagery requests?

Jack Hild

Our satellites supply the content that helps save lives and protect our world...whether the mission is National Security, supporting First Responders in natural disasters or helping scientists understand environmental impacts. **QuickBird**, **WorldView-1** and **2** continue to perform well and our ground station expansion will provide additional imagery and shorter delivery times.



The Mississippi River flooding, Cairo, Illinois, false color image courtesy of DigitalGlobe. Flooded areas are blue, while the healthy vegetation is yellow. Image collected May 5, 2011.

Focus On EO + Imagery

WorldView-3 will be similar to WorldView-2 with evolutionary improvements in storage and transmission rates. The **WorldView-4** design is wide open for now and will be the best combination of what our customers need and the available technology.

SM

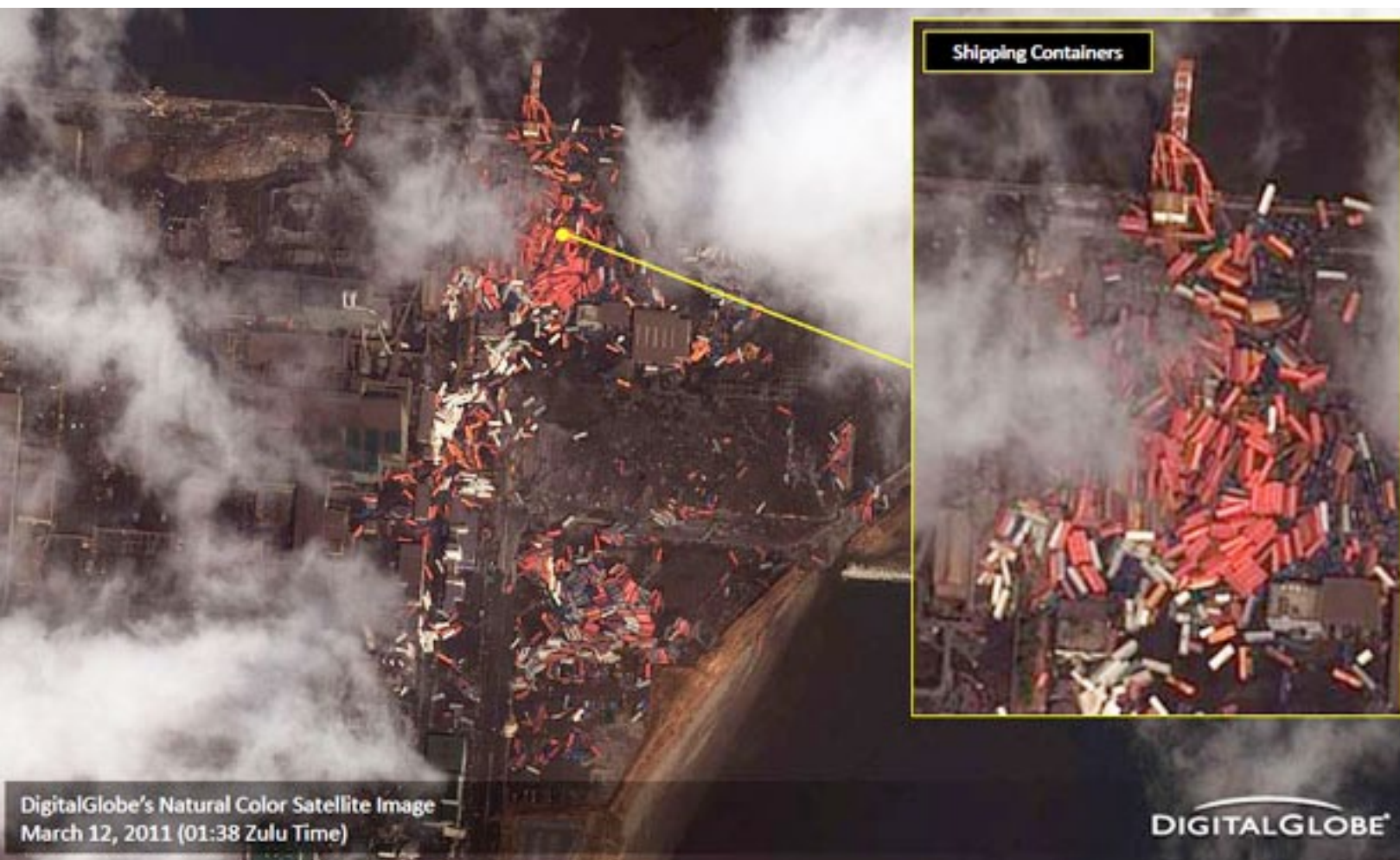
Does DigitalGlobe find an increasing interest within the military/government segment for your product, especially regarding the needs of NGOs and first responders?

Jack Hild

Our government customers have demanding missions that take them to the four corners of the globe, and our constellation has the capacity and agility to be with them. The events of this spring have shown the value of commercial satellite imagery and validate our decisions to continue to invest in processing and dissemination improvements.



Artistic rendition of WorldView-3



Tsunami damage to port facility in Sendai, Japan. Natural color image courtesy of DigitalGlobe

Focus On EO + Imagery

We have already monitored more than 45 events in 2011, including the political turmoil in Egypt and Libya and natural disasters in Japan and Alabama. New images are collected and/or refreshed every day to aid rescue and recovery, document the impact of an event and begin rebuilding.

Our work with the ***Satellite Sentinel Project*** in Sudan shows that NGOs can have a significant impact on world events. We are proud of our role in humanitarian relief efforts.

Even before 9/11, no U.S. National Special Security Event has been planned or executed without commercial satellite imagery. DigitalGlobe supports these types of events for governments around the world.

As First Responders gain more experience with commercial imagery, we expect that segment to continue to grow for planning purposes and, if needed, to support response and recovery actions. As imagery becomes more widely available, image-to-user times reduced, and the tools to exploit it become easier to use, we see even more opportunities to serve those communities.

SM

What is DigitalGlobe's global coverage?

Jack Hild

DigitalGlobe's satellite constellation include three commercial satellites that are capable of collecting approximately two million square kilometers every day, or more than 700 million square kilometers of imagery per year, and of revisiting specific areas on Earth several times a day. The company's *ImageLibrary* is now three times the size of other available high resolution, commercial image libraries. When our new ground

stations become operational they will yield even more capacity.

We see our imagery being used by a growing number of national security professionals, analysts and scientists every day. We're proud of our role in their work and are committed to those partnerships.

Jack Hild is the Vice President, U.S. Defense Strategy, at DigitalGlobe — for further company information, access...

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



Geospatial Information: Managing Our Future

By Rani Hellerman, Director of Business Development, ImageSat International Ltd.

A formative decade has passed, during which the civilian high-resolution satellite data business has reached a critical level of maturity. The timing is auspicious, as the industry applies itself to the growing challenges of managing our world and its resources. ImageSat International is playing a key role in this trend.



Agriculture Monitoring, São Paulo – Brazil

Focus On EO + Imagery

Adapting Military Technology To Civilian Needs

It was not even a decade ago when geospatial information professionals began to evaluate the possibility of augmenting their high-resolution aerial photography with data from high-resolution satellites. The United States clearly dominated the industry and set out to pave the way for global adoption of high-resolution satellite data for commercial use.

In the years since the launch of **Space Imaging's IKONOS** satellite (now owned by **GeoEye**) in September of 1999, we have witnessed marked improvement in the variety and competitiveness of imaging satellites. Their upgraded sensors create higher resolution imagery and they have more efficient platforms and technologically superior ground systems. The improved capabilities and compatibility of data processing software ensure that customers can concentrate more on extracting value from the data, rather than the mechanics of processing them.

While military and homeland security applications still account for the majority of commercial satellite data consumption, a vast civilian industry has emerged. Only now are we starting to tap the potential of high-resolution satellite imagery to address problems of managing our communities, our natural environment and the unprecedented pace of change experienced by both.

There has also been a significant improvement in the competitiveness of international high-resolution sensors, among them **EROS A** and **EROS B**, developed by **Israel Aerospace Industries (IAI)** and owned and operated by **ImageSat International**. EROS B is currently the only non-American satellite with standard, sub-meter resolution, marking the achievement of one of ImageSat's founding principles.

A Multi-Functional Power-Tool

Supported by most of the photogrammetry software in the market, including **Socet Set**, **Erdas** and **PCI**, EROS imagery is becoming a power-tool for experts who process Earth-observation data, helping to monitor and manage communities, the environment and its resources, as well as to keep abreast of the rapid changes evident worldwide.

Urban mapping is among of the fastest-growing applications of EROS imagery, providing infinite value for planning,

management, compliance and change detection. With the rapid expansion of metropolitan areas, it is essential to calculate their evolution and to plan accordingly, whether for adding roadways, neighborhoods, infrastructure, public services or contingency plans. Among ImageSat's clients, for instance, are municipalities which use EROS data to monitor illegal construction through change detection.

Although *Campania* — meaning *countryside* — sounds pastoral, the Campania Region of Italy, located south of Rome, is one of the most densely-populated areas in Europe, with nearly 6 million inhabitants. The *Mediterranean Agency for Remote Sensing and Environmental Control (MARSEC)* initiated a program in early 2007, which employs EROS B imagery to monitor illegal construction in the most critical areas, comprising substantial percentage of the territory. By using change detection techniques, authorities in each municipality can compare new developments with their licensing authorizations to monitor and to curb this problematic trend. Forestry is also high on the photogrammetry agenda, including mapping forests for monitoring and management of growth, replanting, fire safety, regional development, wildlife and illegal logging.

ScanEx R&D Center, a private Russian company employs both EROS A and EROS B to assist in mapping and monitoring illegal logging activities in large mountainous areas that would otherwise be expensive and treacherous to monitor by aircraft or via other means. In addition, ScanEx is taking sub-meter resolution images of cities in Russia for a range of applications.

ScanEx also carried out a *Project for Ships Routing for Harp Seals* breeding zones protection in the White Sea. SCANEX Center has developed the technology for harp seals breeding zone detection using high-resolution optical images.

Other prevalent infrastructure projects include the planning and monitoring of gas and natural gas pipes. As countries share resources, such as electricity and water, satellite images became more and more useful for ensuring accurate implementation and security of these installations, as well as the transport of their resources.

With the rash of more than 40 instances of piracy of oil tankers, cargo vessels, and even cruise ships on the high seas in the last two years, governments and private companies may use very high

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Moses Mabhida Stadium, Durban – South Africa

resolution imagery to identify ships' locations and to continue monitoring and surveillance of the respective area, as contingency plans are set into motion.

Infrastructure planning has gained momentum during the last few years and is expected to be among the leading applications in the coming decade — particularly in the United States, where bridges have been found to be in need of urgent reinforcement, and in Europe, where the subterranean water infrastructure is so old, there are enormous problems with water loss and seepage of sewage. Since the commencement of operation of EROS B, ImageSat has responded to increasing demand for very high-resolution satellite images for monitoring purposes. The **European Union**, the **United Nations**, and other international alliances have set regulations for their members and their beneficiaries, to ensure fairness, human rights and worthiness of funding. For instance, also using EROS B sub-meter imagery, **Amnesty International** monitors migration of refugees in Africa, in hopes of better protecting their human rights.

Following the devastating earthquakes which struck Haiti and Japan, ImageSat and its partners have provided images and processing of high resolution optical satellite Eros B to the relevant humanitarian organizations. With the integration of findings from other satellite operators worldwide, it was possible

promptly to provide a quantity of data, even in the presence of the devastation of primary logistics infrastructure (airports and roads) have proven useful in the early hours after the tragic earthquake relief coordination.

With regard to all of these applications, when things go wrong — such as natural disasters, terror attacks or other tragedies — it is helpful to have baseline imagery in order to conduct disaster assessment. Change occurs fast, especially with regard to disasters; for this reason, police forces and municipalities are sharing data with the city planners and National Guard forces to ensure that all are on the same page before disasters strike.

More traditional GIS applications, including employing remote sensing for agricultural monitoring and management, continue to be in demand globally. For the past six years, the **European Commission's Joint Research Centre (JRC)** project has relied upon imagery from all major commercial sensors, including EROS A and EROS B, to image farmland across the continent, to produce orthophotos and to confirm farmers' declarations regarding growth type, volume and health of their crops.

Forging New Competencies In GIS

During the past decade, we have seen the power of satellite imaging harnessed by the military, then passed from the professional civilian market to the popular market, with **Google Earth** and NASA's **Visible Earth** becoming tools of the trade as well as for hobbyists.

In the coming years, greater sophistication will be achieved in regard to processing capabilities; improved interoperability of software and hardware, yielding new applications; and increased sharing of processed data, providing greater value from satellites and their data.

The Geospatial Information professionals are playing a significant role in this evolution, helping governments, private businesses and individuals to manage and protect our communities, resources and environment.

About the author

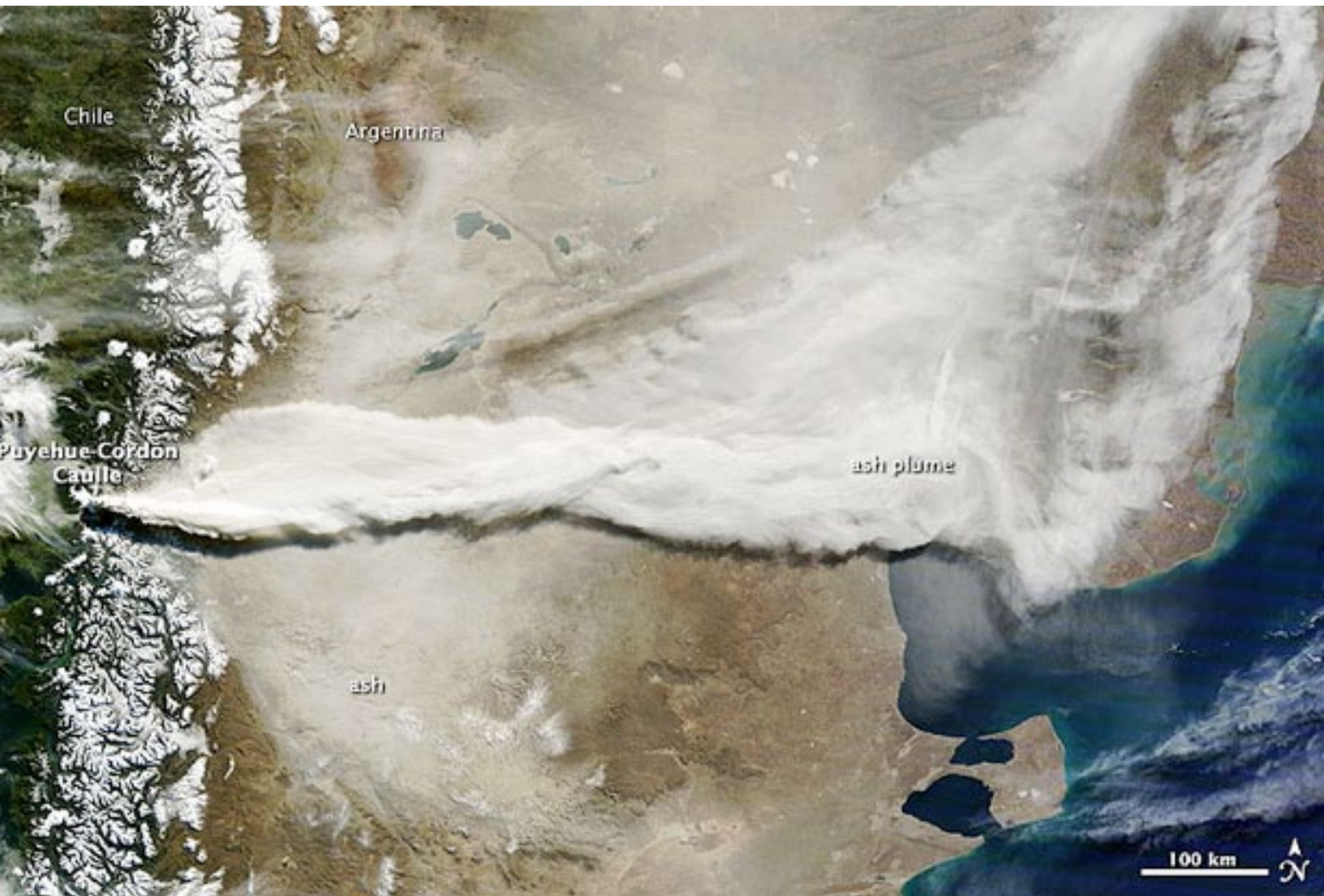
Rani Hellerman is Director of Business Development at ImageSat International Ltd. and has experience working with military and civilian satellite imagery data for more than 17 years.



Natural Disasters + NASA—What Is The Agency's Role? *An Interview with Michael Goodman*

by Michael Carlowicz NASA Earth Observatory

Though our planet has long reminded us of its dynamic, unpredictable, and forceful nature, the past 18 months have been particularly painful for human civilization. It seems like one global disaster has followed another, with dire consequences for millions of people.



Perhaps the greatest danger posed by the erupting Puyehue-Cordón Volcano Complex in Chile is the thick layer of ash being deposited east of the volcano. This image, taken on June 13, 2011, by the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite, shows ash on the ground and a large plume streaming east from the volcano. The image reveals a large plume of volcanic ash blowing about 800 kilometers east and then northeast over Argentina. The plume has disrupted air traffic as far away as New Zealand. NASA image courtesy Jeff Schmaltz, MODIS Rapid Response Team at NASA GSFC. Caption by Holli Riebeek.

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The Port-au-Prince earthquake. The Chilean earthquake. Iceland's Eyjafjallajökull volcano. The [BP Deepwater Horizon](#) oil spill. The heat wave and fire season in Russia. The monsoon floods in [Pakistan](#). The earthquake in Christchurch, New Zealand. Flooding in Australia. Mudslides and floods in Sri Lanka, Bolivia, Brazil, and Thailand. The historic earthquake and tsunami in Japan. And most recently, the record-setting tornado outbreak in the southern U.S. and the flooding along the Mississippi River.

Michael Goodman has had a [busy](#) and sometimes difficult 18 months.

An atmospheric scientist by training, *Goodman* also serves as NASA's manager for **Natural Disasters Applications**. Working with basic researchers, engineers, and applied scientists, he helps assemble and coordinate the agency's response to natural disasters and hazards. He is based at NASA's *Marshall Space Flight Center* in Alabama, which recently suffered damage from tornadoes.

NASA's **Earth Observatory** caught up with *Goodman* to learn more about this behind-the-scenes work at America's space agency.

Earth Observatory (EO)

What is NASA's role in observing and monitoring natural disasters, such as earthquakes, fires, floods, and volcanoes?

Michael Goodman

Our role is to provide spaceborne and airborne observations and data analyses that can assist in damage assessment and aid in the recovery. NASA works closely with several federal agencies — including the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and the Department of Homeland

Security (DHS) — to provide imagery and data analyses for use by first responders to a disaster. Within NASA's Earth Science Division, the goal of the Natural Disaster Application Area is to use our capabilities to improve natural disaster forecasting, mitigation, and response.

EO

What is NASA doing to help with the floods along the Mississippi River?

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Michael Goodman

NASA is providing the Federal Emergency Management Agency (FEMA) with daily flood mapping images of the Mississippi River. The images are being produced through a joint applied sciences project between NASA's Goddard Space Flight Center and the University of Colorado/Dartmouth Flood Observatory. The flood maps from the Moderate Resolution Imaging Spectroradiometer (MODIS) provide a large-scale, birdseye-view of the entire region affected by the floods. FEMA is using the MODIS mapping products and images from the Earth Observing-1 satellite to monitor the areas affected and to help guide response and mitigation efforts.

EO

What kind of assets does NASA have to address natural hazards?

Michael Goodman

Clearly our most important asset is our dedicated scientists and engineers, who use their knowledge and experience to analyze images and data and to develop and apply innovative techniques for studying natural hazards. While our satellites are continually making observations, our scientists work around the clock during disaster events to process data and aid in the damage assessment, mitigation, and recovery.

EO

What kind of hardware assets does NASA have to monitor and study natural hazards?

Michael Goodman

We have many satellite and plane-based sensors, including:

- ◇ The Moderate Resolution Imaging Spectroradiometer (MODIS), on both the Terra and Aqua satellites, provides natural and false-color images of flooding and fires

- ◇ The Multi-angle Imaging Spectroradiometer (MISR) on Terra offers nine camera angles, allowing researchers to collect stereoscopic views of plumes of smoke, dust, or ash injected into the atmosphere
- ◇ The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on Terra is a high-resolution, steerable radiometer that views the Earth in the visible, near infrared, shortwave infrared, and thermal infrared portion of the spectrum
- ◇ The Ozone Monitoring Instrument (OMI) on the Aura satellite can distinguish between aerosol types, such as smoke, dust, and sulfates
- ◇ Hyperion is a high-resolution hyperspectral imager on Earth Observing-1 (EO-1) capable of detailed land classification, such as identifying damaged areas following the tsunami and earthquake
- ◇ The Advanced Land Imager (ALI) on EO-1 provides panchromatic and multispectral imaging for land surface classification
- ◇ The Precipitation Radar and Microwave Imager on the Tropical Rainfall Measuring Mission (TRMM) help researchers see the precipitation that leads to extreme rainfall, floods, and landslides



The Advanced Spaceborne Thermal Emission and Reflection Radiometer is an imaging instrument that is flying on NASA's Terra satellite as part of the space agency's Earth Observing System.

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- ◇ The Autonomous Modular Scanner incorporates sophisticated imaging and real-time data communications in an instrument on unmanned and manned aircraft to observe smoke and haze, to record hot spots, and to monitor the progression of wildfires
- ◇ The Advanced Visible InfraRed Imaging Spectrometer (AVIRIS) is an airborne optical sensor that observes transmitted, reflected, and scattered sunlight and was used extensively during the Deepwater Horizon oil spill
- ◇ The Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) is an airborne radar system that can detect and measure subtle changes in Earth's surface caused by natural events — such as earthquakes, landslides and volcanoes — or human induced impacts — such as oil or groundwater pumping, oil spills, and deforestation

EO

How did NASA respond to the March 2011 Tohoku-oki (Sendai) earthquake and tsunami?



This Advanced Spaceborne Thermal Emission and Reflection Radiometer images was acquired on May 2, 2000 over the North Patagonia Ice Sheet, Chile. The image covers 36 x 30 km. The false color composite displays vegetation in red. The image dramatically shows a single large glacier, covered with crevasses. A semi-circular terminal moraine indicates that the glacier was once more extensive than at present.

Michael Goodman

We had multiple spaceborne instruments that observed the areas affected. These observations and analyses were used during the immediate post-disaster assessment to map the extent of the damage. Additionally, these observations now will be applied to longer-term research of the area.

One of those instruments was ASTER, which is a cooperative effort between NASA, Japan's Ministry of Economy, Trade, and Industry and Japan's Earth Remote Sensing Data Analysis Center. Because the instrument has such fine resolution and can be pointed to view specific areas, ASTER was used extensively in the earthquake and tsunami analyses.

EO

Does NASA have any other role in the aftermath, such as search-and-rescue and environmental monitoring?

Michael Goodman

NASA does not have a direct role in urban search and rescue, but our data sets and analyses are useful in assessing the extent of damage. In the Tohoku-oki earthquake and tsunami, the Hyperion, ALI, ASTER, MISR, and MODIS instruments were all used to determine the extent of the earthquake damage and

the scope of the tsunami inundation. They also monitored the fires and resultant smoke plumes. Many of these same instruments will make repeated observations over the coming months to monitor the area during the recovery period.

EO

In recent years, we have seen extreme satellite close-ups and maps from commercial companies (such as Google, GeoEye, etc.). What do NASA satellites offer that we do not get from commercial satellites?

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**Michael Goodman,
NASA Marshall Space
Flight Center.**

Michael Goodman

Our science instruments are designed for climate change research and for studying a wide range of environmental issues, as our planet is changing on all scales of time and space. Although our instruments do not have the high spatial resolution of commercial satellites, we do have a suite of instruments that can be used for broader and more

frequent hazard assessment. The swath width of MODIS is 2,300 kilometers, which enables it to cover almost the entire Earth every day. And we are fortunate to have two MODIS instruments, so we can revisit a disaster site a combined four times a day (nighttime and daylight for each satellite) enabling frequent daily monitoring. Even the higher resolution (but smaller swath) MISR and ASTER provide much broader coverage than commercial satellites, which is key for providing continuous environmental monitoring.

In addition to the broad swath width and spectral range, we also have an extensive archive of historical data that enables us to detect changes before and after an event. Some of NASA's instruments have been flying for more than a decade.

EO

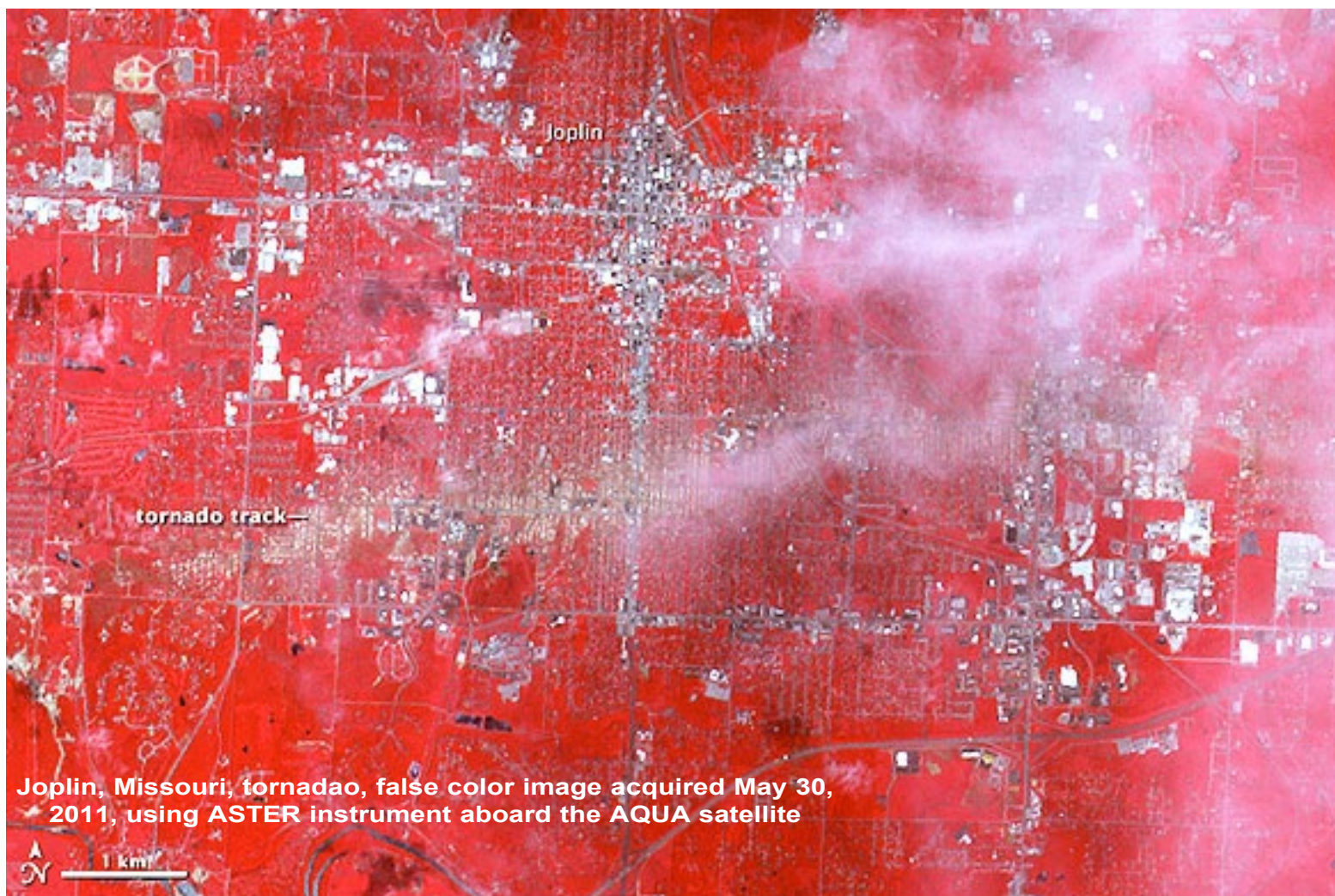
On a personal note, how did the recent tornado outbreak affect you?

Michael Goodman

My house is fine. We were without power for five days, and rotting refrigerated food and cold showers get old quickly. But these are minor complaints compared to the many people in our area who lost everything. Tornado damage in the Huntsville area was very bad.

For further information and additional imagery, head over to NASA's Earth Observatory, located at:

<http://earthobservatory.nasa.gov/>



Joplin, Missouri, tornado, false color image acquired May 30, 2011, using ASTER instrument aboard the AQUA satellite

The DMC Grows Up

by David Hodgson, Managing Director of DMCii

Surrey Satellite Technology Ltd's Disaster Monitoring Constellation is a fleet of small low-cost Earth observation satellites, but despite — or because of — that fact, it has undergone rapid evolution in the last decade, a process set to accelerate further in the next few years.



Artistic rendition of SSTL's Deimos-1 satellite

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‘The perfect is the enemy of the good’ is a saying that should apply to space as much as anywhere else. Except that designers of standard space missions aim for as close to perfection as they can get, with exhaustively-tested space-qualified parts serving as the basis of multiple-redundant subsystems. The ensuing satellites promise to operate optimally for years on end — but such performance comes at an astronomical cost in terms of mass, complexity and time as well as cash. Not to mention the top-of-the-range launchers needed to fly such heavy payloads (the launch typically amounting to upwards of 40 percent of mission costs).

Is any alternative even feasible for working in space, the most unforgiving environment imaginable? Yes, declares the burgeoning NewSpace community, made up of businesses focused on innovative activities such as lower-cost launch services and space tourism. NewSpacers criticize the traditional space sector’s obsession with maximizing mission performance while failing to control costs — a tendency hardly discouraged by decades worth of cost-plus government procurement contracts.

In the end the only way to grow space markets is slashing the cost of doing business in space. When squeezing out that tricky extra 20 percent performance ends up costing 80 percent of your mission budget, why not be pragmatic, and accept 80 percent of performance for a modest 20 percent pricetag instead?

Of course it’s easy to discount the arguments of unproven NewSpace firms that are, with a few honorable exceptions, years away from turning a profit, if at all. However, 26 years ago, long before the term ‘NewSpace’ was even coined, a small U.K. firm called **Surrey Satellite Technology Ltd. (SSTL)** was founded with that same pragmatic philosophy in mind. Today, SSTL is the world’s leading small satellite company.

Founder Sir *Martin Sweeting* realized that the increasing ability of *commercial-off-the-shelf* (COTS) devices could still offer useful functionality within physically small satellite structures. He led

a small team at the **University of Surrey** to design and build the U.K.’s first amateur satellite: *UoSAT-1* launched on October 6, 1981, carrying a reprogrammable onboard computer and a 256x256 pixel CCD to perform Earth observation. A second micro-satellite followed, but funding was tight. SSTL began as a means of helping to finance future small satellite research — a goal it turned out to accomplish in spades. Today, this multi-million pound company employs more than 300 people.

A total of 36 SSTL-built missions have gone into orbit since then, manufactured for customers all over the world. Some things remain the same, however, including the small size of the satellites. This means missions can be developed much more quickly: a typical 100-kg SSTL satellite can be designed, built, tested and made ready for launch in less than two years, compared to a five to 10 year timespan for their standard multi-ton equivalents.

It also makes them much cheaper to build using very much smaller teams, and their performance also benefits greatly from the very latest COTS innovations. SSTL satellites make use of COTS terrestrial technologies to offer much better performance and lower cost than would be the case if only space-specific technologies were used. SSTL has honed its processes and created designs to ensure that the use of COTS does not impact the reliability of the satellites. Of course, the real test is in space, and SSTL’s mission success rate speaks for itself, demonstrating that it is possible to offer both low cost and low risk to customers. As small satellites can be built and flown so much more frequently, technology can be developed on an incremental basis, following the same innovative approach as the microelectronics and software industries. New hardware flight-tested on one mission can be added as standard on the next.

Earth monitoring also remains a core area of interest: Of the 36 SSTL spacecraft flown to date, 27 have been Earth observation satellites, culminating in the ***Disaster Monitoring Constellation (DMC)***. The DMC is a constellation of currently six small satellites which operate together to offer wide-area 32m *ground sample distance (GSD)* coverage of anywhere on Earth within 24 hours, as compared to up to 16 days for *Landsat* and similar times for comparable, single satellites.

The DMC’s highly-responsive nature means it is often tasked to acquire images of disaster zones for civil protection teams and UN agencies through the International Charter ‘Space and Major Disasters’. A steady stream of images are also acquired

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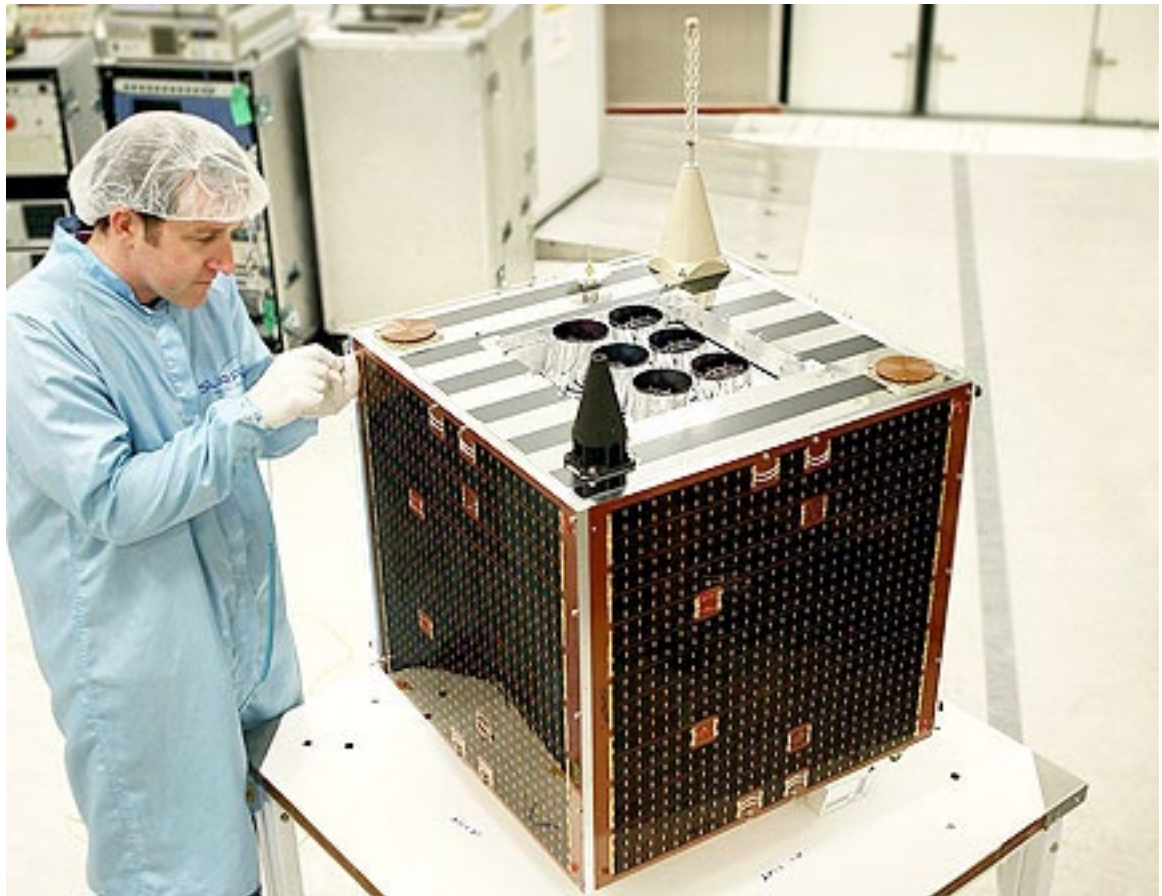
for the national owners of the individual DMC satellites and commercial customers. The constellation is operated by **DMC International Imaging (DMCii)**, a subsidiary of SSTL that also commercially markets DMC imagery.

The evolution of the DMC reveals how SSTL's pragmatic approach works in practice. The project began with a recognition of the need for timely access to low-cost Earth observation data for disaster management, following a call for improved response to natural and man-made disasters at the *Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)* in 1999. Test missions such

as *UoSAT-12* and *TsingHua-1* proved the concept of acquiring medium-resolution multispectral imagery using small satellites, compatible to Landsat in resolution and spectral bands but acquired much more cheaply.

Employing the company's 100-kg class workhorse **SSTL-100** satellite platform, multiple assets could be flown for the equivalent cost of a single large mission — but delivering more capacity than an individual satellite ever could, the combined constellation offering daily access to all parts of the globe. To further boost the constellation's reach, the satellites were given an extremely wide 650 km viewing swath-based on double banks of imagers able to acquire complete regions in a single along-track sweep, instead of having to mosaic together many smaller images acquired at separate times. Such wide-area imaging was the DMC's one essential function — unnecessary capabilities were to be avoided, to control costs.

The low price tag per unit means many different governments could afford to purchase an individual sovereign satellite, gaining technical expertise and hands-on training. In addition, all members of the DMC consortium benefit from shared access to all



The SSTL-100 satellite platform

data acquired by each others' missions. As there is also a revenue stream from commercial sale of DMC data, the constellation is partly self-sustaining, helping to underpin its continued existence. This is in marked contrast to many government-run Earth observation systems, where future data continuity cannot be assured (even the venerable Landsat program risks data gaps due to a repeated delays in completing its follow-up), making DMC data increasingly attractive to long-term users.

The first DMC satellite reached orbit in 2002, with three more launched the following year. In December 2004 the constellation demonstrated its usefulness in dramatic fashion by performing rapid damage mapping across all the far-flung nations affected by the Asian tsunami. The DMC has also developed incrementally along the way. When China's *Beijing-1* joined the constellation in 2005, this larger **SSTL 150** satellite included an additional high-resolution (4m GSD) panchromatic imager to zoom in on areas of interest.

The 2009-launched *U.K.-DMC-2* and *Deimos-1* satellites were based on improved versions of the standard 100-kg class platform, known as **SSTL 100 v2.1**. Improved technology gave them

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enhanced imaging resolution of 22m GSD, effectively doubling the number of pixels they acquire per hectare. Improved onboard memory, power generation and data compression techniques mean these satellites can store an order of magnitude more imagery aboard and downlink data 10 times faster to the ground.

These 'second generation' DMC satellites will be joined this July by the 100-kg-class 22m GSD *NigeriaSat-X* and the very-high resolution 2.5-m GSD *NigeriaSat-2*, the latter's enhanced vision necessitating an enlarged 300-kg class **SSTL 300** satellite platform. The issue here is not only aperture size but the precision attitude control required to point the imager at each required 20x20 km area target — performing rapid roll maneuvers of up to 45 degrees while also compensating for the rotation of Earth's surface.

To make the satellite sufficiently agile for its ambitious variety of imaging modes (including stereo imaging and artificial image widening based on maneuvering), *NigeriaSat-2* has no deployable sections, such as extended antennas or solar wings, to maximize its stability and does without liquid propulsion altogether, which avoids sloshing effects. Instead, an attitude and orbit control subsystem based on momentum wheels overseen by a combination of star trackers, GPS sensors and compact MEMS-based gyro devices derived from terrestrial automobile stability control systems is used.

In SSTL terms, *NigeriaSat-2* is something of an oversized outlier. However, with the majority of DMC missions yet to come, most will retain the heritage SSTL 100 platform. SSTL continues to harness the ongoing advances of the terrestrial electronics industry, so that **SSTL 100 v2.2** will offer a further step change in performance. It will have the same 22m GSD imaging resolution, but a combination of extra onboard memory, faster downlinks and sophisticated data compression techniques mean this next generation will be an 'always-on' satellite capable of generating 62 million km² of image data daily. Every five days a single 'EarthMapper' spacecraft will image the entire land surface of the globe, or a constellation of five such spacecraft can provide global daily coverage.

Satellite tasking procedures will become redundant, simplifying satellite operations. EarthMapper will be able to capture dynamic environmental phenomena such as crop growth, deforestation, urban sprawl, floods or disasters more rapidly and comprehensively than ever before. An 'always-on' constellation would represent a significant resource for the entire remote sensing community.

Agricultural forecasting requires a minimum of three images per growing season, which EarthMapper will easily deliver. Urban expansion could be monitored as it happens, home by home, while illegal forest logging pinpointed for intervention by ground authorities. In disaster situations, before-and-after maps would chart the damage done within a single day. And other previously impractical applications come into reach: imagine wide-area monitoring of water resources upon national or even continental scales, with weekly checks on the evolving surface area of lakes, rivers, dams and irrigation systems.

EarthMapper will have 32 Gigabytes of onboard storage provided by a pair of High Speed Data Recorders (Flash memory systems as used in smart phones and cameras are also in development, offering much higher levels of non-volatile storage). SSTL engineers are deciding the best trade-off between data compression techniques and the number of ground stations required — the less 'lossy' the data the better its quality, but the number of ground stations needed would swell as a consequence, from a minimum of two to a maximum of five, increasing the cost of operations.

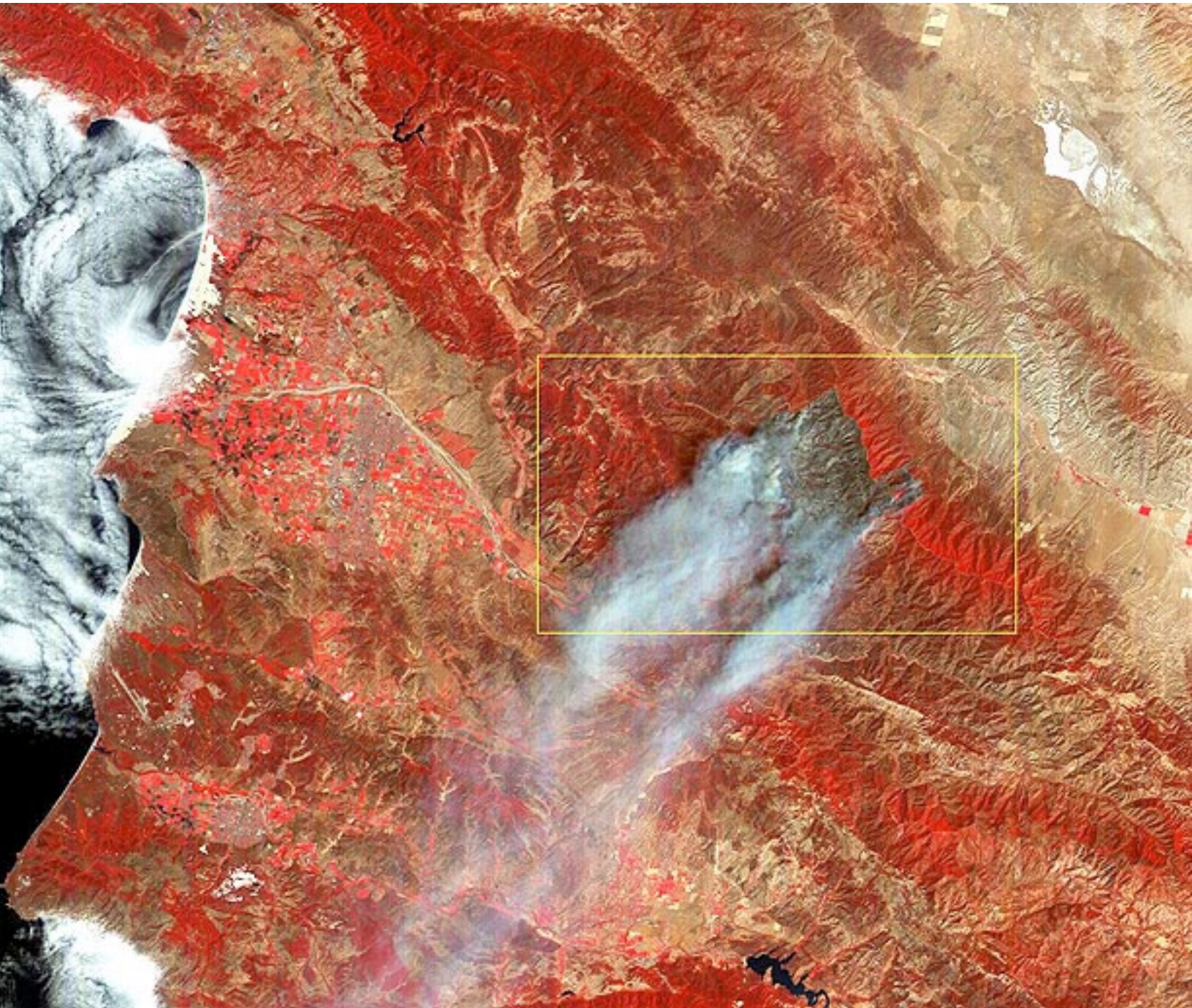
Doubling data downlink rates from the current 80 Mbit/s to 160 Mbit/s would allow lossless compression to a single pair of ground stations, although this transmitter would be too power-hungry for the standard SSTL 100 platform. This could be accommodated by switching the satellite's body-mounted single-junction solar cell panels to more efficient triple-junction cells, so-called because successive layers are tuned to different segments of the overall light spectrum, as well as adding extra solar panels. *U.K. DMC-2* has already flown a deployable triple-junction solar panel. The best solution for EarthMapper might well be a combination of high- and low-powered transmitters on the satellite, offering users a choice between lossless and lossy imagery, with a tried and tested system backing up the newer high-power design to reduce mission risk. The first EarthMapper satellite could be flying as early as next year, with a full constellation in operation in the second half of this decade.

The EarthMapper SSTL 100 v2.2 will become the new standard for the DMC, but that standard will, in turn, give way by mid-decade to the **SSTL 100 v3**, planned to incorporate a new imager that is currently at the prototype stage, offering increased resolution and access to two new spectral bands.

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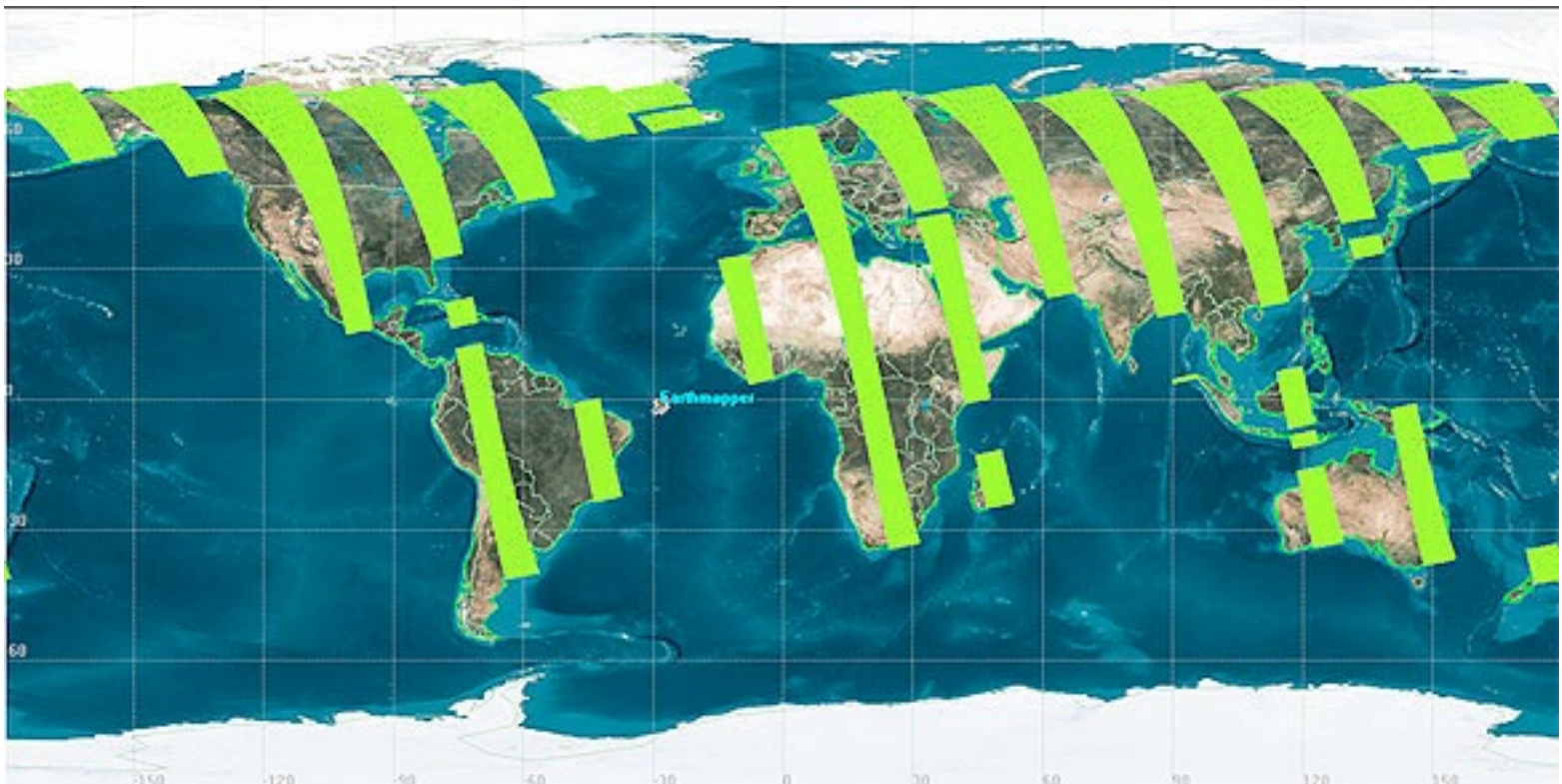
This new design combines the red, green and *near infrared* (**NIR**) channels of current DMC missions with the addition of *short-wave infrared* (**SWIR**) — capable of identifying the water content of crops and soil — and blue. The visible and NIR bands have 10 – 15m GSD, with SWIR of 20 – 30m GSD, with a swath of 440 km for all bands. The SSTL 100 v3 will continue to provide information to the current users, but will better respond to the needs of some core users such as the agricultural sector, adding important capabilities to the DMC.

Another planned evolution of the basic platform, the **SSTL 100 HR** would use the same avionics as the EarthMapper to provide 3-m GSD panchromatic-sharpened RGB (red green blue) imagery with a 24 km swath. Any greater resolution than that and the laws of physics kick in to demand a larger aperture. For the next iteration of the DMC, the **DMC3**, SSTL intends to offer 1m panchromatic resolution imagery with 4-m RGB and NIR using a still larger version of its agile SSTL 300 platform, the **SSTL 300 SI**, differentiated by a large telescope extending from its body.



Wild fires in Los Padres National Forest, California, as captured by SSTL's Deimos-2 satellite

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EarthMapper coverage map

DMC3 will also follow a new business model, with customers leasing access to satellite capacity.

The past and future evolution of the DMC demonstrates how incremental improvements of 'fit for purpose' engineering can give rise to a broadened suite of capabilities. Previous constraints on image resolution and data timeliness of data are both being tackled while preserving the constellation's low cost and sustainable nature. Beyond that, the fundamental limitations on DMC imagery remain only clouds and darkness. This, too, is being addressed, with a new *synthetic aperture radar* (SAR) mission in the planning stages.

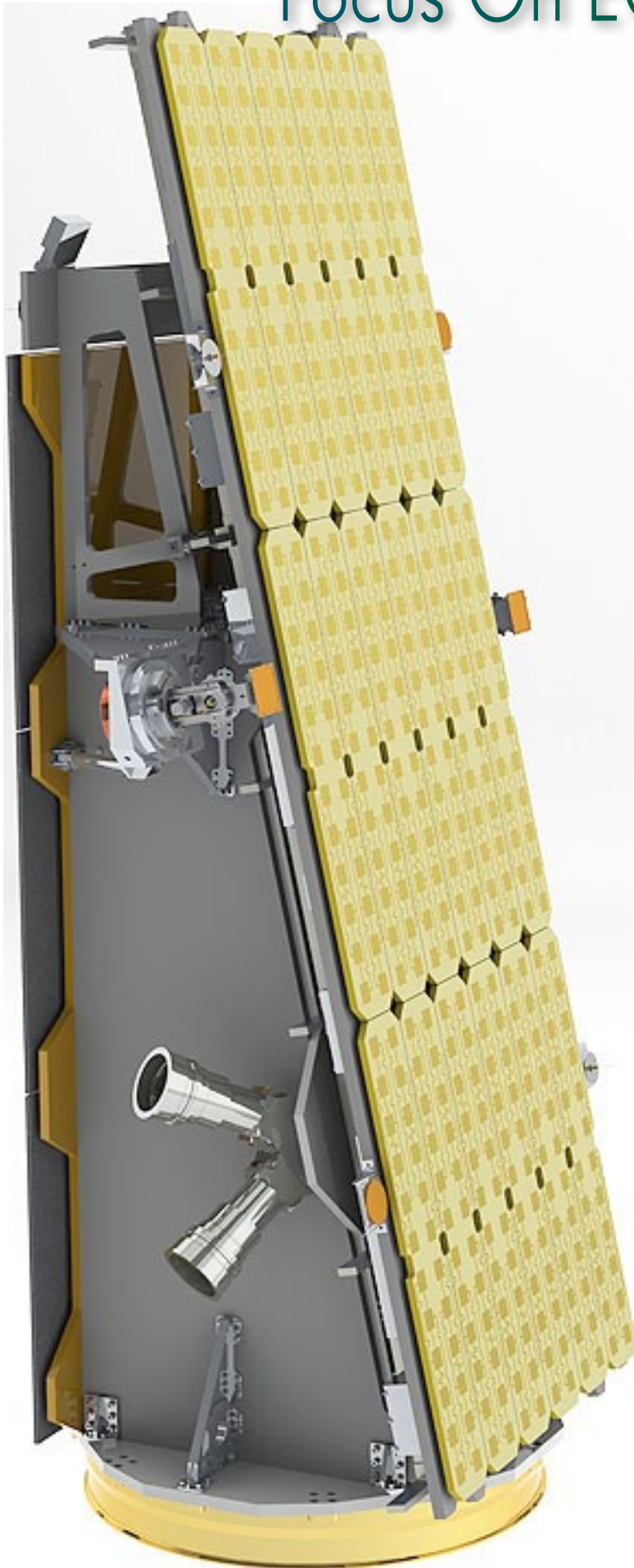
Power-hungry SAR has traditionally been the province of large, multi-ton satellites such as Canada's 2.7-ton **Radarsat**, Germany's 800 kilogram **SAR-Lupe**, or the **European Space Agency's** 8.2-ton **Envisat**. Past Russian military SAR missions even required orbital nuclear reactors to make them practically feasible. SSTL, by contrast, has been developing a small satellite SAR to add an all-weather night and day capability to the DMC, offering affordable SAR data to expand its user base, following SSTL's same approach to its optical missions.

Throughout last year, SSTL worked with its long-term SAR partner **EADS Astrium U.K.** on a mission and payload design, with airborne trials using a demonstrator being carried out last summer and a prototype payload unit being readied for tests to prepare for a proposed launch as early as 2013. The payload will offer multi-mode SAR imagery at a variety of resolutions and swaths, from 3-6 m at 20-30 km swath up to 30 m at 750 km. It will operate in S-band in multiple polarization's to add 'color' to its images.

SSTL's **NovaSAR-S** platform borrows the avionics heritage of the SSTL 300 with a novel wedge-like structure: The 400-kg satellite's Earth-facing side incorporates a 3x1m radar antenna while its other, Sunward side is covered with triple-junction solar panels. Power constraints mean 'always-on' operation is not an option, but the NovaSAR-S will be able to cover upwards of one million km² daily, making its radar imagery available at a cost comparable to its optical DMC counterparts, with a multi-satellite constellation envisaged.

Potential applications include more frequent monitoring of cloud-mired rain forests, monitoring ships in protected marine zones (vessels appear as bright points in radar images) surveying rice

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Model of SSSL's NovaSAR-S platform

crops and also flooding — the world's most single most costly type of natural disaster.

By 2017, all these DMC satellites should be operational in orbit, offering customers a complete portfolio of Earth observation imagery at the same traditional low cost. The take-home lessons from the DMC's success apply to NewSpace and old space alike: building a sustainable business around space is much more an economic challenge than a technical one. Maintain a laser focus on a narrow but marketable field of endeavor while keeping costs low. Innovative business models — such as the DMC's multi-owner jointly-operated satellite constellation — are at least as important as technical innovations. Incremental development offers a way to increase capabilities and grow markets, but costs must still be kept in line.

Finally, and most important of all: Offer something useful and inexpensive and customers will gladly pay for it.

About the author

David Hodgson is the Managing Director of DMC International Imaging Limited. He has worked in satellite related industries for over 19 years and is the Past Chair of the British Association of Remote Sensing Companies (BARSC). He holds a degree in computing and a Masters degree in business administration. David also serves on the Executive Secretariat of the International Charter, 'Space & Major Disasters'.



Landsat – A Historic Perspective

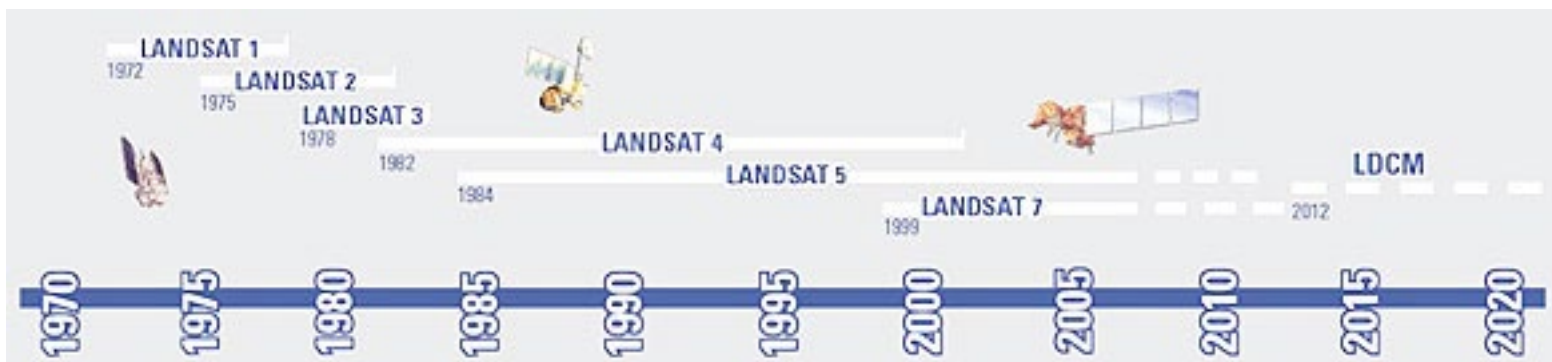
By Jos Heyman, Tiros Space Information

The *U.S. Geological Survey* (USGS) now has almost 40 years of archived data of the Earth's continental surfaces obtained from the Landsat program to support global change research and applications. This data, which has been supplemented by some pre-Landsat military programs, constitutes the longest continuous record of the Earth's surface as seen from space. These millions of images have been distributed throughout the world for use in a wide range of disciplines, including global change research, agriculture, cartography, geology, forestry, regional planning, surveillance, education and national security.



Artistic rendition of a U.S. Landsat satellite. Credit: NASA

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Landsat time line (USGS)

The **Landsat** program was started in 1966 under the name **Earth Resources Technology Satellites Program**. The program was then undertaken by **NASA** and the name was changed to Landsat in 1975.

In 1979, the U.S. Government transferred the program to the **National Oceanic and Atmospheric Administration (NOAA)** with the intention of eventually transferring responsibility to the private sector. This happened in 1985, when the **Earth Observation Satellite Company (EOSAT)**, a partnership of **Hughes Aircraft** and **RCA**, took over the processing, archiving, and sale of Landsat data. EOSAT was also responsible for the development and launching of new satellites (**Landsat-4** and **-5**) with government funding through NOAA.

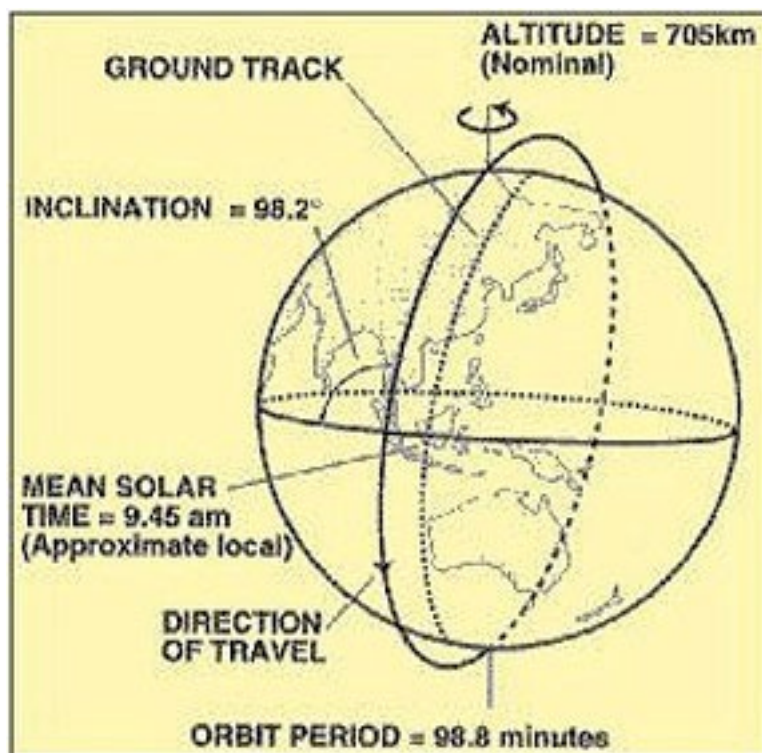
However, continued government funding of Landsat was under a constant threat and, in 1989, consideration was given to closing the operation of the then operational Landsat-4 and -5 satellites. Fortunately, emergency funding allowed the program to continue. By the end of 1992, EOSAT ceased to process Landsat data, but resumed it once again in 1994.

During the EOSAT era, many Landsat observations were missed because there was no obvious or immediate buyer. Collecting data for scientific purposes for use in future scientific study was relegated to a low priority status.

To correct this, the U.S. government decided in 1992 to abandon the commercialization of the Landsat program and launched **Landsat-6** and **Landsat-7** as a government program, with the **U.S. Geological Survey** being responsible for the processing, archiving, and distribution of the data.

In November 1996, EOSAT was acquired by **Space Imaging Inc.**, a company owned by **Lockheed Martin**, **Raytheon E-Systems** and **Mitsubishi**, as well as some companies who acquired minor interests in the firm. This company, which had rights to sell remote sensing data from the Indian **IRS**, the Japanese **JERS** and European **ERS** satellites, as well as their own launched **Ikonos** satellites, continued to be responsible for Landsat-4 and -5 data until July 1, 2001, when that data was transferred to the USGS. Space Imaging was acquired by **GeoEye** in 2006.

The initial core instrument of the Landsat program was the **Multi Spectral Scanner (MSS)** which was developed by the **Hughes Santa Barbara Research Center** in 1969. The MSS was gradually replaced by *thematic mapper* instruments. Landsat-1, -2 and



Landsat orbit
(Landsat-7 Science Data User Handbook¹)

Focus On EO + Imagery

-3 were placed in a polar orbit of about 900 km, whereas later Landsat satellites were placed in orbit with an altitude of about 700 km. In these orbits, the spacecraft crosses the equator from north to south between 10:00 a.m. and 10:15 a.m., local time. With a speed of 75 km/sec, each orbit requires about 99 minutes — it makes 14 orbits each day. In this way, a single satellite covers the entire Earth between 81 degrees North and 81 degrees South once every 16 days.

Currently the leading Landsat ground stations are at Sioux Falls, SD (LGS), the Alaska Ground Station (PFS) and the Svalbard Norway Ground Station (SGS). In addition there are a number of ground stations around the world that download Landsat data for processing and distribution to their user community.

The ground stations, which include several short term 'campaign' ground stations, are located at Córdoba, Argentina (COA), Alice Springs, Australia (ASA), Hobart, Australia (HOA), Cuíaba, Brazil (CUB), Gatineau, Canada (GNC), Prince Albert, Canada (PAC), Beijing, China (BJC), KaShi, China (KHC), Matera, Italy (MTI), Malindi, Kenya (MLK), Chetumal, Mexico (CHM), Irkutsk, Russia (IKR), Magadan, Russia (MGR), Moscow, Russia (MOR), Hartebeesthoek, South Africa (JSA), Maspalomas, Spain (MPS), Kiruna, Sweden (KIS) and Bangkok, Thailand (BKT).

Inactive ground stations are situated at Neustrelitz, Germany (NSG), Parepare, Indonesia (DKI), Hatoyama, Japan (HAJ) and Hiroshima, Japan (HIJ).

ERTS (Landsat)-1

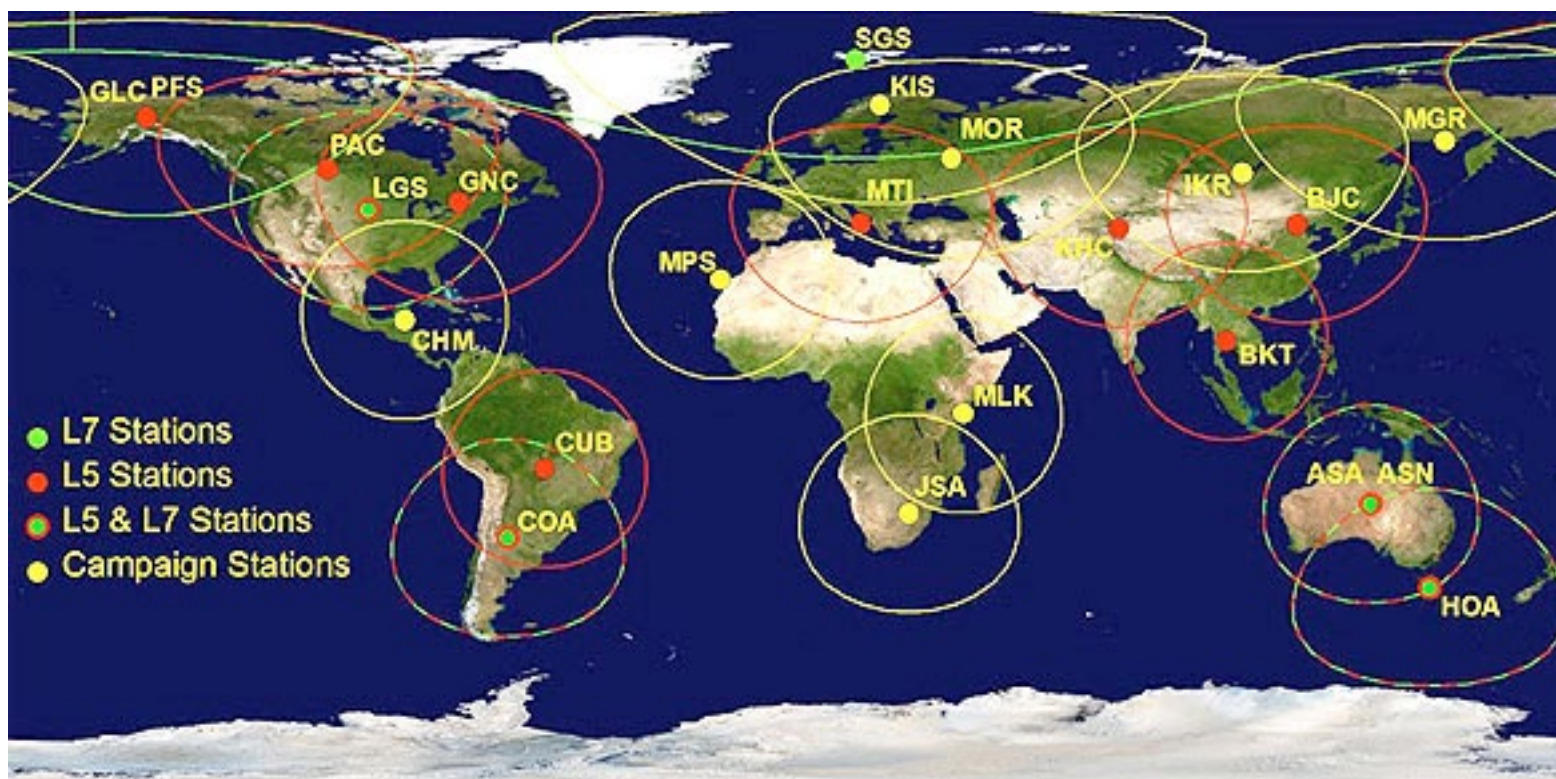
The *Earth Resources Technology Satellite* (ERTS)-1 satellite, renamed *Landsat-1* on January 14, 1975, was launched on July 22, 1972.

The satellite was based on the *Nimbus* series of three axis stabilised meteorological satellites and was equipped with:

- Three Return Beam Vidicon (RBV) cameras which operated in the 0.48 – 0.57 μm , 0.58 – 0.68 μm and 0.70 – 0.83 μm band of the electromagnetic spectrum with a 80 m resolution
- A Multi Spectral Scanner (MSS) which operated in the 0.5 – 0.6 μm , 0.6 – 0.7 μm , 0.7 – 0.8 μm and 0.8 – 1.1 μm bands with a 80 m resolution

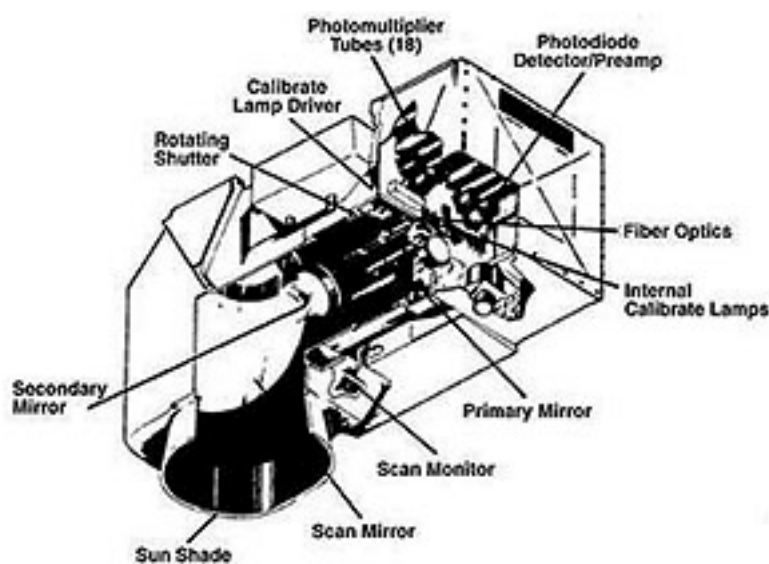
It also carried two tape recorders to store data.

The 816 kg satellite was built by **General Electric** and was shut down on October 7, 1978, by which time the two tape recorders had failed, attitude control problems had been encountered, and



Active Landsat Ground Stations (NASA)

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MSS instrument

the green band MSS sensor had failed. By then the satellite had returned 3,000,000 images.

Landsat-2

Landsat-2 was placed in orbit on January 22, 1975. It was similar to Landsat-1 and was placed in such an orbit in relation to Landsat-11 that the two satellites combined ensured full global coverage every eight to nine days. Landsat-2 was removed from service on February 25, 1982.

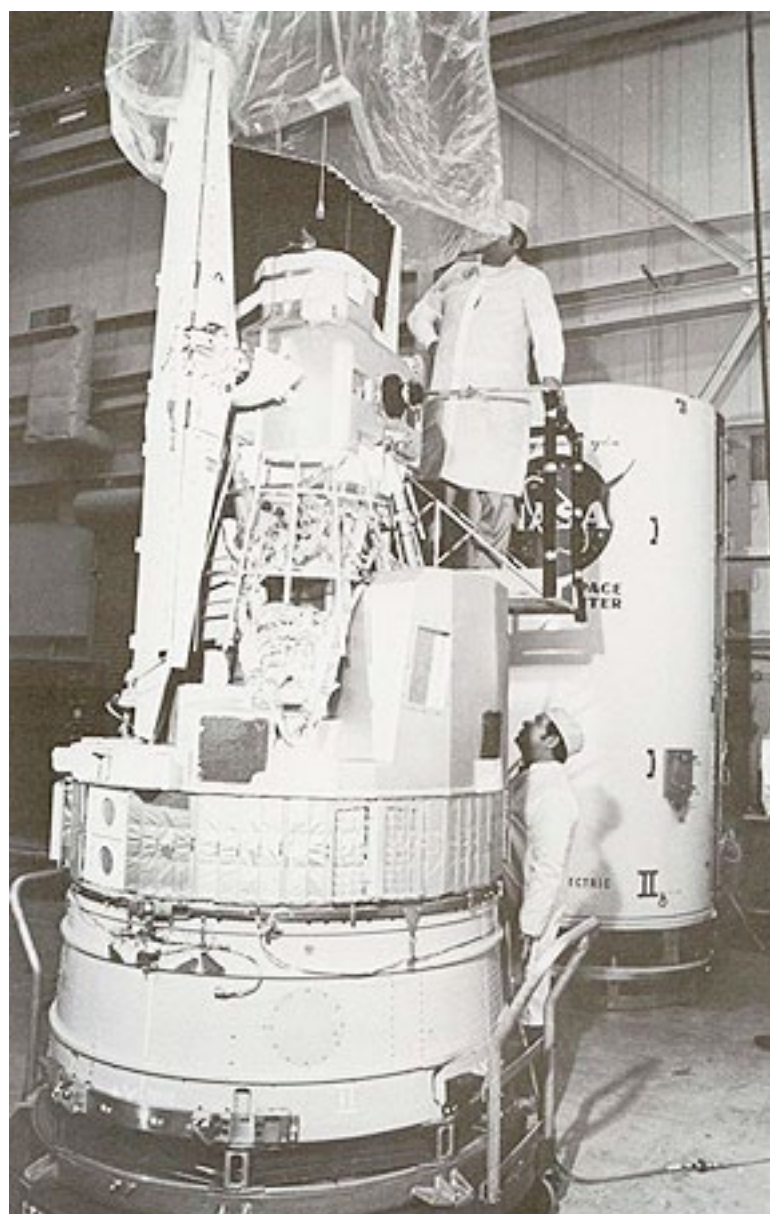
The *RBV* system was operated primarily for engineering evaluation purposes and, only occasionally, RBV imagery was obtained primarily for cartographic uses in remote areas.

Landsat-3

Landsat-3, launched on March 5, 1978, again used the basic *Nimbus* spacebus, but also incorporated various improvements in instrumentation:

- Two Return Beam Vidicon cameras which could produce two side-by-side images of the same ground surface in the 0.505 to 0.75 μm band with a resolution of 40 m
- A MultiSpectral Scanner which operated, in addition to the same bands and resolution as for the scanner of Landsat 1 and 2, in the 10.4 to 12.6 μm band with a resolution of 240 m to detect emitted thermal energy

In addition the 960 kg satellite, which replaced Landsat-1, carried a data collection system. The improved instrumentation on board



Landsat-2

Landsat-3 increased the resolution of the images to 40 m. The satellite was retired on March 31, 1983, although some references quote September 7, 1983.

Landsat-4

The *Landsat-4* Earth resources satellite introduced a new design that incorporated an manoeuvring engine and also facilities for retrieval by the Space Shuttle, thereby allowing the satellite to be refurbished. It was launched on July 16, 1982, and the instrumentation consisted of:

- A MultiSpectral Scanner operating in the 0.50.6 μm , 0.60.7 μm , 0.70.8 μm and 0.81.1 μm bands of the electromagnetic spectrum with a resolution of 80 m and a swath width of 185 km

Focus On EO + Imagery

- A thematic mapper operating in the seven bands in the 0.45 – 0.52 μm , 0.52 – 0.60 μm , 0.62 – 0.69 μm , 0.76 – 0.90 μm , 1.55 – 1.75 μm and 2.06 – 2.35 μm ranges of the electromagnetic spectrum with a resolution of 30 meters, as well in the 10.4 to 12.5 μm range with a 120 m resolution

The satellite, with a mass of 1942 kg, was placed in such an orbit that it provided a global coverage every 16 days — unfortunately, the satellite lost 50 percent of its power after only a short time in orbit. Although it was intended to repair the satellite in orbit at a later date, such a repair mission was never carried out. The satellite, which was operated as a civilian spacecraft, was closed down on December 14, 1993, after it experienced further problems in functionality.

Landsat-5

Landsat-5, launched on March 1, 1984, was similar to Landsat-4 save for some minor improvements to avoid the power problems encountered with Landsat-4. The satellite, which had a mass of 1938 kg, was placed in such an orbit that, combined with Landsat-4, global coverage could be achieved every eight days. This satellite continues to remain operational.

Landsat-6

Launched on October 5, 1993, the Landsat-6 satellite (*pictured below*) failed to reach orbit due to the failure of the **Star-73** kick motor. The satellite was built by **GE Astrospace** and was based on the **Tiros N** meteorological satellite.

The instrument of the 1740 kg satellite consisted of an *Enhanced Thematic Mapper* operating in the same seven bands as the Thematic Mapper of Landsat-4 and -5, but with an eighth panchromatic band 0.50 – 0.60 μm with a resolution of 15 m. Landsat-6 would have been fully compatible with Landsat-4 and -5.

Landsat-7

Landsat-7 was launched on April 15, 1999. It was built by **Lockheed Martin** and was based on the **Tiros N** meteorological satellite. The 1969 kg satellite was specifically used for the global monitoring of deforestation, soil moisture estimation, flood monitoring, and the observation of earthquake and volcanic eruption damage. The satellite carried the *Enhanced Thematic Mapper Plus*, a multispectral scanner operating in 8 bands (0.45 – 0.52 μm , 0.52 – 0.60 μm , 0.63 – 0.69 μm , 0.76 – 0.90 μm , 1.55 – 1.75 μm , 2.08 – 2.35 μm) with a resolution of 30 m, 10.4–12.6 μm with a resolution of 60 m, and panchromatic 0.50 – 0.60 μm with a resolution of 15 m.

LDCM

The **Landsat Data Continuity Mission (LDCM)** will continue to provide repetitive gathering of high resolution multispectral data of the Earth's surface on a global basis. It is scheduled for launch in December 2012.

The 2623 kg satellite is being built by **General Dynamics Advanced Information Systems**, a subsidiary of **Orbital Sciences**. The instruments that will be carried by LDCM are:



Focus On EO + Imagery

- The Operational Land Imager (OLI) which will collect images for nine spectral bands in the shortwave portion of the spectrum (0.43 - 0.44 μm , 0.45 - 0.48 μm , 0.52 - 0.56 μm , 0.63 - 0.65 μm , 0.84 - 0.86 μm , 1.56 - 1.61 μm , 2.1 - 2.2 μm , 1.36 - 1.37 μm) with a resolution of 30 m, and panchromatic 0.5 - 0.59 μm with a resolution of 15 m
- The Thermal Infrared Sensor (TIRS) which will collect data in two longwave bands (10.8 and 12 μm) with a resolution of 120 m.

It is expected that the satellite will be called Landsat-8 once in orbit.

Landsat Users Study

A recent study for the U.S. Geological Survey² surveyed the users of Landsat imagery as well as its applications. Of the 4,753 users that had initially agreed to take part in the study, 2,523, or 53 percent, actually completed the survey.

The study found that 33 percent of users came from academic institutions, 18 percent from private business, 17 percent from federal government, 16 percent from state government and 10 percent from local government with the remaining 5 percent other users.

The 37 different application areas that were identified in the study were collapsed into nine categories for the purpose of analysis. Using these categories, it was found that more than 40 percent of the usages were for environmental science and management applications with 17 percent for land use/land cover, 11 percent for planning and development, 8 percent for education and 8 percent for agriculture.

More than 91 percent of respondents used Landsat imagery to answer questions or solve problems. 57 percent used the imagery as a basis for decisions whilst more than 80 percent considered the imagery as somewhat or very important to their work. Of all imagery used, 54 percent came from Landsat with the remaining coming from commercial and other sources.

Forty-five percent of the respondents obtained their data directly from the U.S. Geological Survey EROS office, while more than 20 percent downloaded the imagery from the Internet. However, about 25 percent did not know the source of the imagery they were using.

Focus On EO + Imagery

References

¹ Landsat-7 Science Data Users Handbook, NASA 2009 (?)

² Miller, Holly M et al, The Users, Uses, and Value of Landsat and Other Moderate-Resolution Satellite Imagery in the United States—Executive Report, Reston, VA, 2011



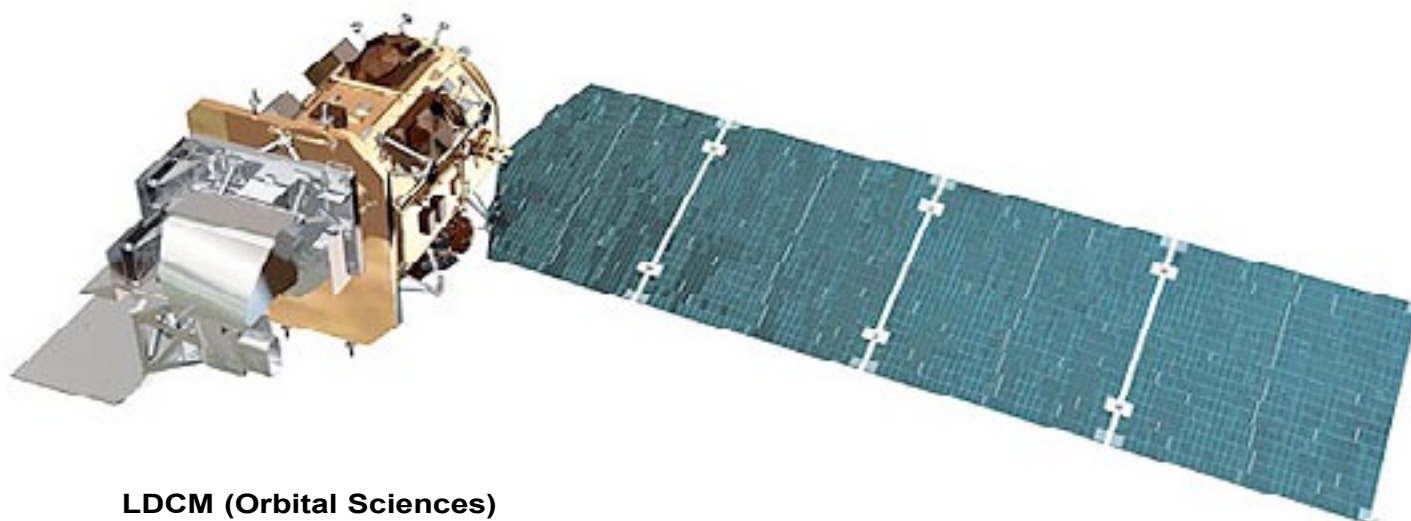
About the author

Jos Heyman is the Managing Director of Tiros Space Information, a Western Australian consultancy specializing in the dissemination of information on the scientific exploration and commercial application of space for use by educational as well as commercial organisations. An accountant by profession, Jos is the editor of the TSI News Bulletin and is also a regular contributor to the British Interplanetary Society's Spaceflight journal.



Satellite	Sensor	Bandwidths	Resolution	Satellite	Sensor	Bandwidths	Resolution
LANDSATs 1-2	RBV	(1) 0.48 to 0.57	80	LANDSATs 4-5	MSS	(4) 0.5 to 0.6	82
		(2) 0.58 to 0.68	80			(5) 0.6 to 0.7	82
		(3) 0.70 to 0.83	80			(6) 0.7 to 0.8	82
	MSS	(4) 0.5 to 0.6	79			(7) 0.8 to 1.1	82
		(5) 0.6 to 0.7	79		TM	(1) 0.45 to 0.52	30
		(6) 0.7 to 0.8	79			(2) 0.52 to 0.60	30
		(7) 0.8 to 1.1	79			(3) 0.63 to 0.69	30
						(4) 0.76 to 0.90	30
LANDSAT 3	RBV	(1) 0.505 to 0.75	40			(5) 1.55 to 1.75	30
		(4) 0.5 to 0.6	79			(6) 10.4 to 12.5	120
	MSS	(5) 0.6 to 0.7	79			(7) 2.08 to 2.35	30
		(6) 0.7 to 0.8	79	LANDSAT 7	ETM ⁺	(1) 0.45 to 0.52	30
		(7) 0.8 to 1.1	79			(2) 0.52 to 0.60	30
		(8) 10.4 to 12.6	240			(3) 0.63 to 0.69	30
						(4) 0.76 to 0.90	30
						(5) 1.55 to 1.75	30
						(6) 10.4 to 12.5	60
						(7) 2.08 to 2.35	30
						PAN 0.50 to 0.90	15

Landsat bands (Landsat-7 Science Data User Handbook)



LDCM (Orbital Sciences)

Forrester's Focus

By Chris Forrester, Editorial Director, Broadgate Publications

The satellite industry has just completed its quarterly reporting season, and there's little doubt that the FSS sector is in great shape. Satellite operator SES, as of March 31st, was fully using 995 transponders out of a fleet total of 1249 (79.7 percent, and up 32 full transponders on the same period last year) with markets such as India filling "every available transponder" on its *SES-7* craft. This is the reason why SES has ordered a new 33-transponder satellite (*SES-8*) to boost India coverage. India is proving to be a hot market for SES, where it has about 50 percent of the local DTH market. Its capacity is leased via India's ISRO space organisation, usually on five-year contracts for DTH clients. India's DTH demand is growing exponentially, up from 20 million at the end of 2009 to more than 32 million homes today.

Prospects over Germany are also much better, helped by **SES Astra's HD+** platform (now at 769,000 connections) and renewals are running at more than 66 percent and "beyond our expectations," according to the company. **SES** confirmed that nine of its 33 German analog transponders have been re-contracted for HDTV transmissions by Germany's public broadcasters. Moreover, HD+, a system where free-to-air (FTA) network broadcasters can receive a modest income for switching into HDTV, is now the standard

in the market, stretching across German cable and IPTV-delivered services. The growth of hybrid boxes, combining satellite and cable/IPTV services, is also looking far healthier.

SES' president/CEO *Romain Bausch* said the German consumer is — at last — starting to embrace high-definition (HD) and pay-TV in general. **News Corp**-backed **Sky Deutschland's** improved HD offering will continue to drive the consumer's interest in pay-TV,



Artistic rendition of the SES-7 satellite

he suggested. Two or three new HD+ channels will also be added by year-end, he added. "There is progress in the market." Astra at **19.2 degrees East** currently could be left with around 20 unused transponders once Germany switches off its analog transmissions.

The move forward resulted in SES' Q1 operating profits which grew 6.7 percent to 206.3m euros, and with revenues up 4.2 percent to 428.4m euros. SES reiterated that its capital expenditure would continue to fall in the period to 2014 (down to about 10-15 percent by 2014, from 45 percent last year). There are 12 satellites scheduled for launch by the end of 2014, adding 293 incremental transponders and thus delivering 23 percent of extra capacity (compared with the position at December 2010).

However, SES' big news was an explanation of how its **OneSES** restructuring would work (see box). The operative words were "streamlining" and "refocusing" and how such will boost overall efficiency as well as seek new commercial opportunities, particularly in emerging markets. "SES is recruiting extra staff on a regional basis," said *Bausch*, to achieve the company's aims. SES' new management structure kicked in on May Day, May 1st, which saw a consolidation of its activities under a single operational system. This will help to deliver around 10 to 15m euros in cost savings per annum by 2012, building to a savings/increased revenues of 25 to 30m euros per annum by 2013.

SES' 2011 fleet additions

Astra 1N	Q2/11 (replacement)
QuetzSat 1	Q3/11 (+32 transponders)
SES-3	Q3/11 (replacement)
SES-2	Q4/11 (replacement)
SES-5	Q4/11 (+64 transponders)
SES-4	Q4/11 (+27 transponders)

Notes:

SES-2 has slipped its original Q3 launch plan due to a U.S. military CHIRP payload

SES 3 is delayed from Q2 because of delays from its co-passenger on a Proton rocket

SES-4 has slipped a "few months only" from a planned Q3 launch

QuetzSat is fully pre-leased to Echostar

This year will see six new satellites added to its fleet, with three of the craft adding incremental transponders. This includes **Yahsat 1A**, operating over the Middle East, Africa, Europe and parts of Asia, where SES Astra has a partnership to sell the DTH capacity on the craft. Yahsat 1A launched on April 22nd. The other six satellites will create a busy launch schedule, said *Bausch*.

Bausch added, "SES' financial results are on track, reflecting business developments in the first quarter. A number of contracts were signed for new DTH and broadband services in Europe, and the development of HD programming in Germany was given a boost as the German public broadcasters committed to five transponders to follow the termination of analogue broadcasting in April 2012. New capacity agreements for broadcast and broadband

SES Restructures Into OneSES

Satellite operator SES has restructured its senior management under the "OneSES" banner. The decision was flagged some weeks ago at the company's AGM, and sees the former subsidiary operating companies of SES Astra and SES World Skies come together under a streamlined management structure. A new executive committee of senior management emerges under the presidency/CEO position of Romain Bausch.

Romain Bausch, President and CEO
Andrew Browne, Chief Financial Officer,
Martin Halliwell, Chief Technology Officer,
Ferdinand Kayser, Chief Commercial Officer
Gerson Souto, Chief Development Officer

Robert Bednarek, formerly President and CEO of SES World Skies, assumes the role of strategic advisor.

"We are excited to serve our customers with a single face to the market and with our global fleet. By adapting our organisation, we expect to optimize the execution of our growth strategy and to maximize the potential for our satellites in emerging markets, to which the vast majority of our incremental upcoming capacity is dedicated," explained *Bausch*.

services in Central and Latin America were signed, and additional capacity was contracted for global maritime services.” However, *Bausch* was also cautious about some markets, especially Romania, where DTH consolidation was likely, and this would lead to some lost transponders to the industry as a whole.

SES is sticking with its formal guidance, which is to deliver three percent growth in recurring revenues this year, as part of the four to five percent CAGR anticipated in the 2010-2012 time-frame. SES Astra is carrying 211 HD channels across the fleet as of March 31st, up from 190 at the close of 2010.

Eutelsat Ups Guidance

As good as SES’ numbers were, it was **Eutelsat** which took the market by surprise, with the FSS operator telling analysts that it would exceed its already upbeat guidance, and by a decent margin. Eutelsat also said that a long-running squabble between Deutsche Telekom (and Media Broadcast) over frequency rights at the ‘Astra’ second orbital position of **28.2 degrees East**, where Eutelsat operates its **Eurobird** satellite alongside at **28.5 degrees East**, is being submitted for arbitration before a *International Chamber of Commerce* tribunal. “The rights to certain frequencies at this orbital position are currently exploited by Eutelsat within the context of an agreement dating from June 1999 between Eutelsat and Deutsche Telekom (which has since transferred its satellite activity to Media Broadcast).”

Eutelsat’s numbers (in euros m to March 31st)

	3Q		change	9 months		change
	2010	2011	percent	2010	2011	percent
Video applications	189.6	198.5	+4.7	551.0	590.5	+7.2
Data and Value-Added	52.0	58.9	+13.3	148.4	175.7	+18.4
Multi-usage	25.1	32.6	+29.9	69.6	90.0	+29.3
Other revenues	0.7	3.2	NM	3.4	10.1	NM
Sub total	267.4	293.2	+9.6	772.3	866.3	+12.2
Non-recurring rev’s	0.9	2.0	NM	4.0	4.7	NM
TOTAL	268.3	295.2	+10	776.3	871.0	+12.2

Data: Eutelsat, May 10

A little history: The **DFS-Kopernikus** fleet, as far as operational/frequency rights are concerned, went to SES Astra for **K-1** and **K-3** (at 23.5 degrees East) following an agreement signed around 2000. However, K-2’s frequencies, which operated at 28.5 degrees East, went to Eutelsat following their agreement with **Deutsche Telekom** (DT) in 1999. The deal with DT, signed on June 30, 1999, enabled Eutelsat to take over the DFS **Kopernikus 2** satellite at 28.5 and to subsequently deploy a new Ku-band, 24-transponder satellite at the end of 2000. Cheekily, at the time, Luxembourg’s **PTT** contracted for many of the transponders which they immediately sold on to SES Astra!

Eutelsat, however, impressed the market with an impressive set of Q3 numbers (to March 31st) and also formally raised its guidance some 40m euros. In doing so, the Company told everyone it would exceed this year’s trading targets. Revenues rose 10 percent, and the satellite operator says it now expects its full year numbers to exceed 1.16bn euros (\$1.62bn). “Demand remains strong,” said CEO *Michel de Rosen*.

Eutelsat’s satellites carried 3,835 channels, up from 3,539, a year earlier, an increase of 8.4 percent.

Indeed, Mr. *de Rosen* was able to show that revenues grew (compared to the same period last year) in all segments of Eutelsat’s business, with double-digit growth in its Data, Value-Added and quite spectacular expansion from its Multi-usage segment. Q3 numbers were up 10 percent to 295.2m euros, and nine month revenues to March 31st rose by 12.2 percent to 871m euros. Q3 video revenues rose from 189.6m euros last year to 198.5m euros.

De Rosen said, “We are delighted to report third quarter revenue growth of 10 percent. This growth was driven by further strong momentum in all our markets; an exceptionally strong contribution from our Multi-usage activity as demand from government agencies was high; and by the continued optimisation of our in-orbit resources, with the fill rate standing

Forrester's Focus

at above 90 percent since 31st December 2010. We are raising our objective for the full year and now expect to deliver revenues of over 1,160 million euros. Looking ahead, demand remains strong in all of our regions and our significant fleet expansion plan in the coming years will ensure that we are well-positioned to capture this growth.”

Investment bankers **Morgan Stanley**, in a note to investors, said they remain upbeat on Eutelsat (and the satellite sector in general). “The fixed satellite service industry presents numerous advantages in an uncertain market environment. Demand for transponder capacity is poised to grow over the next three years, driven by (i) the accelerating take-up of HD / 3D in mature markets (ii) the proliferation of digital channels in emerging markets, and (iii) demand from government services.”

Eutelsat says two other key video neighbourhoods attracted new customers. At the 16 percent East position, notably covering Central Europe, the leading telecom operator in Croatia selected Eutelsat to optimise the footprint of its TV platform in areas beyond its DSL network, particularly in the Adriatic archipelago. Elsewhere, one of Russia's principal suppliers of uplinking services for payTV platforms and channels selected Eutelsat's video neighbourhood at **36 degrees East**, the leading orbital position serving Russia, to launch a new platform.

The operator said video applications continue to benefit from positive long term global trends including the growing number of homes equipped for DTH and the increasing number of TV channels worldwide. As of March 31, 2011, Eutelsat's satellites carried 3,835 channels, up from 3,539, a year earlier,

an increase of 8.4 percent. The number of HD channels broadcast by the fleet stood at 210, up from 120, an increase of 75 percent over the previous 12 months.

All of this past quarter's activity excludes ***Ka-Sat*** which is only just now coming into service and should kick in with meaningful revenues next year, and building to be worth 100m euros by 2014. ***W3C*** and ***Atlantic Bird 7***, both due to be launched later in 2011, will also start to earn their investment back this coming winter.

Eutelsat's planned launch schedule

Satellite	Estimated launch	Transponders
W3C	Sept 2011	53 Ku/3 Ka
Atlantic Bird 7	Sept-Dec 2011	50 Ku
W6A	Sept–Nov 2012	40 Ku
W5A	Oct–Dec 2012	48 Ku
W3D	Jan–March 2013	53 Ku/3 Ka
Eurobird 2A*	April–June 2013	16 Ku/7 Ka

* Partnership satellite with ictQATAR, transponders indicated for Eutelsat portion only

An additional four satellites are currently under construction: **W6A**, **W5A**, **Eurobird 2A** and **W3D**. These satellites are scheduled to be launched between September 2012 and June 2013.

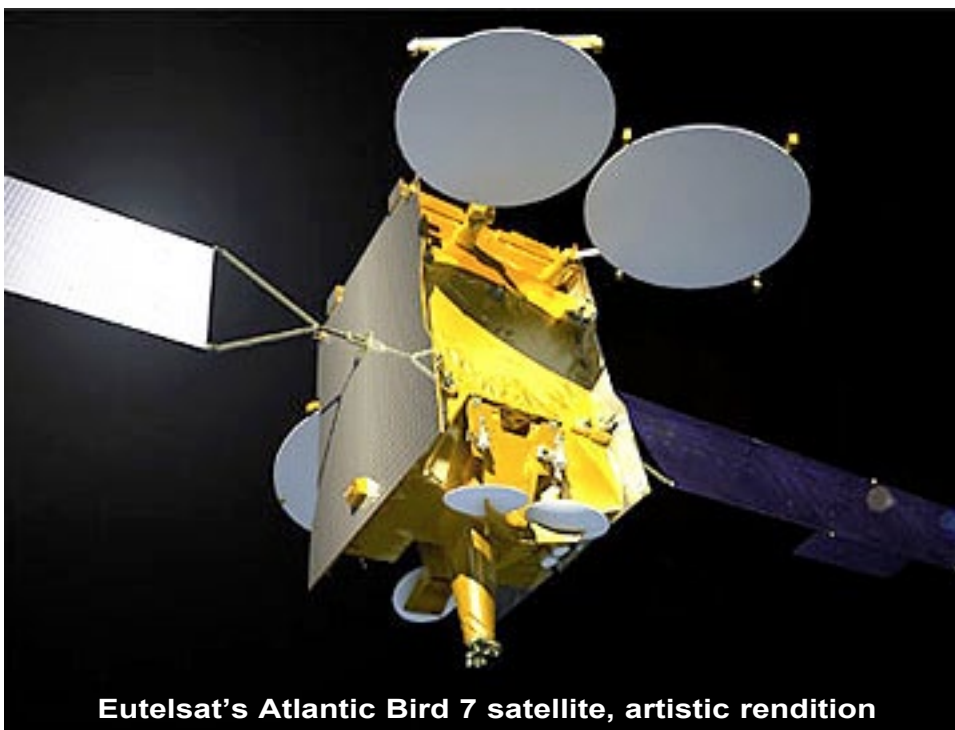
Morgan Stanley's advice to investors on May 11th spoke of it remaining 'overweight' in Eutelsat (and SES) and the bankers being upbeat on Eutelsat's performance. "Eutelsat plans to launch an additional six satellites by the end of calendar Q1213, after having successfully launched Ka-Sat in December 2010. These satellites will increase the group's transmission capacity by 273

transponders on top of the 82 spot beams on Ka-Sat. For modeling purposes, we assume one spot beam equals one transponder. This means that between December 2010 and June 2013, ETL will have increased its capacity by 355 transponders."

The bank's forecasts look more than healthy for Eutelsat, growing beyond this year's revised revenues of 1.169bn euros, to 2012's 1.253bn euros, 2013's 1.34bn euros, and 2014 reaching 1.41bn euros. By 2015, says the bank, Eutelsat should have annual revenues almost reaching 1.5bn euros.

About the author

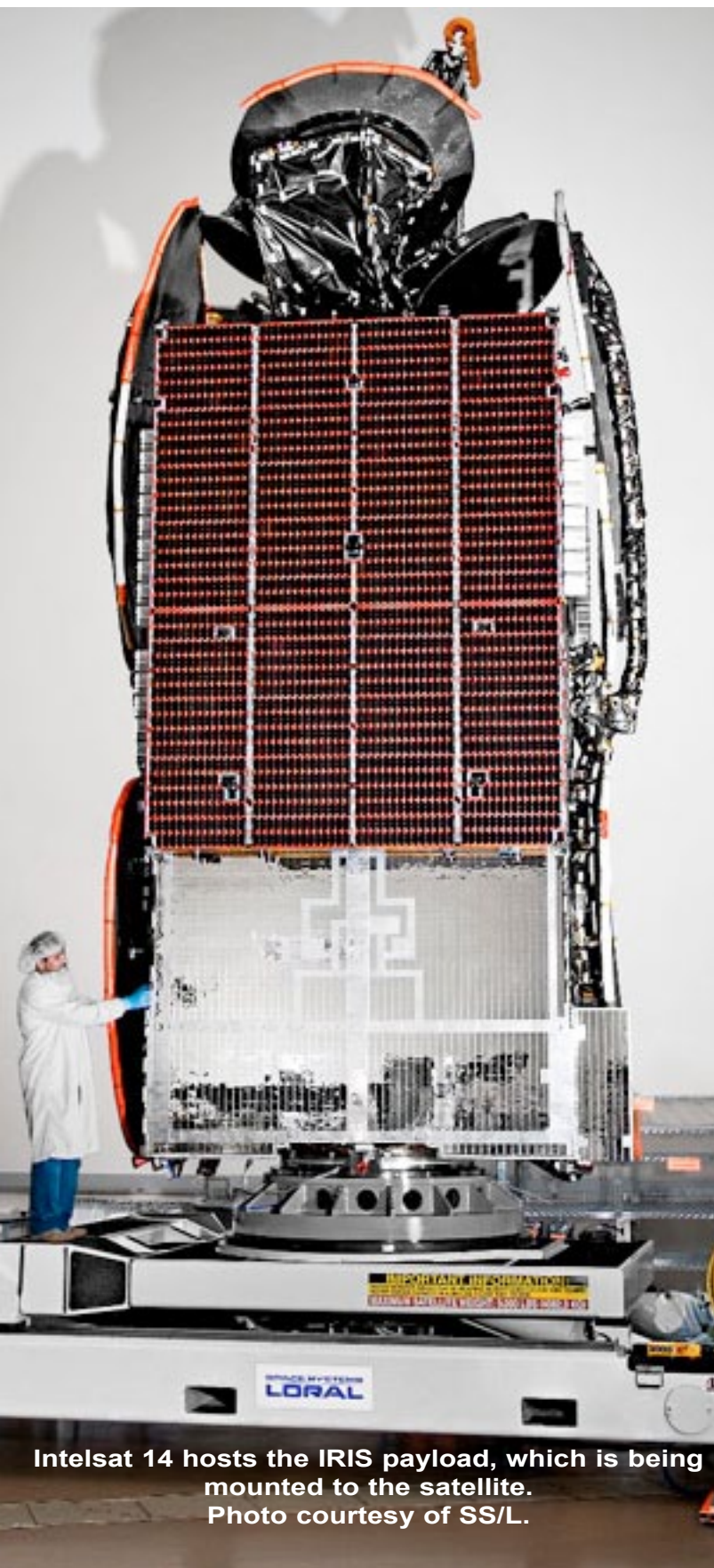
Chris Forrester is a well-known broadcasting journalist and industry consultant. He reports on all aspects of broadcasting with special emphasis on content, the business of television and emerging applications. This includes interactive multi-media and the growing importance of web-streamed and digitised content over all delivery platforms including cable, satellite and digital terrestrial TV as well as cellular and 3G mobile. Indeed, he has been investigating, researching and reporting on the so-called 'broadband explosion' for more than 25 years. He has been a freelance journalist since 1988.



Eutelsat's Atlantic Bird 7 satellite, artistic rendition

Focus On The Hosted Payload Alliance

HPA — What It Is + What It Does...



The Hosted Payload Alliance (HPA) is a new industry trade group that was formed by leading satellite companies to advance the use of hosted payloads on commercial satellites and to create the opportunities for dialogue between government and industry on the issues affecting hosted payloads, at the policy and program level.

The Steering Committee Members

- *Boeing Space & Intelligence Systems*
- *Intelsat General Corporation*
- *Iridium Communications Inc.*
- *Lockheed Martin Space Systems*
- *Orbital Sciences Corporation*
- *SES WORLD SKIES,
U.S. Government Solutions*
- *Space Systems/Loral*

The *U.S. National Space Policy* published in 2010 calls for an increasing role by commercial space to meet government requirements. The policy also explicitly directs the use of non-traditional options for the acquisition of space goods and services, and cites hosted payloads as one of these non-traditional options. The policy notes that public-private partnerships with the commercial space industry can offer timely, cost-effective options to fill government requirements.

**Intelsat 14 hosts the IRIS payload, which is being mounted to the satellite.
Photo courtesy of SS/L.**

Focus On The Hosted Payload Alliance

The HPA's Goals

- Serve as a bridge between government and private industry to foster open communication between potential users and providers of hosted payload capabilities.
- Build awareness of the benefits to be realized from hosted payloads on commercial satellites.
- Provide a forum for discussions, ranging from policy to specific missions, related to acquisition and operation of hosted payloads.
- Act as a source of subject-matter expertise to educate stakeholders in industry and government.

Membership in HPA is open to satellite operators, satellite manufacturers, system integrators and other interested parties.

To obtain more of an understanding of what the HPA means to the industry, we were able to speak directly with members of the Alliance and asked each subject-matter expert the same questions regarding the Alliance. We asked members of the HPA's Steering Committee identical questions and also requested information about their backgrounds. . .

Jim Mitchell, Vice President, Boeing Commercial Satellite Services

I have spent more than 25 years in the satellite industry working at Hughes and then Boeing. Most of my focus over that time period has been on commercial satellite sales and business strategies, including product line pricing strategies, vendor financing arrangements, delivery-in-orbit contracting, and remarketing agreements. Over the past couple of years, however, my focus has been on business plans for using commercially hosted payloads to augment existing government constellations, including Wideband Global and UHF Follow On.



Don Thoma, Executive Vice President, Marketing, Iridium, + Chairman, Hosted Payload Alliance

I joined the company in 2001 and held previous positions as executive vice president of corporate development, executive vice president of vertical markets, and executive vice president of data services. Prior to joining Iridium, I served as vice president of marketing and business development for ObjectVideo, Inc. Before that, I held various positions at ORBCOMM, ranging from senior director of transportation to founder and general manager of the vantage tracking solutions business unit and vice president of business development. Previously I was a captain for the U.S. Air Force Space Division.



Tim Deaver, Vice President, Hosted Payloads Development, SES WORLD SKIES, U.S. Government Solutions

I joined SES WORLD SKIES, U.S. Government Solutions in January 2008 (which at the time was referred to as AMERICOM Government Services) and currently serve as the Vice President of Hosted Payload Development. I lead the management of all Air Force programs and provide direct support to the Corporate Development team in their quest to find innovative ways to use commercial communication satellites to meet the needs of our U.S. Government customers. I also serve as the Program Executive for the Commercially Hosted Infrared Payload (CHIRP) program. Prior to joining SES, I served 22 years in the U.S. Air Force in various jobs closely associated with Space Systems. My career included assignments in Space Operations, Space Intelligence, Space System Acquisition and Space Policy.



David Anhalt, Vice President, U.S. Government Solutions, Space Systems/Loral

I joined SS/L earlier this year after spending seven years at Orbital Sciences Corporation and 28 years serving in the U.S. Air Force. At Orbital Sciences I was the architect and program manager for the Commercially Hosted Infrared Payload (CHIRP) flight demonstration, which is one of the U.S. government's first experiments with hosting a military payload on a commercial spacecraft.



Focus On The Hosted Payload Alliance



An artist's rendering of a Boeing satellite with a hosted payload. The hosted payload is the four-pronged square facing toward Earth. Image is courtesy of Boeing.

SatMagazine (SM)

Please tell our readers why you feel hosted payloads are such an important issue?

Jim Mitchell, Boeing

The military has several choices to meet its communications needs over time. These choices include dedicated government spacecraft, leased commercial capacity, and government payloads hosted on commercial spacecraft. The U.S. government's current demand for broadband military satellite bandwidth over time is estimated to be as much as two to three times more than will be available. The US Government already relies on commercial providers for over 80 percent of their satellite communications needs. At the same time the defense budgets of the U.S. and our strategic allies are under pressure. In this environment commercially hosted government payloads can be an attractive part of a solution, from both a schedule and a cost perspective, particularly if the payloads are tailored to augment the existing government constellations. Where typical military satellite systems generally take up to 10

years to come to fruition, taking into account the budgeting cycle all the way through launch and start of service, a new commercial satellite can generally be competed, ordered, manufactured, launched, tested, and place into service in about three years.

Don Thoma, Iridium

Access to space is expensive, and in the current economic and political climate, federal budgets for space programs are shrinking. The U.S. Government is delaying — or even axing — some programs. As you know, the 2010 National Space Policy calls for the wider use of public-private partnerships with the commercial space sector to meet mission requirements that the government cannot afford to fund on its own. The document specifically cites hosted payloads

on commercial satellites as a viable option. The simple fact of the matter is that hosted payloads will be the only way to fill the gap in the data from many space missions being cancelled — some of them critical to national security and the scientific community.

Tim Deaver, SES UGS

With the increasing cost of dedicated systems and declining federal budgets on a global scale, government users must look at alternatives to dedicated systems to meet the growing demand for space capabilities. In addition to providing operational capabilities, hosted payloads are a great mechanism for the development of future technologies or in risk-reduction programs. For example, the Commercially Hosted Infrared Payload (CHIRP) flight demonstration program is accomplishing 85 percent of the U.S. Air Force's stated objectives for 15 percent of the cost of building and launching their own dedicated spacecraft. The payload would not have made it to orbit if it weren't for the commercially hosted payload option.

Focus On The Hosted Payload Alliance

David Anhalt, SS/L

The demand for satellite services is at an all time high, yet government spending for space-based infrastructure is expected to decrease dramatically due to budgetary pressures. Hosted payloads have the potential to provide the government with a variety of space-based capabilities including satellite communications, faster and at far less cost than if they were to procure dedicated satellites.

This approach also enables the government to disaggregate its space capabilities. A distributed architecture, with more numerous, smaller payloads on a broad range of commercial satellites increases resiliency compared to the traditional approach of relying on dedicated satellites that aggregate lots of services in one place. Disaggregation means that any kind of failure has less overall impact to the country's space capability overall. Leveraging the commercial space sector through hosted payloads makes disaggregation affordable.

There has been much discussion of the cost savings and resiliency benefits for putting government payloads on commercial satellites, but the looming budgetary crisis in military space provokes urgent need to take action and tackle the issues that have kept this topic one that is talked about but not acted upon.

SM

Why did your company decide to join the Hosted Payload Alliance?

Don Thoma, Iridium

The National Space Policy statement is clear and direct. The devil is in the details, and implementation will not be easy. It will require a paradigm shift within the halls of government. Talking informally with other satellite companies, we realized that there is a pressing need to create awareness for the commercially available hosted payload capability across the industry, and to open better channels of communication between government and industry to enable its use. That's why we decided to form the HPA — to create a bridge between the public and private sectors in overcoming the challenges of implementing the goals set forth in the National Space Policy.

David Anhalt, SS/L

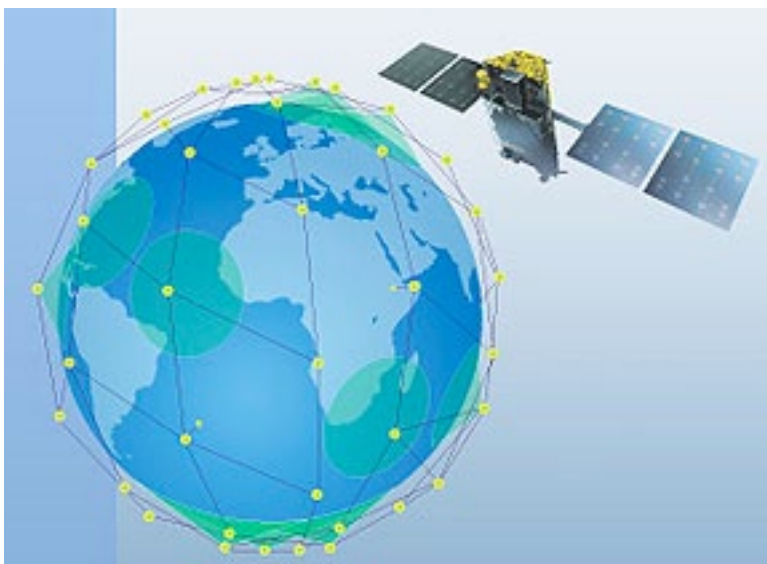
We think the Hosted Payload Alliance has the potential to dig into the issues that need to be addressed before government agencies are truly comfortable with hosted payloads. The HPA provides a neutral forum for a valuable dialog between government and private industry. The alliance is promoting discussions, ranging from policy and standards to government acquisition practices and commercial contracting.

Jim Mitchell, Boeing

The Hosted Payload Alliance is a valuable policy forum for the advancement of hosted payloads on commercial satellites. The HPA has convened members of industry to address market needs and to expand the dialogue between potential users and providers. Hosted payloads are not currently included in government roadmaps, the budgeting process, etc. That needs to change.

Tim Deaver, SES UGS

As one of the founding members of the Hosted Payload Alliance, we believe in the need for an unbiased industry consortium to help increase awareness of the advantages of hosted payloads on commercial satellites. Because there are differences between industry and government, from terminology to the way we handle and account for our money, it is critically important to educate each other so there are no preconceived notions,



“Iridium NEXT represents a once-in-a-lifetime opportunity to place additional mission payloads on the farthest reaching commercial satellite constellation, which will provide 24/7 low-latency visibility over the entire Earth’s surface and its atmosphere.”

— Matt Desch, CEO, Iridium Communications

Focus On The Hosted Payload Alliance

misunderstandings, or assumptions made about the benefits and risks associated with hosted payloads.

SM

Hosted payloads are not a brand new concept. There are precedents. Can you tell us about some of the hosted payload programs your company is involved in?

David Anhalt, SS/L

Space Systems/Loral has a lot of experience with hosted payloads from the manufacturing perspective. We have proven that technical issues are not the barrier. We built the Intelsat satellite that hosts the Internet Router in Space (IRIS), which is a Defense Department Joint Capability Technology Demonstration (JCTD) managed by Cisco and Intelsat General Corp. The satellite was launched in November 2009, and hosts the first IP router in space. We also have a satellite under construction that will host a navigation payload which is part of the European Geostationary Navigation Overlay Service, (EGNOS), for the European Union. That satellite is expected to launch in late 2011. Additionally, we are building a commercial satellite that includes both a Ku-band and Ka-band payload for the Ministry of Communications in Qatar, which is scheduled to enter into service in early 2013.

Don Thoma, Iridium

When the Iridium constellation was launched in the late 1990s, hosted payload capacity was not designed into the satellites. Nonetheless, we have managed to repurpose some of the systems and sensors on the satellites for secondary missions. For example, we have been working closely with the Johns Hopkins University Applied Physics Laboratory and the National Science Foundation to use the magnetometers on the Iridium satellites to monitor and measure magnetic fields around Earth. This has resulted in an enormous improvement in the ability to forecast magnetic storms, which can be devastating to systems such as GPS and utility grids.

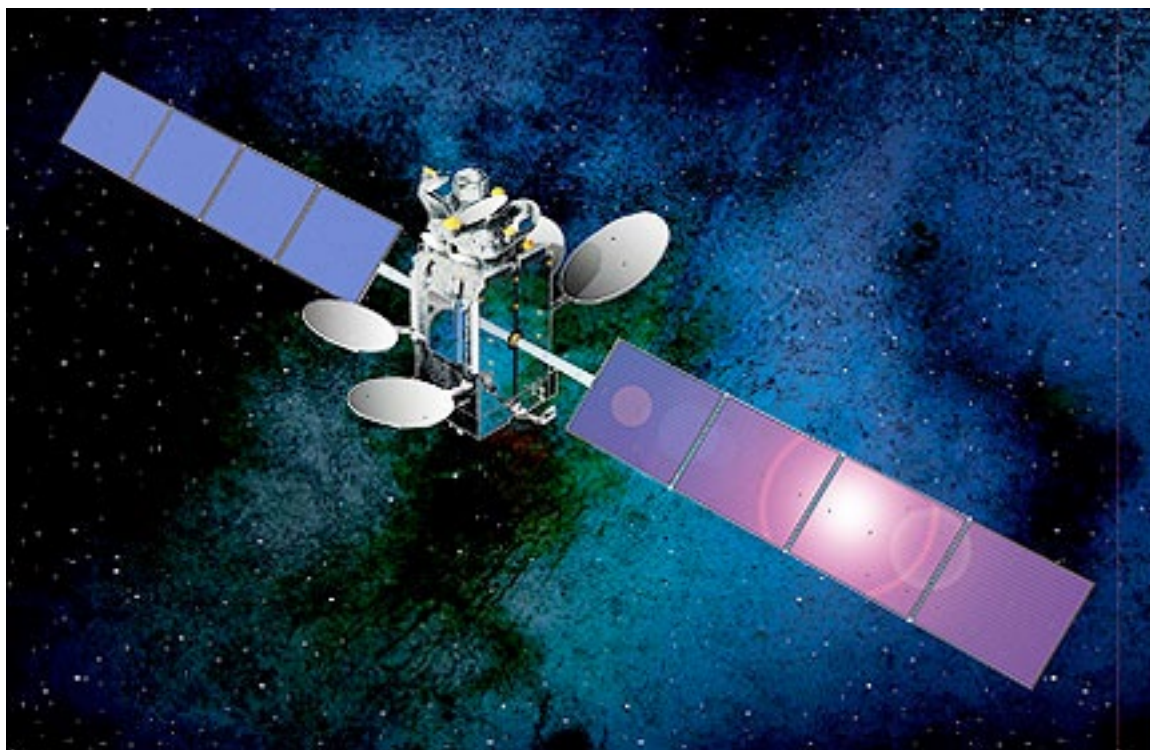
Jim Mitchell, Boeing

We have built and integrated government payloads hosted on commercial spacecraft for a variety of customers, including companies based in Australia, Japan and Brazil. In a different context, the Anik F2 spacecraft we built for Telesat included a hosted payload for Wild Blue, which they used to jumpstart their satellite broadband business in North America.

We can also point to the UHF Follow On Program, when the company helped the U.S. Navy upgrade its ultra-high frequency (UHF) satellite communications system by augmenting several

vehicles to host an extremely high frequency (EHF) payload as well as the first military Ka-band payload, which has provided Global Broadcast Service capabilities since 1998.

In July 2009, Boeing announced a four-satellite contract from Intelsat; two of these satellites will incorporate hosted payloads in the UHF band. In August 2010, Inmarsat ordered three Boeing 702HP satellites, each of which will carry a secondary government oriented payload that will be part of the overall Global Xpress service offering.



SES Sirius 5 is a powerful multi-mission satellite, which will deliver high performance and extensive coverage for direct-to-home broadcasting, broadband, point-to-point, and VSAT services in Europe and Africa. Sirius 5 will also include a hosted payload for the European Union.

Focus On The Hosted Payload Alliance

Tim Deaver, SES UGS

SES currently has three active hosted payload programs for government customers. The CHIRP program is on the SES-2 spacecraft and will be launched in August 2011. Both the ASTRA 5B and SES-5 spacecraft will carry the European Geostationary Navigation Overlay Service (EGNOS) payload for the European Commission. SES is very active in discussions with several governmental agencies for future opportunities. A variety of government agencies are looking at how hosted payloads fit into their future architectures and we believe we will see many RFPs over the next few years as studies conclude and turn into acquisition programs.

SM

What are some of the mission areas that are likely candidates for hosted payloads, in your view?

Jim Mitchell, Boeing

Our current focus is on the government communications market, narrowband, wideband, protected, etc. However, we also see a sizable market for sensor and remote sensing classes of payloads.

Don Thoma, Iridium

I'll let my associates from the other companies speak to the mission areas they are addressing. As an LEO operator, we are looking at different types of hosted payloads than GEO operators. Unlike the major GEO operators, which have ongoing launches taking place from year to year, Iridium expects to begin launching its 66 cross-linked satellites and in-orbit spares in a very condensed period of time. From the beginning, we recognized that this program — which we call Iridium NEXT — would present a once-in-a-lifetime opportunity for hosted payloads. Our LEO cross-linked

constellation will provide 24/7 visibility over the entire face of the planet and its atmosphere, much like what we do today. So from the earliest design stage of Iridium NEXT, we designed in a specification for hosted payload packages up to 50 kg. We are exploring hosted payloads that could go on all 66 satellites or some percentage of them. They include scientific observations, space situational awareness, weather sensors, aircraft tracking services for the FAA and other regulatory bodies, and research programs.

Tim Deaver, SES UGS

Hosted Payloads (HPs) can support our customer needs in several areas. In the research and development arena, HPs can support Risk Reduction Activities, Technology Advancement and Flight Qualification of hardware. The CHIRP program is a perfect example of all three of these. The lessons learned during the process of making the hardware “flight qualified” will dramatically improve the performance of any follow-on wide field-of-view staring sensor program.



Optus C1 With Hosted Payload, photo courtesy of Space Systems/Loral

Focus On The Hosted Payload Alliance

In the Operational arena, HPs can support a multitude of missions to include Space Situational Awareness, Tailored Communication Systems (Ku, Military Ka, Protected EHF, etc.), Space Environmental Monitoring, Space-Based Augmentation for Navigation, and Earth Monitoring.

SM

What factors, in your opinion, are holding back wider use of hosted payloads on commercial satellites?

David Anhalt, SS/L

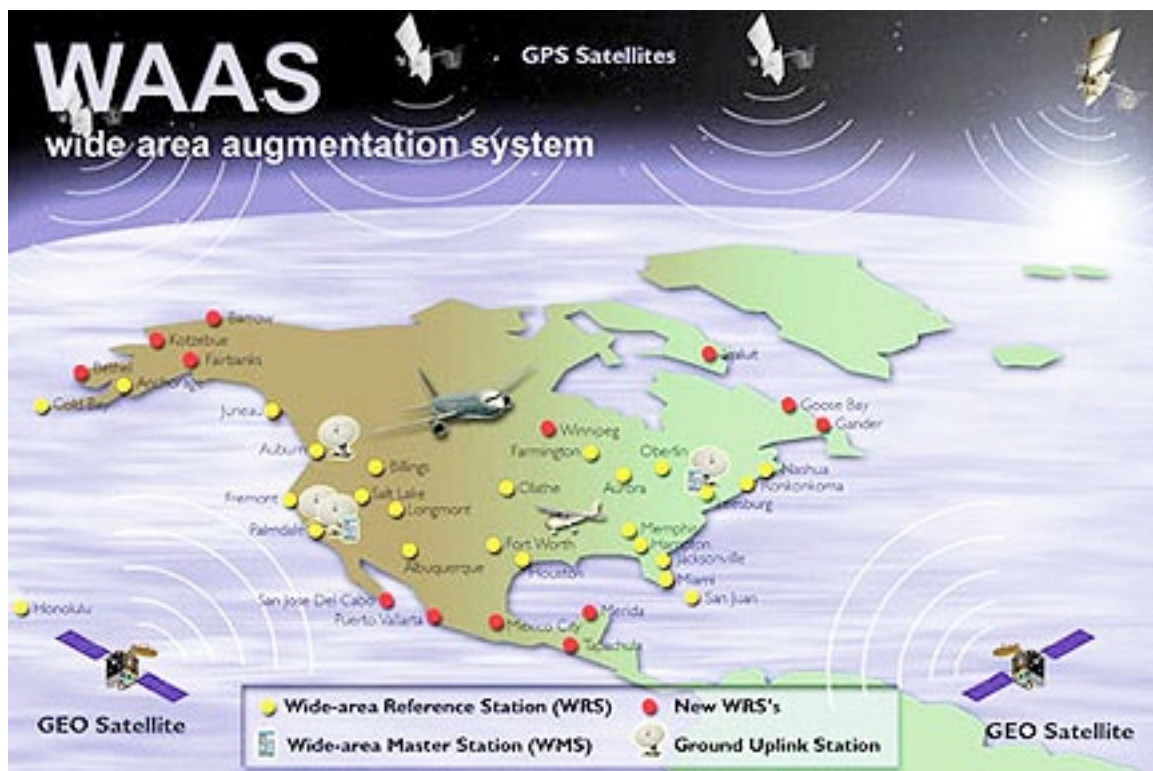
There are commercial, contractual, and programmatic challenges to overcome before hosted payloads on commercial satellites become routine. Scheduling compatibility, ownership control rights, and the complexity of three-way contacts are a few examples. It is going to take Government leadership to urgently insist on major improvements in space system affordability and resilience in order to overcome the institutional inertia to change government acquisition practices. Industry has an obligation to help make this shift fruitful by offering affordable alternatives that leverage the commercial sector's inherent advantages of date-certain delivery and cost accountability.

Tim Deaver, SES UGS

I don't see any factors that are holding back hosted payloads on commercial satellites. Several agencies are actively pursuing hosted payloads and the FAA has had an active Hosted Payload program in WAAS since the mid-1990s. We are seeing other agencies with increasing interest in the use of hosted payloads but starting programs or changing architectures takes time. The USAF's Space and Missile Systems Center (SMC) embarked on a MILSATCOM study in 2010 to consider hosted payloads and freeflyers to meet the needs of the Airborne ISR (AISR) community. The results will feed into an architectural study and eventually (we hope) into an acquisition program for hosted payloads.

Jim Mitchell, Boeing

From a program and operational perspective, most of the concerns center around aligning the government hosted payload plans with those of the primary commercial mission. There are many questions that need to be answered. Can both payloads fit on existing platforms, can one orbit slot be chosen that meets both mission needs, can both payloads be built and integrated in time to meet the combined mission schedule requirements, etc. Additionally, can we achieve the autonomy that is required by the government customers.



Hosted payloads example: FAA's WAAS flies on Intelsat and Telesat satellites, providing airline pilots with precision GPS guidance

From a financial perspective, hosted payloads are not currently in the out-year budgets, so currently satellite operators must take on significant financial risk to go forward.

Don Thoma, Iridium

Although there have been plenty of precedents for hosted payloads on commercial satellites, these were mostly one-off programs accomplished through heroic efforts by committed individuals to fill a pressing need. There has not been a systematic movement to implement hosted payloads as the "standard way of doing business." This is partly because

Focus On The Hosted Payload Alliance

the commercial space industry works under different rules of engagement than government space programs. Companies must deliver on time and on budget to meet shareholders' expectations. That means time lines are shorter for designing, engineering and deploying commercial satellites into space.

SM

What do you see as the biggest challenges facing government departments and agencies in implementing the National Space Policy?

David Anhalt, SS/L

For the government to effectively leverage the commercial and international space sectors in the new way called out in the President's National Space Policy, there will need to be change in both what is purchased and how it is bought. During the planning of new acquisitions, Government analysts should consider architectural alternatives that can incorporate new ways of acquiring services through hosted payloads on commercial and internationally owned spacecraft. This approach will bring in new suppliers not currently serving the U.S. military marketplace. Managing change while maintaining the continuity of existing critical services will be the biggest challenge.

Jim Mitchell, Boeing

The 2010 National Space Policy sets a vision that is a departure from the status quo that has existed for many years. Successful implementation of this new vision requires a variety of government organizations to recognize that a change is necessary, and then work together in concert to achieve that goal. We see signs of progress, but there is much to be done.

Don Thoma, Iridium

I don't see any insurmountable problems. There are already many senior officials within key government departments and agencies working very hard on this. I think it's really just a matter of aligning commercial practices with government requirements and aligning the procurement processes, and that can be best accomplished by opening lines of communication among stakeholders on both sides.

Tim Deaver, SES UGS

We have already found ways to implement hosted payloads, just not as timely and as efficiently as we need to in the future. The U.S. Space Policy encourages the use of Hosted Payloads when compatible with National Security Interests and the recently released National Security Space Strategy moves us a great distance along the path to implementing the goals and objectives of the policy. I believe the best way to continue to implement hosted payloads is by earning from the experiences. The NSSO sponsored a series of Hosted Payload workshops and it did a great job of educating both the space industry and the government customers and what is and what isn't possible. It is through continued open dialogue that the entire community can move forward and minimize some of the missed opportunities we see today.

SM

Just to view the other side of the coin, are there missions and payloads that could not be hosted on commercial satellites?

Don Thoma, Iridium

Of course there will be certain military and intelligence missions that will not be appropriate for commercial satellites, but I can't talk to those specific programs.

Jim Mitchell, Boeing

Certainly. Commercially hosted payloads are not the best alternative for key military strategic missions such as ICBM command and control or missile warning.



**The IRIS payload (Cisco IP Router),
carried aboard Intelsat-14**

Focus On The Hosted Payload Alliance

David Anhalt, SS/L

I am convinced that there are many operational missions that can benefit from hosted payloads, including communications, missile warning, space situational awareness, navigation augmentation, and ISR. However, there will continue to be functions that are best suited to dedicated satellites.

Tim Deaver, SES UGS

There are a couple of areas that come to mind very quickly. Some missions are so critical to national security that you must have dedicated, protected and robust satellites. For example, hosted payloads would not be a good fit to perform the Strategic Missile Warning and Strategic Protected SATCOM missions. On the other hand, hosted payloads are a great way to augment these capabilities in their tactical roles and expand the space-based

capabilities to additional users. The DoD is looking at ways to increase the resiliency of their critical space systems and we believe hosted payloads offer a great way to help accomplish this goal. With the increasing costs of dedicated military systems and decreasing budgets, the military seems to be coming to the conclusion that their plans should include a mixed architecture of commercial and dedicated systems.

SM

How do companies that are/could be competitors in the marketplace work cooperatively together? What is the "glue" that holds the HPA together?

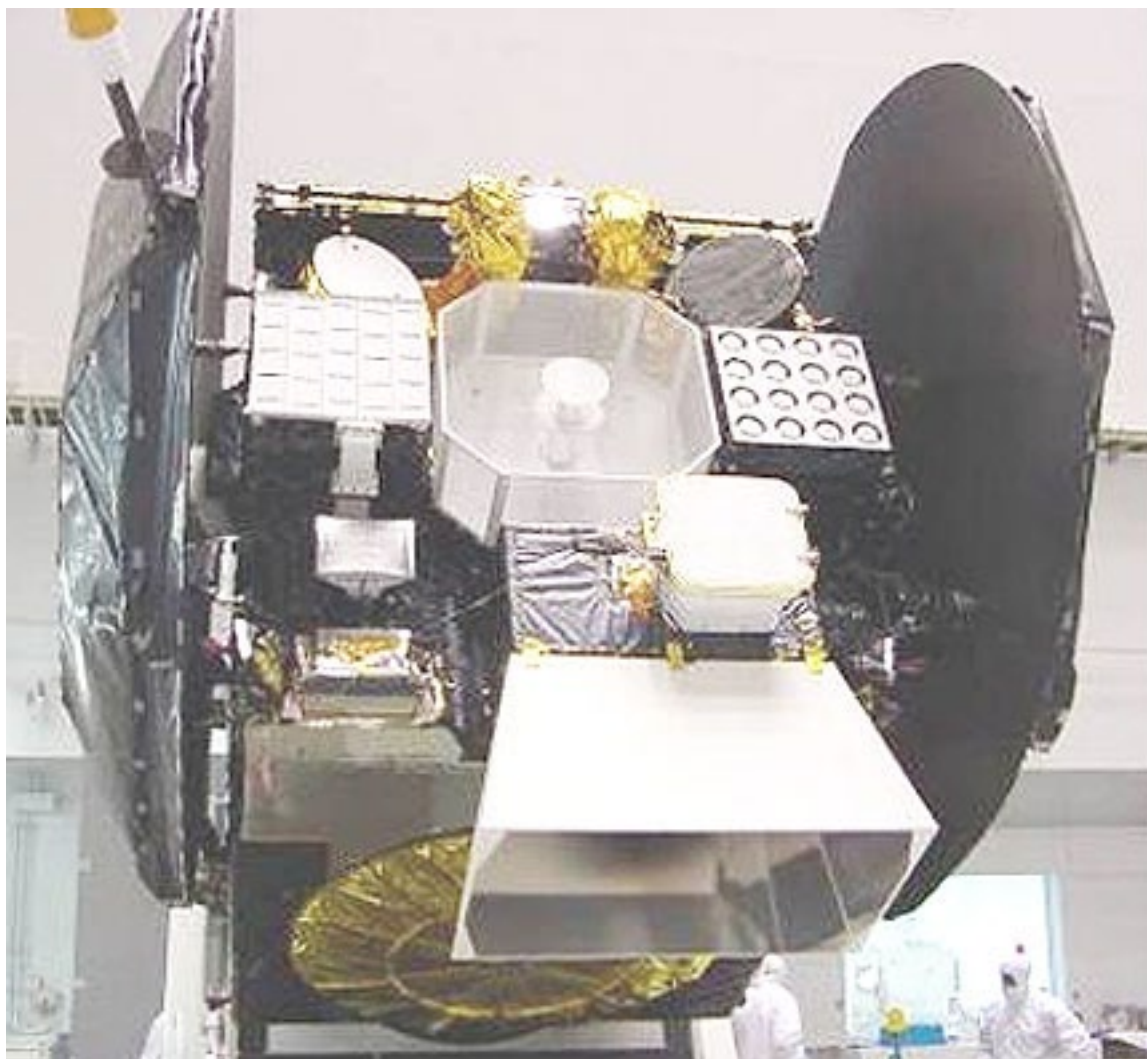
Tim Deaver, SES UGS

Many alliances are comprised of "competitors" when they recognize the need to accomplish certain objectives to further

improve the competitive environment. In our case, we believe that if the HPA achieves its goals, there will be an increased marketplace for hosted payload opportunities. Now as competitors, once an opportunity is out for bid, all bets are off.

David Anhalt, SS/L

The four manufacturing companies and three telecommunication companies that formed the Hosted Payload Alliance understand that the acquisition practices that served us well in the past may no longer be in the best economic interest of our country going forward. For one thing, the U.S. commercial space sector has greatly matured since the beginning of the space age, and is now relied on worldwide for high reliability missions that last 15 years. By working together, we hope to form a new market of ideas, services and architectures that are



MTSAT-1R air traffic control, GPS augmentation, with meteorological payloads for Japan. Photo courtesy of Space Systems/Loral

Focus On The Hosted Payload Alliance

more innovative and affordable. Necessarily, we in industry see the advantage in cooperating to build this new commercially leveraged marketplace for serving our government customers.

Don Thoma, Iridium

We all have a common goal — to advance the wider use of hosted payloads on commercial satellites. I think the old saying that “a rising tide lifts all ships” applies nicely. The HPA Steering Committee is comprised of the world’s commercial experts on hosted payloads. They have a tremendous amount of knowledge and expertise to work toward this goal.

Jim Mitchell, Boeing

The HPA is very similar to the Satellite Industry Association. Each member has its business plan, but when the whole group is able to advance a concept, it benefits all. The member companies are similar at the policy level, but as we get closer to the actual program or mission, each will compete in good faith.

SM

Will the HPA be also attempting to introduce this concept on an international basis as well as for domestic endeavors?

Jim Mitchell, Boeing

There is no reason not to do so. Many of our strategic allies participate in joint operations and therefore have many of the same communications requirements as the U.S. military.

Tim Deaver, SES UGS

The HPA’s focus is currently on the U.S. Government; however, we do believe it will grow beyond that at some point. Other governments are already active in the hosted payload arena. For example, SES was awarded two contracts for the European Commission’s European Geostationary Navigation Overlay Service

(EGNOS) hosted payloads and Intelsat was awarded the Australian Defence Force’s contract for a UHF hosted payload.

Don Thoma, Iridium

While our primary attention is largely focused on the U.S. Government for now, the marketplace for hosted payloads is international. As you know, several of the companies in the HPA are currently involved in hosted payload initiatives in Europe, Australia and elsewhere. The inaugural meeting of the HPA included attendees from many interested user communities.

David Anhalt, SS/L

The commercial space industrial base is inherently globalized. Most of the large telecommunications companies are headquartered in European and Asian nations who enjoy friendly ties with the United States. Many European militaries are already acquiring satellite communications and ISR services from commercial companies. It stands to reason that the affordability and resilience of hosted payloads will be as compelling to our Allies as it is to the United States Government.

SM

Looking to the future, do you feel that hosted payloads will become widely accepted within the next few years as the new paradigm for access to space?



The Intelsat-22 satellite (IS-22) is one of four 702MP satellites ordered from Boeing by Intelsat Ltd. and will carry a UHF payload that will provide service to the Australian Defence Force. The launch of this satellite is scheduled for 2012. Image courtesy of Boeing.

Focus On The Hosted Payload Alliance

Jim Mitchell, Boeing

Yes. Boeing believes so strongly in this opportunity that it formed a separate unit, Boeing Commercial Satellite Services, to market hosted payloads. Government bandwidth requirements will continue to grow, and those needs must be met in a cost effective and timely manner.

Tim Deaver, SES UGS

Absolutely. We believe hosted payloads can benefit all segments of the government that require access to space. We see a growing understanding among government planners that a mixed architecture of dedicated military satellites and commercially available capabilities is an acceptable approach to meet their needs. The military systems would focus on highly specialized military functions and the commercial capabilities would be used in the areas where they currently excel, for example broadband communications.

In other areas supporting the Defense Department, we've seen numerous examples where commercial industry is providing capabilities previously supplied by the government. For example, not too long ago military transport and cargo ships were the predominant means in the transportation of troops and supplies to an area of operations. Today, this form of transportation is largely accomplished by commercial airlines such as United and FedEx. Through the use of hosted payloads we offer affordable, dependable and frequent access to space.

Don Thoma, Iridium

Emphatically yes. The logic of the argument for hosted payloads on commercial satellites is inescapable. It just makes good sense. Budget pressures for government space programs will not ease any time soon. Hosted payloads can and will continue to provide faster and less costly access to space well into the future.

David Anhalt, SS/L

Absolutely. Today there are more than 40 GEO communication satellites in manufacturing flow in the United States alone. All 40 are expected to be in orbit within the next 36 months. This reliable, responsive access to space is ready to be tapped. Once the distributed resiliency of this resource is realized, I am sure the Government will embrace new architectures that take advantage of hosted payloads. What is more, the backdrop of hosted payloads will change how our military buys dedicated platforms. I believe that dedicated platforms can be relieved of much of their complexity when their functions are conceived as part of a hybrid mix of hosted and dedicated platforms. We see the same sort of dynamic playing out today with manned and unmanned aircraft.



In March of this year, Boeing completed the Preliminary Design Review (PDR) for the Inmarsat-5 spacecraft and hosted payloads.

A Discussion With Greg Quiggle, iDirect's VP of Product Management

With iDirect's new TDMA and SCPC Return switching capability, service providers gain the flexibility to adjust service levels to meet dynamic application needs and changing traffic patterns, while maintaining an economical way to use total network capacity and optimize operational efficiencies.

SatMagazine (SM)

What is iDirect's new SCPC Return feature and why is it needed?

Greg Quiggle

The vast majority of satellite communications networks are either SCPC or TDMA, and service providers need to support both if they want to meet a broad range of customer applications. However, this incurs unnecessary capital expense and operational inefficiencies. For example, network operators need to invest in and manage two separate technology platforms. Changing a customer from one technology to the other involves costly site visits and service interruptions. Further, network operators are unable to share satellite capacity across their entire customer base or re-allocate excess bandwidth from typically over-dimensioned SCPC links. This is hard to justify in an industry where space segment is both scarce and expensive.

Service providers have come to accept this as a cost of doing business in the satellite industry. But all that changes with the introduction of iDirect's new **Evolution** operating software — **iDX 3.0**. With a simple software upgrade, any Evolution router can now run in TDMA or SCPC mode on the return channel. An iDirect router can be switched back and forth between TDMA

and SCPC based on time of day or the volume of traffic being carried by the remote.

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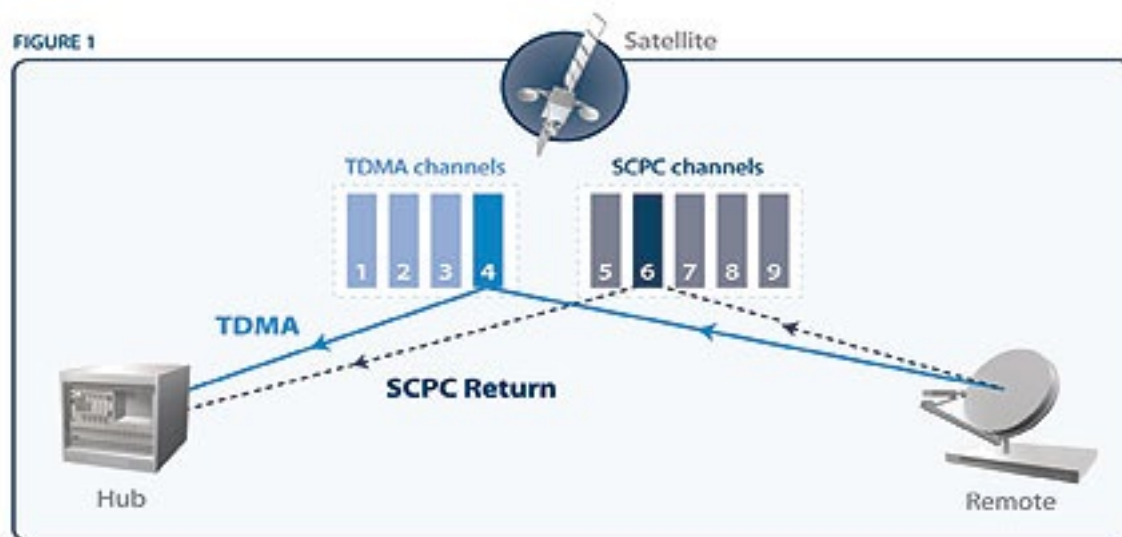
What are the key differences between SCPC and TDMA technology?

Greg Quiggle

SCPC (*Single Channel Per Carrier*) refers to satellite channels in which only a single device is configured to transmit on the channel. SCPC equipment is a relatively simple technology, with a guarantee that bandwidth is always available at the site where it is installed. Typically, sites with high, constant bandwidth requirements are good candidates for SCPC equipment. However, if traffic is not constant, the SCPC link will need to be over-dimensioned based on peak bandwidth demand, resulting in wasted capacity when the link is under-used.

TDMA (*Time Division Multiple Access*) is an alternate means of using the bandwidth in which multiple devices share the same channel by transmitting short bursts of data. The benefit of this system over an SCPC link is that many devices can be supported on the link, each of them using it as the need arises. In a standard TDMA network, multiple devices share a common

FIGURE 1



< Scenario 1

An iDirect router can switch between TDMA and SCPC based on time intervals to fit the bandwidth needs of applications running on the network.

outbound channel. Of course, the ability to flexibly share the bandwidth between multiple devices on the inbound incurs some additional overhead, leading to some loss in throughput efficiency. Traditionally, operators would evaluate network needs and usage at a specific site, and determine whether SCPC or TDMA equipment was best suited for that site. The most important factor in that decision is the perceived need for continuous bandwidth: Sites with high bandwidth or continuous data requirements would likely get SCPC equipment, and sites with more dynamic bandwidth requirements would get TDMA equipment on an appropriately over-subscribed network.

To overcome at least part of the problem of unused capacity, particularly in links with asymmetric traffic, some networks now feature a shared outbound channel, similar to TDMA networks, but with SCPC on the return channel. Of course, any SCPC channel requires some minimum bandwidth to each site, which can still be expensive.

SM

What is the rationale behind supporting TDMA and SCPC Return on one platform?

Greg Quiggle

There are numerous situations in which a network operator might want greater flexibility, but is limited by the availability of equipment which can operate in either TDMA or SCPC mode.

First, the bandwidth needs of the customer may not be constant enough to require a dedicated link all of the time. Since the link must

be sized to accommodate the peak traffic, if there is any variance in the traffic, the customer has paid more for excess bandwidth.

Second, there might be network growth or a change in usage patterns at a remote site. Initially an operator may project very low traffic volume for a given site, but expect traffic to eventually increase enough to require a dedicated link. The operator must install SCPC equipment, and augment the channels later as traffic demands warrant. Until the projected growth occurs, that operator must maintain a large pool of underutilized SCPC links, where a properly subscribed TDMA network would be preferable.

Finally, network operators often rely on different manufacturers for their TDMA or SCPC equipment. An integrated platform reduces operating and infrastructure costs, making it far more economical to switch hardware between TDMA and SCPC, roll out new applications faster, and upsell customers as sites grow larger. With iDirect's **SCPC-Return** feature, network operators can configure select remotes within an existing TDMA network, and reconfigure them to transmit in SCPC mode on the inroute. No changes to the infrastructure are required to effect this change, and the remote can be returned afterwards to TDMA operation.

SM

What is a scenario in which an operator might want the ability to switch between TDMA and SCPC Return modes based on time requirements?

Greg Quiggle

One example is a VSAT operator that manages a number of maritime customers, as well as networks from exploration platforms. To support this customer base, the network operator



maintains a large pool of TDMA and SCPC inroutes active at all times. These inroutes could be supported on individual (single-channel) line cards, or groups of inroutes operating on the **XLC-M** line card in multi-channel mode. Customers on the exploration platforms periodically require an increase in inroute bandwidth for the transfer of large sets of data such as high-resolution images, seismic data or other information. These customers require the delivery of this data in a timely fashion, so a temporary increase in throughput is warranted. To support these requirements, the operator can reconfigure a remote from a pool of remotes sharing a TDMA inroute, to have its own dedicated SCPC-Return inroute. When the requirement for the increased bandwidth is over, that site could be returned to TDMA-mode operation.

Using **iBuilder**, the iDirect **NMS** configuration tool, the remote is simply removed from a shared TDMA inroute group, and assigned to one of the pre-defined SCPC-channels. The operator does not reconfigure any channels, but simply reconfigures select remotes to use one inroute channel or the other. By taking advantage of equipment that can switch between TDMA and SCPC, the network operator has avoided deploying equipment scaled to their intense requirements, which would have remained largely idle during other periods.

SM

What is a scenario in which an operator might want the ability to switch to SCPC Return mode based on traffic volume requirements?

Greg Quiggle

Another VSAT operator is supporting cellular backhaul in a remote region, where significant traffic growth is expected in the near future. For now, TDMA is the most bandwidth efficient solution to support smaller, yet dynamic traffic volume from scattered villages. But as the traffic increases at those sites, SCPC becomes more efficient. The ideal solution is for this operator to operate the sites in TDMA mode until traffic at those sites warrants a switch to SCPC.

A smaller operator is not likely to have the resources to maintain a large pool of TDMA- and SCPC- inroutes, so instead might choose to repurpose leased space segment from a TDMA inroute for an SCPC-Return inroute. In this case, the operator would select an inroute channel from its pool of TDMA inroutes, and dynamically remove it from the system configuration. The operator would then activate a previously configured SCPC-

Return channel in the same space segment and the base station site needing an SCPC-Return inroute would be configured to use this inroute. The network operator has simplified its deployment with equipment that is able to modify its mode of operation to best meet the growing needs at each site.

SM

What hardware or software does an operator need to purchase in order to gain SCPC Return capabilities?

Greg Quiggle

For existing iDirect Evolution network operators, the SCPC-Return feature is enabled by a software upgrade to iDX 3.0, and requires no new hardware. By upgrading to iDX 3.0, an operator with existing TDMA remotes can now offer customers the efficiency of an SCPC channel on the inroute, on a temporary, semi-permanent, or permanent basis. Returning the remote to TDMA-mode is also simple, and can be achieved quickly through iBuilder.

Though not required to support SCPC-Return, operators managing a large pool of inroutes will almost certainly want to take advantage of the flexibility offered by iDirect's new multi-channel demodulator. With software key licensing available through iDX 3.0, an Evolution line card — such as the XLC-M or the eM0DM — can now support up to 8 TDMA or 8 SCPC channels. While the multichannel demod is not required for the SCPC-Return feature, its ability to operate up to 8 return channels in SCPC mode greatly enhances the flexibility of the network on the hub side. It gives the network operator the ability to reconfigure the hub side of his network with ease. Further, it allows service providers to gain efficiencies in their hub infrastructure of up to 40 percent due to fewer line cards and chassis space required. SCPC-Return channels up to 15 MSps are supported.

Greg Quiggle current serves as the VP of Product Management at iDirect. Prior to joining the team, Greg served as the Executive Vice President of Marketing for Tollgrade Communications and the Vice President of Marketing for Acterna Corporation (now JDS Uniphase). In these roles, Mr. Quiggle has spent over 18 years conceptualizing and executing successful corporate-level product strategies within the communications industry.



Executive Spotlight

Stanley O. Kennedy, Jr., V.P. + GM, Comtech Aero Astro

Mr. Stanley O. Kennedy, Jr. serves as the Vice President & General Manager, *Commercial, Civil, International* (CCI) Programs for Comtech AeroAstro, Inc. In this role, Mr. Kennedy is responsible for executing all CCI program activities to include Space Systems and Space Product development. Prior to this appointment, Mr. Kennedy was Vice President and General Manager, Programs for Comtech AeroAstro, Inc. Mr. Kennedy has 26 years of hands-on experience in aerospace engineering; his extensive small satellite, launch vehicle, upper stage and ground systems experience coupled with mission domain knowledge in military, intelligence, civil and commercial markets supports Comtech AeroAstro's development of innovative solutions for key customers. Prior to joining Comtech AeroAstro, Mr. Kennedy held senior leadership positions developing innovative small satellite systems and concepts for Lockheed Martin Space Systems Company and General Dynamics Advanced Information Systems.



Mr. Kennedy is an Associate Fellow and lifetime member, since 1983, of the *American Institute of Aeronautics and Astronautics* (AIAA). He is currently serving as the Technical Chairman, *AIAA/Small Satellite Frank J. Redd Student Design Competition*, Utah State University, Logan, Utah, and is the *Aerospace Industry Association* (AIA) *Space Trade & International* subcommittee chair.



Executive Spotlight

On April 8, 2011, **Comtech AeroAstro, Inc.** announced a new business unit to capture emerging opportunities in commercial, civil and international markets. *Stanley O. Kennedy, Jr.*, Vice President and General Manager of Commercial, Civil, International Programs will lead the new unit. The business unit will focus on providing Comtech AeroAstro's enabling technologies in standard interface, flexible, low-cost satellites and satellite components to a new and emerging customer base. Comtech AeroAstro, Inc., is a wholly owned subsidiary of **Comtech Telecommunications Corporation** (NASDAQ:CMTL) in Melville, NY. Comtech AeroAstro, Inc. is a leader in satellite systems, components, payload and mission domain expertise and advanced communications technologies.

SatMagazine (SM)

Mr. Kennedy, please describe Comtech AeroAstro's early years and how the Company has evolved.

Mr. Kennedy

Comtech AeroAstro has been providing space components and microsatellites to our customers since 1988. Prior to 2001, the focus was on technology development efforts with universities and

government laboratories. We also participated in multiple *Small Business Innovative Research (SBIR)* contracts. These early efforts established Comtech AeroAstro as thought-leaders in the rapid and responsive microsatellite market.

Our first spacecraft was launched in 1993. **ALEXIS** was built for the *Los Alamos National Laboratory (LANL)*. The mission life requirement was specified as six months, ALEXIS operated for over 12 years reporting science data to the customer. Similar successes followed with several more microsatellite launches. Between 2001 and 2007, Comtech AeroAstro focused primarily on *Department of Defense (DoD)* and *National Administration of Space and Aeronautics (NASA)* space program efforts.

Of particular note is the *DoD Space Test Program Satellite 1 (STPSat-1)*. This spacecraft was the first contractor built vehicle successfully integrated onto the *Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA)* ring. STPSat-1 exceeded its mission lifetime requirements by more than a factor of two. Also during this period, Comtech AeroAstro built and flew X-Band radios on the NASA **ST-5** mission.

From 2007 through present day the Company has expanded its products and services to include *Miniature Star Trackers, Coarse and Medium Sun Sensors, S-band Radios, Imagers* and high-performance *microsatellites* in the <500 Kg regime. Comtech AeroAstro is currently building the *Joint Milli-Arcsecond Pathfinder Survey (JMAPS)* spacecraft bus for the **Naval Research Laboratory**. We are also one of the prime contractors on the *Air Force Research Laboratory (AFRL) Advanced Plug-n-Play (APT)* program.



STPSat-1, artistic rendition

Executive Spotlight

SM

What prompted the establishment of the Commercial, Civil, International line of business?

Mr. Kennedy

We have been closely following the DoD and Intelligence Community (IC) funding profiles and believe these will remain flat and could potentially decline (in real-dollars) over the next few years due to pressures related to reducing the U.S. national debt. This, along with relatively strong growth forecasts in commercial constellations and space services, and recent reform efforts on international trade and export control, led Comtech AeroAstro

to establish the new CCI line of business. With the potential transfer of ComSat technologies and components jurisdiction from *Category XV* of the *United States Munitions List (USML)* in the *International Traffic in Arms Regulations (ITAR)* to the **Department of Commerce's Commerce Control List (CCL)**, Comtech AeroAstro sees increased growth opportunities in non-U.S. component and satellite sales.

It is interesting to note that with the austere projections within the DoD/IC budgets, Comtech AeroAstro continues to anticipate stronger demand for smaller, more capable spacecraft to augment and potentially replenish or reconstitute traditional large national systems. Based on the recently released *U.S. National Security*



NASA's FASTSAT, artistic rendition

Space Strategy there is a "potential for strategic partnerships with commercial firms to both stabilize costs and improve the resilience of space architectures upon which we rely." Comtech AeroAstro will actively pursue Defense and Commercial, Civil, International programs for the foreseeable future.

SM

What is Comtech AeroAstro working on now?

Mr. Kennedy

In addition to the JMAPS and the APT programs, Comtech AeroAstro is executing a number of advanced technology development efforts. One of these efforts is the *Payload Alert*

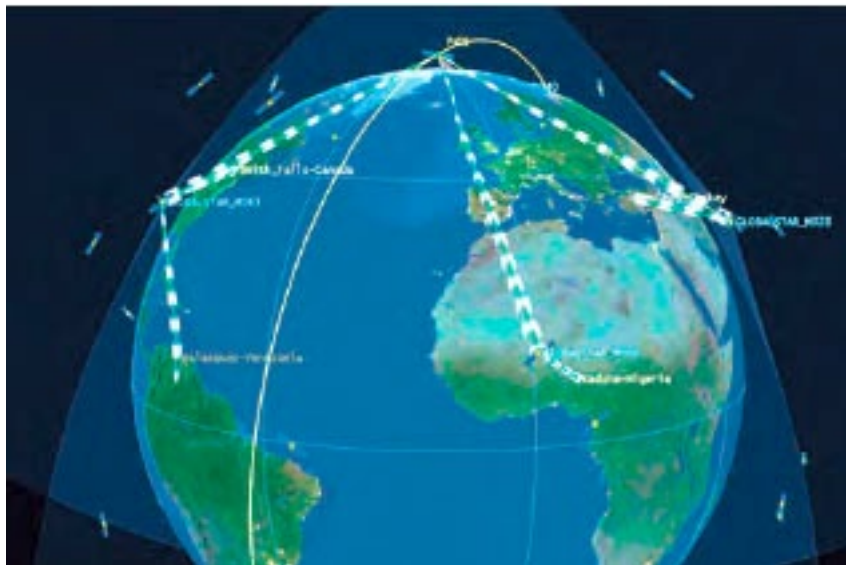


Company homepage link

Executive Spotlight

Communications System (PACS) which is intended to be a beacon for Space Traffic Control. As Low-Earth orbit becomes more congested, contested, and competitive, Comtech AeroAstro believes there will be a need for an equivalent system to the Air Traffic Control system for space assets.

We are continuing to offer our cost-effective components and technologies to customers worldwide. In November 2010, we flew multiple sensors on the *Space Test Program (STP)-S26* mission



PACS data sheet available here

launched from Kodiak, Alaska. Manifested on that flight were the *STP Standard Interface Vehicle (STPSat-2)* and the **NASA FASTSAT** spacecraft. Comtech AeroAstro built the STPSat-2 bus and delivered it to the Prime for this mission. Comtech AeroAstro provided a *Miniature Star Tracker*, *Medium Sun Sensors*, and a *Miniature Imager* for the NASA FASTSAT vehicle. Lessons learned from these missions are being incorporated into *Pre-Planned Product Improvements*.

Comtech AeroAstro has received numerous requests to support future missions with these flight proven components. Our S-band Transceiver is integrated on the **NEOSSat** spacecraft that will be launched in 2012. Comtech AeroAstro is also pursuing a number

of proprietary *Internal Research and Development (IRAD)* efforts that we believe will fundamentally change the way we operate in and through space.

SM

Do you have any additional thoughts or comments that you would like to share with our readers?

Mr. Kennedy

Yes, I would like to spend a little time discussing Aerospace workforce development and *Science, Technology, Engineering, and Mathematics (STEM)* outreach. The current Aerospace workforce is rapidly approaching retirement age. This, coupled with a declining number of new start programs, has dissuaded U.S. students from pursuing Aerospace technology focused degrees. I believe the U.S. needs to stimulate STEM outreach programs and focused training curricula, that will develop tomorrow's engineers and support continued innovation. I also believe that the U.S. needs to recognize the overwhelming number of foreign students in our advanced engineering degree programs and allow industry to hire and employ these individuals. The current process for obtaining permanent residency and eventual citizenship should be reviewed and streamlined to avoid losing this technical expertise.

In closing, I appreciate the opportunity to showcase Comtech AeroAstro, and in particular the new Commercial, Civil, International line of business. I am excited to be a part of the Space industry as we continue to design and develop new systems and capabilities. I look forward to continued collaboration with our customers, teammates, suppliers, and stakeholders both now and in the future.



Executive Spotlight

David Hartshorn, Secretary General, GVF
Martin Coleman, Executive Director, sIRG

In order to tackle the ever increasing problem of interference, GVF established a global *VSAT Installation* training program, which has proven extremely successful, with many operators now promoting and sponsoring the initiative worldwide. The *Satellite Interference Reduction Group* (sIRG) has been focusing a great deal of its effort on helping to promote this worthwhile initiative.

Conversations with David Hartshorn, GVF's Secretary General, and Martin Coleman, Executive Director of sIRG, have obtained their insights into the initiative and the problems surrounding satellite interference.



Top:
David Hartshorn

Bottom:
Martin Coleman

Executive Spotlight

SM

Martin, you have been actively promoting GVF's global VSAT Installation Training Programme, why do you feel it is important?

Martin Coleman

Interference is a massive issue in our industry, with millions of dollars being lost each year. A great deal of manpower is tied up tracking down the causes we are experiencing that a lack of knowledge is one of the biggest causes of interference. Therefore it is definitely worth focusing our attention on improving that. Too often VSAT systems are installed by people who simply don't understand the technology requirements of such an installation. This is mainly found with many small antenna installations, which are often not located in the best environment, badly pointed, constructed or any of the above!

SM

Do you think that training will make a big difference?

Martin Coleman

Absolutely, a process of both training and certification is in fact by far the easiest and most effective way to overcome this. By giving those installers and indeed suppliers, the tools and skills to do their job effectively, we can greatly reduce the install errors. A system of installer certification can further incentivise that, but it also means that operators looking for installers know exactly who has received the appropriate training to install an effective, well thought-out transmission site. Our groups, with others, are working together to adopt similar processes across our industry in all operational areas of satellite transmission.

SM

David, GVF has been focusing a lot of energy on its installation-training programme; how has that initiative been received so far?

David Hartshorn

We have been extremely pleased with the response to our installation-training programme. The industry as a whole is quite frankly fed up with interference and welcomes steps being taken to reduce the problem. For this reason, we are receiving the support and backing of a number of leading companies within the industry, including satellite operators, manufacturers, and value-added resellers.

We have had approximately 4,000 installers through the various courses, meaning that organisations now have a wealth of trained professionals to call upon, the details of whom can be obtained via the GVF Certified Installer Database at <http://gvf.coursehost.com>.

SM

There is a global need for this type of training, how do you handle that on a practical level?

David Hartshorn

We place a lot of emphasis on our online courses. Naturally, there is a hands-on element and instructors can offer supplementary classes where needed, but by teaching a lot of the theory online, we can make our courses more affordable and widely accessible across the globe.

We recognise that developing countries also need this training, but are often not in a position to afford it, therefore for students and organisations in those areas there is the GVF Andrew Werth Scholarship Program, which offers a 50 percent cost reduction, making it feasible across the entire globe.

SM

Of course, every student will require a different level of training. Do you have a structure in place to accommodate that?

David Hartshorn

Yes. Everyone begins with the basic level, a GVF Basic VSAT Installation Certification, which gives them the basic skills absolutely essential for all VSAT installers to help prevent interference. This is done through the completion of an online course and followed by a Hands-on Skills Test.

Expert VSAT field technicians can then go onto complete the Advanced VSAT Installation and Maintenance Certification, which is done through a series of online courses, and again followed by that all important, Hands-on Skills test.

Executive Spotlight

For those installers who need that extra level of manufacturer-specific training and certification — for example, Gilat, Hughes, iDirect, Schlumberger, Seatel, and others — there are Speciality Certifications, which are available through a choice of online courses, depending on the requirement of that individual.

SM

What effect is the training having on the industry as a whole?

David Hartshorn

The installers being trained through this programme are emerging with a much deeper understanding of the industry, effective VSAT installation and maintenance techniques, and the high level of performance that the industry expects of them. Further, the programme has proven that everyone benefits from Certification: The trainees advance their skills and careers, the operators can use those installers with confidence, VSAT service providers realise reduced costs and stronger network performance, manufacturers see increased sales, and the end users enjoy improved quality of service.

The industry as a whole is recognising the benefits of this training, and many organisations are only prepared to use certified installers now. There is more work to be done, however, to ensure we reach the ultimate goal, which is, of course, that only trained and certified installers are used. If we can get to that point, we really will see a great reduction on the level of satellite interference.

SM

With that in mind, how do you see that ultimate goal being achieved, and in what sort of timeframe?

David Hartshorn

We have been working hard on increasing awareness of these courses, and of their importance, and that is an area in which other groups, such as the Satellite Interference Reduction Group have really helped and are continuing to assist.

It is starting to have a certain amount of positive effect, with Satellite operators beginning to co-ordinate with GVF to increase the delivery of training, as well as heightening awareness, as preparation for the day when Certification will become a requirement.

For the most part, satellite operators will actually wish to use a certified installer, however by making it compulsory we can be absolutely sure that happens. The first regions where this is being implemented are South America and the Middle East. Asia will probably be next. Everyone who completes the programme will receive Certification, so anyone commissioning a new install or amending an existing one, should ask their installer whether they are certified, or contact GVF for details.

About GVF

The GVF is the global non-profit association of the satellite communications industry. The association represents more than 200 Member companies involved in the business of delivering advanced fixed and mobile satellite systems and services to consumers, and commercial and government enterprises worldwide.

Full details about the GVF Certification Programme are available at <http://gvf.coursehost.com>

About Satellite Interference Reduction Group (sIRG)

Satellite Interference Reduction Group (sIRG) is the global industry organisation, established to combat the increasing and costly problem of satellite radio frequency interference. It also, as a group, focuses on the future of satellite communication technology and the effects or issues of that technology relating to interference.

For more information, please visit <http://www.satirg.com>



New Technologies Bring Peace Of Mind

by Eugene Keane, President, Media Networks Division, Nevion

Broadcasting infrastructures today must be flexible and highly efficient. Contribution quality content comes from a wide range of sources — satellite, fiber, and, more recently, Ethernet. A single feed may feature a mixture of fiber and satellite routing, and with the increasing use of IP, new complexities and challenges come to the fore.

In addition to compatibility issues, mixing content formats and sources requires encoding, decoding and re-encoding, which can cause signal degradation. At the same time, rising adoption of HD, 3G and more live programming require the highest quality content.

The good news? Advanced compression schemes such as *JPEG 2000* provide visually lossless compression with very little degradation even after multiple encode/decode cycles. New monitoring and control capabilities in the form of integrated software solutions provide comprehensive monitoring, and control across the video transport chain ensuring quality of service.



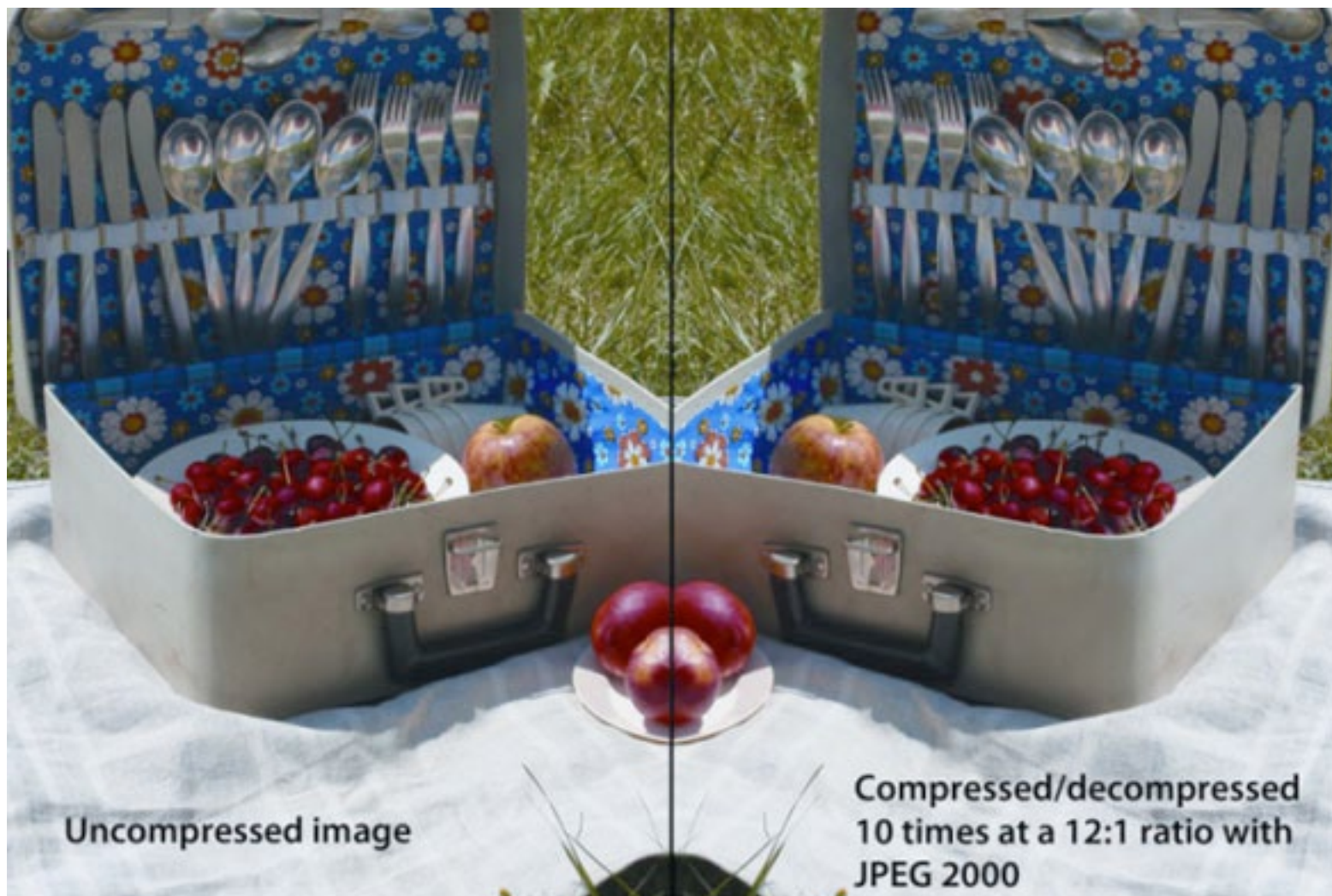
JPEG 2000 — Compelling Benefits

There are a range of options for advanced, professional-grade compression including **MPEG-2**, **H.264**, and **JPEG 2000**. Ultimately, network infrastructure, bandwidth requirements and budget all help to define the “right” choice for each circumstance.

While MPEG-2 and H.264 are good options for next-generation multimedia applications, a strong case can be made for JPEG 2000, whose advanced intra-frame based encoding provides a degree of flexibility and control not found in other compression schemes. The surge in the amount of video transport applications requiring both very low latency and very high visual quality make JPEG 2000 an optimum solution to meet the demands of a video landscape rapidly moving toward HD.

JPEG 2000 is a wavelet-based image compression standard originally developed as an image — not a video — codec. In the realm of video, its intra-frame based encoding scheme limits losses to a single frame or less, bringing vital benefits, especially with the expectation that HD provides high quality, and any distortion can drastically reduce the usability of content.

In fact, JPEG 2000’s underlying structure is the key to its advantages. The highly flexible codestream obtained after compression of an image is scalable and can be decoded in a variety of ways. The high bitrates achieved by JPEG 2000 compression are also critically important. As a standard, JPEG 2000 allows for high bitrates — much higher in implementation than H.264. This is key for high quality transport, because



certain infrastructure types might impose bandwidth limits that are strict, but not severe. For example, HD will not fit into **Gigabit Ethernet** or **OC-12** (622Mbps), but the entire pipe can be dedicated. You can compress very lightly to fit into the pipe and achieve high-quality, visually lossless, compression. This also leverages the bandwidth scalability that is inherent in IP, where video can be transported at a desired rate with JPEG 2000, never consuming more bandwidth than is required.

—Image Quality

JPEG 2000 is perhaps best known for the high quality of its output. At high bitrates, no artifacts are perceptible, and at lower bit rates, video quality tends to degrade gracefully. JPEG 2000 operates on the entire frame while other compression schemes require the image to be broken up into smaller blocks, causing quality to diminish unevenly and to vary from frame to frame. This creates the visually annoying digital artifact known as **blocking**. With JPEG 2000, quality loss occurs evenly across the entire frame and appears visually as blurring, which is less visually disturbing than blocking. Blurring occurs naturally with the eye and people are accustomed to this due to their experience with analog.

Even with extreme compression, JPEG 2000 compressed images degrade with subtle blurring — not annoying blocking and tiling.

—Scalable bit rates

With sufficient data, JPEG 2000 offers accurate rate control. If there is sufficient content to compress, the desired rate will be consumed to provide the highest quality possible. This is not the case with motion-predicted codecs where intra-frames require many more bits relative to predicted-frames and bidirectional-frames, resulting in substantial quality variation from frame to frame. The JPEG 2000 standard also provides lossless and lossy compression through a single algorithm in a unified codestream.

Video can be coded into a mathematically lossless bitstream but rate-limited into a lossy bitstream. JPEG 2000 lossless compression provides bit-perfect reproductions with absolutely no difference between the source and the output video. JPEG 2000's error resilience is another compelling benefit, providing resilience against bit errors introduced by noisy communication channels.

Low Latency, Low Complexity... Low Cost

JPEG 2000's low latency — typically 1.5 frames or less — is critical for live and interactive applications. Its low latency is due to the fact that each frame is coded separately and independently. The relatively low complexity of JPEG 2000 also provides a cost advantage. As it does not include motion prediction, JPEG 2000 compression is less complex than H.264. With MPEG-2 and H.264, the encoder must be efficient and is of much higher complexity than the decoder. In contrast, JPEG 2000 encodes and decodes are nearly equally complex. Lower cost and less complex, it is also efficient in terms of power consumption and space requirements. JPEG 2000 achieves higher port density in a smaller amount of space than H.264.

Ensuring high quality content does not end with successful, low latency compression. Monitoring and controlling that content is equally significant. There has never been a better time to take advantage of sophisticated market solutions that mitigate transport risks, eliminate signal interruption, and ensure that high quality is maintained across the video transport chain.

Comprehensive Control + Monitoring

The most effective in-service monitoring systems ensure that services achieve target quality-of-service standards 24 hours a day, 365 days a year. These state-of-the-art video, in-service monitoring systems are able to provide centralized, non-intrusive monitoring of a large number of **DVB-ASI**, **HD/SD-SDI** and **video-over-IP** traffic. The most comprehensive systems monitor integrity, presence and activity on each channel, allowing users to pinpoint quality of service issues and proactively correct problems before they affect services. The support for video over IP includes wire-speed monitoring of video over IP traffic at the Ethernet, IP, UDP and RTP layers, enabling the monitoring of high video-over-IP traffic of different formats without the risk of signal interruption.

Systems are designed for passive monitoring of DVB-ASI, HD-SDI and SD-SDI signals, according to DVB and SMPTE recommendations. Often this remote video circuit monitoring is provided through a built-in web interface, which details



Implementation Holds The Key

Specialized knowledge is required as well as the correct products to maximize the quality, flexibility, and scalability that the latest technologies — JPEG 2000 compression, monitoring and control among them — can bring — ultimately, the benefits these technologies deliver depend upon their specific implementations. Keeping abreast of the latest technological developments and the equipment providers behind these innovations are crucial in successfully handling multi-

information about each transport stream — testing signals without breaking any feeds, monitoring multiple signals at once, and pinpointing signal failures down to the transport stream level.

format content and assuring that your infrastructure is ready for the future.

Standards + Compliance

Systems such as these monitor automated *Service Level Agreements (SLA)* compliance and provide valuable input to create SLA reports. Built-in web interfaces provide access for local monitoring and configuration, with **SNMP** And **XML** for remote access and reporting.

Adherence to standards is also a critical function. DVB-ASI signals are checked according to **ETR 290**, SD-SDI signals according to **SMPTE-259 (EDH)** and HD-SDI signals according to **SMPTE-292**. The DVB-ASI measurement and monitoring process follows the recommendations of ETR 290 and is augmented by service critical analysis. SD-SDI monitoring makes use of EDH checks with extensive analysis that includes embedded audio of up to 16 channels. HD-SDI monitoring utilizes check words in the HD signal as defined in SMPTE-292.

Modular platforms are designed to integrate with larger network management systems or third party systems via SNMP, providing complete monitoring and control and end-to-end network management.

About the author

Dr. Eugene Keane is president of Nevion's Media Networks Division. He's based at Nevion's U.S. headquarters in Oxnard, California and has more than 20 year's experience providing video transport solutions to carriers around the world. Eugene founded Video Products Group (VPG) which was acquired by Nevion in 2008. His work with the organization extends back to 1989 when he worked for PCO, a joint venture between Plessey and IBM, where he led the fiber-optic video transmission group, which subsequently grew into VPG. For over twenty years under several different corporate umbrellas, Eugene has provided vital technology and business leadership for the team developing Nevion's carrier-class Ventura solutions for video transport service providers. He holds EE, ME and PhD degrees from University College Cork, Ireland.



Event: IBC 2011

Hailed as a game changer in some quarters for the way we interact with stories and brands, Transmedia is gaining prominence as a concept and technique for producers to engage with consumers across multiple connected devices. It is a logical extension of ideas such as cross platform and 360-degree production but its roots lie decades back, albeit in other guises. Stories were extended onto different platforms for ‘Star Wars’ where it was mostly seen as a marketing and merchandise exercise. Now the web allows the audience to immediately feedback their thoughts to writers and producers — the audience becomes a participant in the story’s creation.



Event: IBC 2011



The term itself was first floated in the early 1990s to represent the idea that narrative can flow from one media platform to the next and resurrected in 2006 by MIT professor *Henry Jenkins* whose work *Convergence Culture* lent the movement a conceptual template.

In April of last year, the credit *Transmedia Producer* was officially ratified by the **Producer's Guild of America**, as the person “responsible for shepherding narrative content across at least three different media platforms.”

For its exponents, transmedia is not simply about porting the same content across multiple media but doing so in such a way that each platform contributes a new and unique aspect to the story. Transmedia storytelling can be envisaged as a giant jigsaw, where the pieces exist across platforms and as the user consumes these isolated story chunks, they combine to create a bigger story.

Speaking at an **IBC** conference session on the use of social media, *Tom McDonnell*, founder of cross platform content specialist Monterosa, explained, “Large studios and broadcasters, as well as indie producers, can tell various parts of the same story using distinct media, exploiting the qualities unique to each platform. When you watch a TV show, you might follow a sub-plot that spills on to the web, then read the dénouement in a graphic novel.”

Lost, *Heroes* and *Skins*, are examples of linear TV programs conceived with a complementary online narrative that feeds characters and subplots back into the TV show. Characters may be given *Facebook* pages so that, between episodes, fans can keep up to date with them

via video blogs and status reports. A transmedia approach gives the story depth and keeps it alive long after the basic TV content has aired. Rather than producing a TV show which is aired once and then forgotten about, transmedia permits the creation of persistent storyworlds which extend the life of the product.

Other classic examples come from feature film (*Head Trauma*) and gaming (**Electronic Arts'** *Dead Space*). The Spanish version of Endemol's *Big Brother* has its own 24 hour program, clothing brand, online games, websites, and social network communities to generate much more of a story than the straightforward audiovisual product. The multiplicity of net-enabled devices and near instantaneous broadband connections have certainly helped evolve cross-platform projects into transmedia ones but smartphone growth has arguably been the biggest catalyst for its take-off.

As people carry mobiles with them everywhere, the phone — especially those with GPS functionality — may be used to weave in all manner of locations, objects or events into a narrative blurring the line between reality and fiction.

“The crux to getting transmedia right lies in the interface between technology and narrative,” advises *McDonnell*.

It's no coincidence that **Nokia** has made the biggest impact so far in this space having sponsored a number of projects and even created one of its own (*Conspiracy for Good*). Brands can, of course, be co-opted to fund transmedia projects in the first place. Indeed, what may define its potential is whether transmedia can generate new revenue streams for broadcasters to invest in content. The attraction of transmedia to brands is that it encourages participation and chance to shift from intrusive display advertising into genuinely compelling experiences. It could all of course be a passing fad but to others it's transmedia represents a paradigm shift in content production. They argue that, if done properly, it speaks to a generation of people who are already moving rapidly and instinctually from one platform to the next. The problem right now is that most of their content is not moving at the same pace with them.

IBC 2011 is definitely the major trade show event located in Europe where transmedia will be demonstrated, discussed, and analyzed. The incorporation of various technologies to feed content via various pipelines and channels for transmedia creation, production and

Event: IBC 2011

delivery will all be found on the show floor and in the special sessions. The first IBC was held in 1967, in the **Royal Lancaster Hotel** in London. There were just 32 exhibitors and 500 conference delegates, and, of course, broadcasting was a very different business.

In the 1960s, broadcasting was very much an analog world, where the introduction of color television was still a new innovation. What would have been the reaction of the delegates to that first IBC to be told that, 40 years later, they would have a computer on their desk and that it would be capable of editing high definition (HD) video. And that they would carry a telephone in their pocket wherever they went in the world — which would also be an HD video camera?

IBC lasted just one year in the Royal Lancaster Hotel before needing more space. It went to the **Grosvenor House** hotel on London's *Park Lane* for a period, with a venture to the **Wembley Conference Centre**, before heading south to *Brighton*. At first, the **Grand Hotel** in Brighton could accommodate it, but rapid growth meant that it ended up filling the **Metropole Hotel** and the Conference Centre as well — and one memorable year there was a pavilion on the beach, too!

However, by 1990, the lack of exhibition and meeting space — and a chronic shortage of hotel rooms — had reached crisis point. Under the inspired and visionary leadership of *John Wilson*, IBC embarked on a program of dramatic change.

The first IBC came about because a group of manufacturers wanted to organize an exhibition. From 1968, it was managed by the *Institution of Electrical Engineers (IEE)* — now the **IET**, following the merger between IEE and IIE in 2006 — with advice from the RTS, as an event (now a conference as well as an exhibition) run by the industry for the industry.

Under *Wilson's* guidance, IBC became an independent body, owned by six partner bodies: IABM, IEEE, IET, RTS, SCTE and SMPTE, with a full-time professional staff. The strong association with these leading trade bodies, and the committee structures for exhibition and conference, ensured that the event was still run by the industry for the industry, but the dedicated staff meant that the organisation could be much more flexible and responsive.

IBC also moved from the U.K. to the Netherlands. After very careful research into venues capable of meeting the very specific demands of IBC, the **Amsterdam RAI** was selected, hosting its first IBC in July 1992 (the normal September dates not being available that year). From 1994, IBC became an annual event, and it has remained in Amsterdam ever since.

Today, IBC's management is continually looking at ways to develop the event to meet the rapidly changing needs of the industry. It has extended its reach, for example, becoming one of the most influential events in digital cinema worldwide, thanks to its ability to demonstrate to the very highest standards as well as host top-level debates. It has also extended its reach into other digital communications media, like mobile television and digital signage, such as the *Connected World*.

IBC remains the leading event on the global stage for everyone involved in content creation, management and delivery. By remaining close to its industry roots, it continues to deliver a conference and exhibition which are comprehensive, stimulating and relevant to the real needs of its visitors.

To participate in this stellar event, proceed to the IBC 2011 registration page at <http://www.ibc.org/page.cfm/link=399>

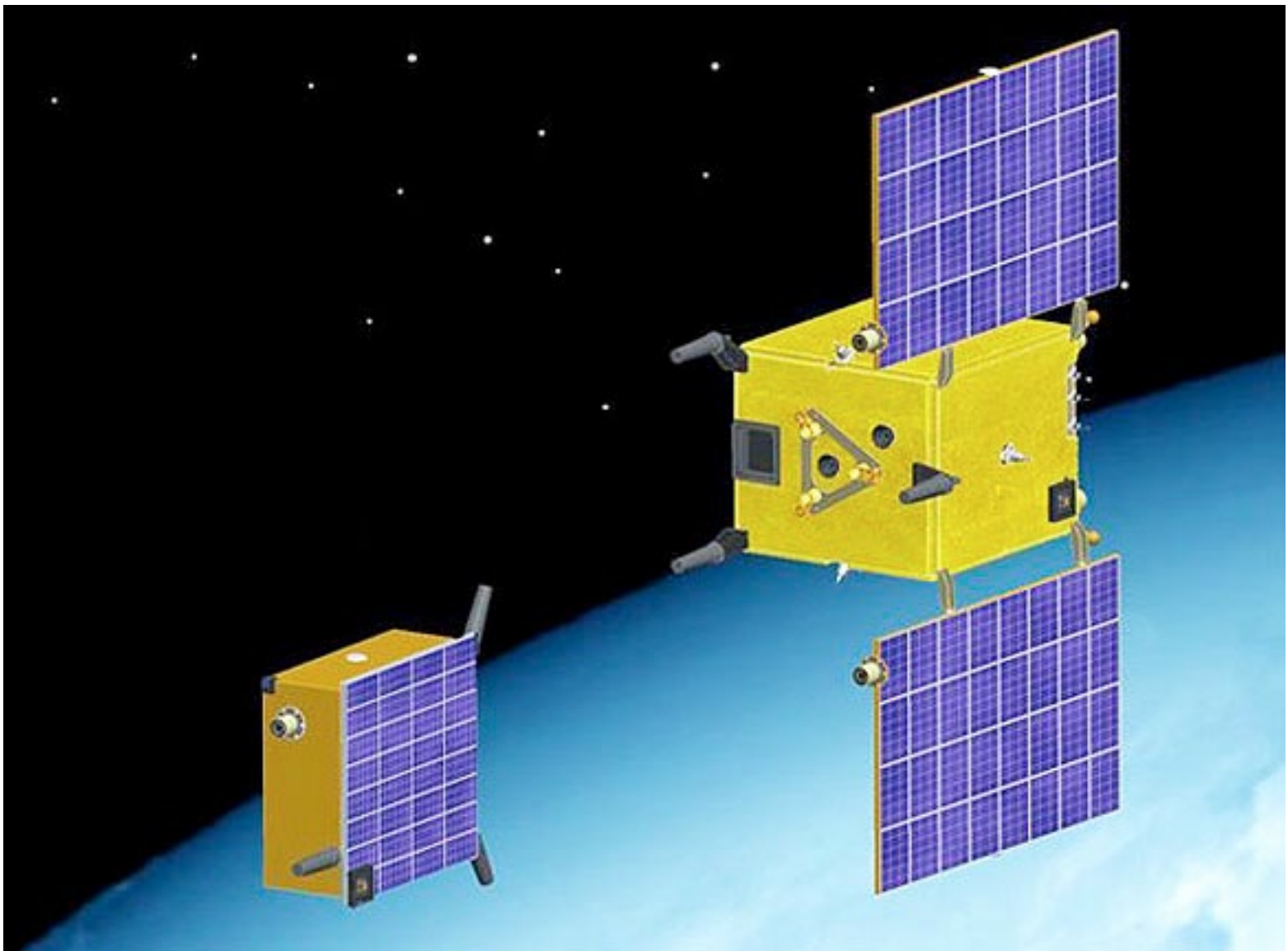


A Case In Point

Developing Satellite Formation Flying Software With Model-Based Design

by SSC and MathWorks' Engineering Team

Today's satellites support a wide range of civilian and military applications, including televisions, cell phones and Global Position Systems (GPS). As demand for these applications increases, the satellite industry must continue to innovate to provide faster, more efficient, and more cost-effective service. Instead of deploying large, complex geosynchronous satellites, the industry is moving to constellations of smaller satellites flying in formation. These smaller satellites provide the same functionality as their bigger predecessors, but are less expensive to build and launch.



Tango and Mango, the two small satellites making up the PRISMA mission. Credit: CNES

A Case In Point

Challenge

While the cost of manufacture and launch scales down with satellite size, the engineering development cost for satellites does not — engineering development cost is mainly driven by the new technology incorporated into the satellite and operational complexity. For example, formation flying will require satellites to possess new technology to communicate with one another as well as complex algorithms to position themselves relative to each other in real time. To meet these new functional requirements, engineers need to explore a wider range of design alternatives, which further drives up development cost.

Increased engineering costs are not the only challenge associated with formation flying, particularly for systems developed using a

traditional development process. In such a process, requirement, design, implementation, and test tasks are performed in different tool environments, with many manual and duplicated steps. Textual requirements, captured in tools such as Microsoft Word or IBM Rational DOORS, can be difficult to analyze. For instance, it is difficult to spot inconsistencies between different subsystem requirements when there are thousands of such requirements. Furthermore, designs completed using domain-specific tools cannot be tested at the system level until after they are implemented in software or hardware. In the coding phase, software engineers manually translate code from design documents produced by the algorithm engineers, which can be a time consuming and error-prone process. The test phase is the catch-all for all the defects that accumulate and flow through the

Traditional Workflow

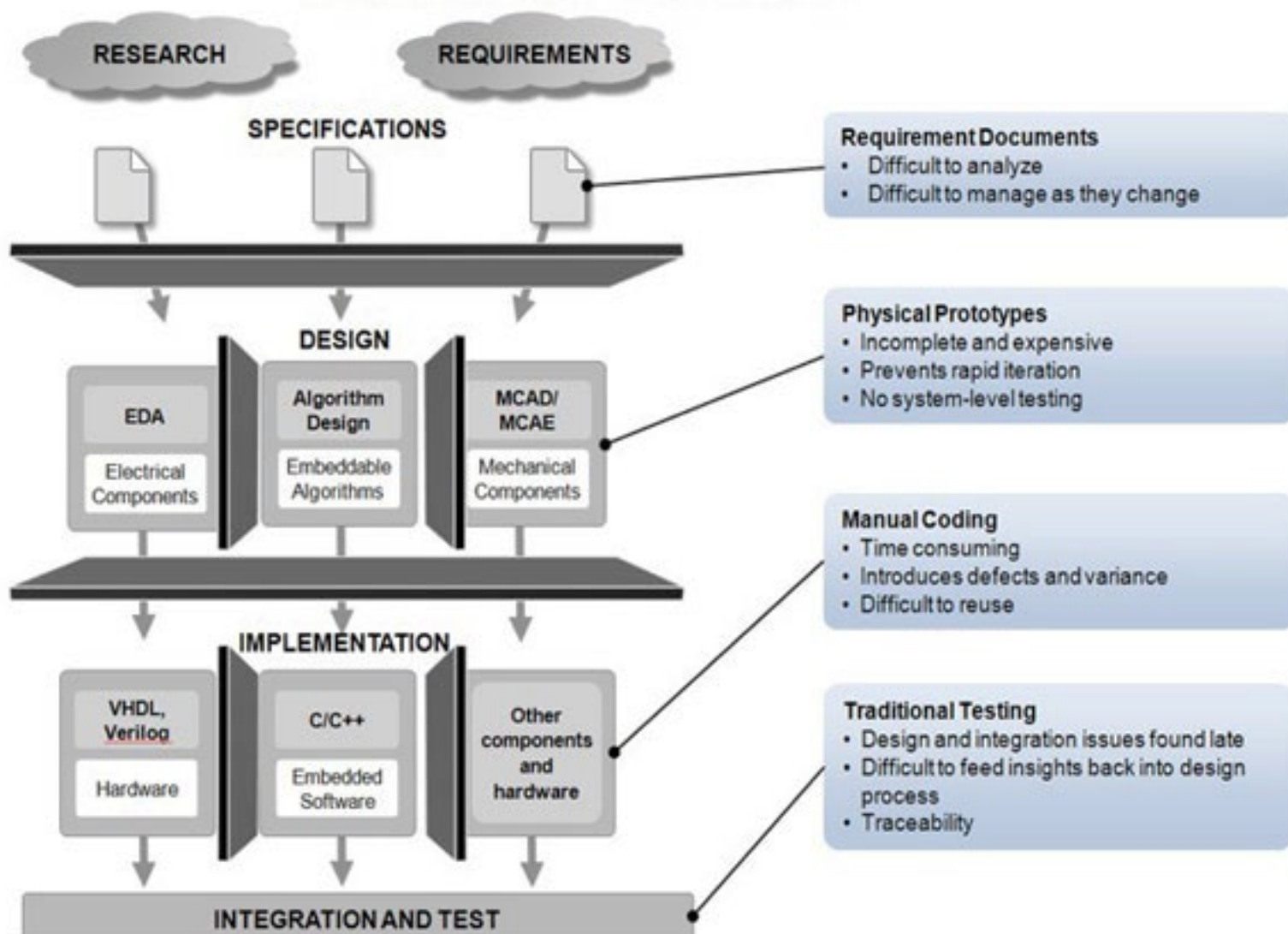


Figure 1. Traditional development methods involve a series of isolated, manual steps that are time consuming and error-prone.

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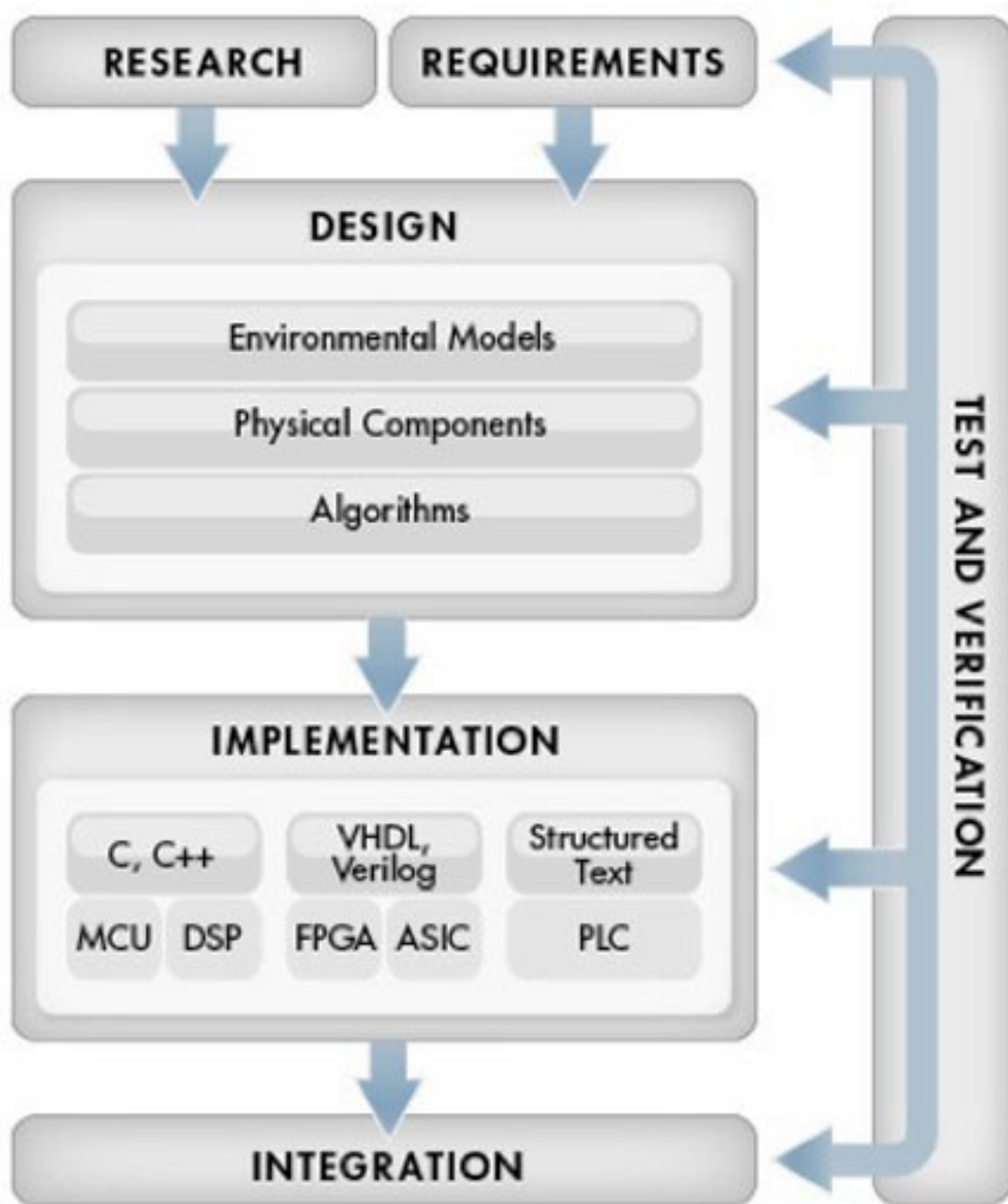


Figure 2. In Model-Based Design, the system-level model serves as an executable specification throughout development. This design approach supports system- and component-level design and simulation, automatic code generation, and continuous test and verification.

by traditional development methods. Engineers need tools that enable them to efficiently explore design alternatives for formation flying systems, reuse existing designs, incorporate new technologies, and optimize system-level performance.

Solution

Model-Based Design

starts with the same set of requirements as a traditional process. However, instead of being manually translated into textual specifications, these requirements are used to develop an executable specification in the form of models. By simulating the executable specification, engineers can identify and fix inconsistent or vague requirements early in development. In the design phase, executable specifications serve as a foundation from which algorithm designers elaborate their designs. As the complete design is created in a single modeling environment, subsystem designs spanning multiple domains can be integrated, optimized, and function tested before implementation. Once the

previous phases (see *Figure 1*). As a result, the test phase often constitutes the bulk of development time and cost. The lack of a common tool environment, reliance on manual steps, and inability to discover defects until the latest stages of the project drive up the total time and cost of development.

The already difficult challenges inherent in designing formation flying systems are compounded by additional obstacles imposed

design is finalized, the models are used to automatically generate production code and test cases. Finally, engineers can reuse the models to validate software and hardware test results.

With Model-Based Design, engineers stay in the model environment from requirements to test, minimizing manual work and translation errors (see *Figure 2*). Testing begins at the requirement phase instead of the test phase, shifting defect

A Case In Point

discovery and elimination earlier in the development process. By enabling engineers to work in the same tool environment, reduce the number of manual tasks, and find defects earlier, Model-Based Design reduces the total cost of development.

SSC: A Case Study

Engineers working on SSC's *Prisma* project, a civil mission, used Model-Based Design to develop two satellites, *Mango* and *Tango*, which are capable of autonomous formation flying, autonomous rendezvous, and proximity operations. As part of the project, SSC engineers developed new *Guidance, Navigation, and Control (GNC)* algorithms for formation flying that took advantage of advanced sensors and propulsion systems. Typically, integrating new algorithms and components would increase the time needed for development.

As with many satellite programs, *Mango* and *Tango* were based on a previous design, in this case a **European Space Agency (ESA)** project named *Small Missions for Advanced Research and Technology (SMART-1)*. SSC developed the *attitude and orbit control system (AOCS)* of SMART-1 using **MATLAB** and **Simulink**. Building on their experience using Model-Based Design, SSC engineers reused the models and flight code from SMART-1, made changes to accommodate the new sensors and actuators, and met new mission requirements.

For *Mango* and *Tango*, SSC engineers used MATLAB, Simulink, and Stateflow to develop the algorithms, run system-level closed-loop simulations in real-time, and generate flight code. Real-time simulations of the plant models with xPC Target enabled the



Tango (top) and Mango (bottom) are mated into their launch configuration in May of this year. Photo is courtesy of SSC.

A Case In Point

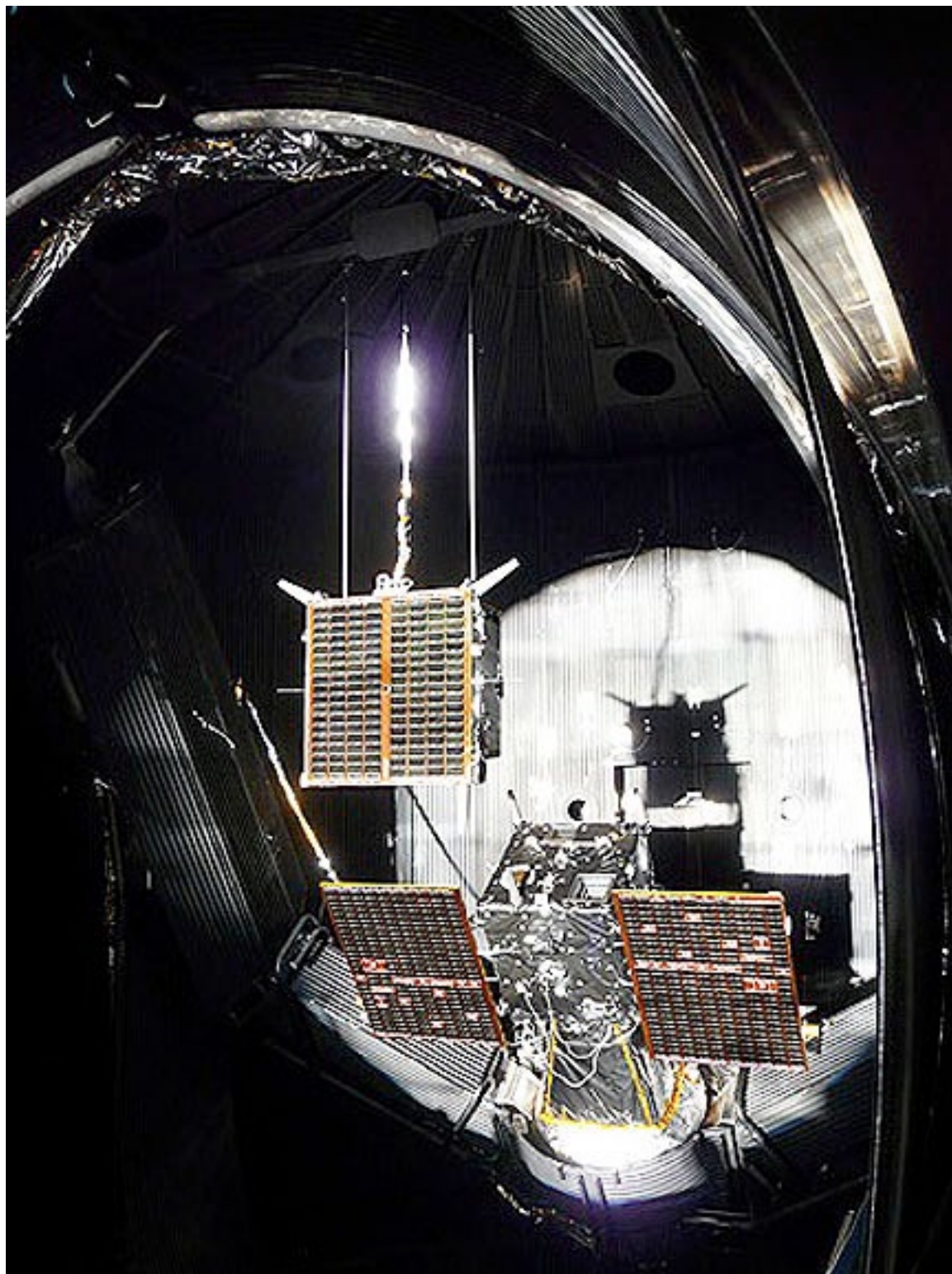
engineers to reuse the models to rehearse for the actual mission flight operations and verify flight command sequences.

Unlike traditional methods in which control engineers capture the algorithm design in text and diagrams before passing the document to software engineers who interpret it and manually write code, Prisma project engineers reused the same set of models

from concept to implementation.

Starting in the requirement phase, the engineers used models to communicate with teammates at the French and German space agencies, as well as at the **Technical University of Denmark**. The models provided an unambiguous set of executable specifications, which helped the multinational team to find and address defects early in the requirement and design phase. Using one set of models also eliminated the need for data reentry and conversion between disparate tool environments. To further improve efficiency, SSC engineers reused SMART-1 models to run tests early in the development process and reused those same tests throughout development to ensure consistency and eliminate redundant work.

Using Model-Based Design to develop formation flying systems on the Prisma project enabled SSC engineers to reuse 70 percent of the attitude control models developed for SSC's SMART-1 satellite, explore design alternatives, rapidly develop designs that incorporated new sensors and actuators, and reduce total development time by 50 percent.



In this test, with Mango and Tango in the space simulator, the aim was to validate the thermal mathematical model and to test how the systems functioned at extreme temperatures.

Credit: Swedish Space Corporation (SSC).



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DVB-S2 + DVB-RCS: Challenges + Benefits

by Mark Lambert

Over the last 18 months, Advantech Wireless has explored the synergistic use of the DVB-S2 and DVB-RCS to enhance both data networking and, coming full circle, IPTV solutions. Particularly satisfying was to see the U.S. Department of Defense announce, in February of 2006, that their policy for the transmission of IP of both commercial and military satellites was to use the DVB-S2, DVB-RCS and MIL-STD-188-165 standards.

The Company has been successfully deploying such systems from early 2006 for commercial and defense applications. In addition, Advantech Wireless recently collaborated with Telesat Canada and the Canadian Space Agency (CSA) to demonstrate the first use of DVB-S2 in a DVB-RCS system with a satellite operating at Ka-band. *(The major advantage of Ka-band from the stand point of the end user is lower service pricing, made possible as a result of the spot beams and frequency reuse in Ka-band satellite design).*



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DVB Standards

DVB-S was introduced in 1993 to standardize the distribution via satellite of digital television services to consumers. This standard proved quite successful in driving down the cost of satellite modems and, within a few years, it was used for digital television distribution as well as for data distribution as the ‘low-cost’ demodulator chipsets allowed the development of new satellite data distribution markets.

The success of DVB-S encouraged **DVB** to study an extension, DVB-RCS, which added a standardized satellite-based return channel for multi-user data distribution. In addition to data distribution, DVB-S was also being used for television news contribution via satellite (**DSNG**) applications and for distributing television and radio channels to terrestrial transmitters.

DVB-S was only specified with **QPSK** (Quadrature Phase Shift Keying). QPSK is a form of *Phase Shift Keying* in which two bits are modulated simultaneously, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth. modulation, which allows a maximum of 2 bits/Sec/Hz efficiency in a satellite link. This is a limitation for professional applications, which can use larger satellite dishes and smaller symbol rates than the consumer transmissions and, hence, can support more advanced modulation schemes. Therefore DVB created yet another standard in 1999 (**DVB-DSNG**) which standardized **8PSK** (*Phase Shift Keying*) and **16QAM** (*Quadrature Amplitude modulation* — more efficient than QPSK but requiring more link margin) to be used for professional applications.

However, despite this continued standardization process technology continues to advance and, since 1994, silicon density has increased by 16 times and *Forward Error Correction* (**FEC**) has been transformed by iterative decoding. FEC provides a mathematical means of correcting errors in a transmission link enabling the efficiency of the link to be improved. More advanced FEC schemes approach the theoretical *Shannon* limit (this refers to the maximum signal-to-noise ratio improvement which can be achieved by the best modulation technique, as implied by *Shannon’s* theorem relating channel capacity to signal-to-noise

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ratio) for transmission efficiency. Since the creation of DVB-S, the world has also become much more IP focused. In 2002, DVB decided to create a new satellite specification, including a radical new FEC scheme that was designed to take advantage of latest silicon process technology and to enable more efficient and higher throughput satellite transmissions — DVB-S2 was conceived. The key driver for the rapid development of DVB-S2 was the scarcity of available Ku-band spectrum in the USA coupled with the approaching launch of bit rate and bandwidth hungry HDTV Digital satellite Television systems. DVB-S2 aimed to improve the efficiency of transmission by 30 percent. In other words for any given link budget the target was to get 30 percent more data through the link.

In parallel with this drive for efficient satellite transmission the DVB-S2 committee also designed a ‘professional’ mode for the standard, which included radical advanced modulation schemes such as **16APSK** and **32APSK**. These modulation schemes are not suitable today for consumer applications but have an application in high data-rate large dish point-to-point links. This professional mode has been designed to replace the DVB-DSNG standard. The ultimate target was to have one satellite standard addressing as many consumer and professional applications as exist in the market.

Wait, there is more. Until the advent of DVB-S2, two-way VSAT systems had limited support for fade adaptation in the return link only, notably power control in the user terminal and diversity switching in the hub. A DVB-S forward link (*i.e.*, hub outbound) has no direct adaptation possibilities (except the possible use of *Uplink Power Control* — an established technology). The use of

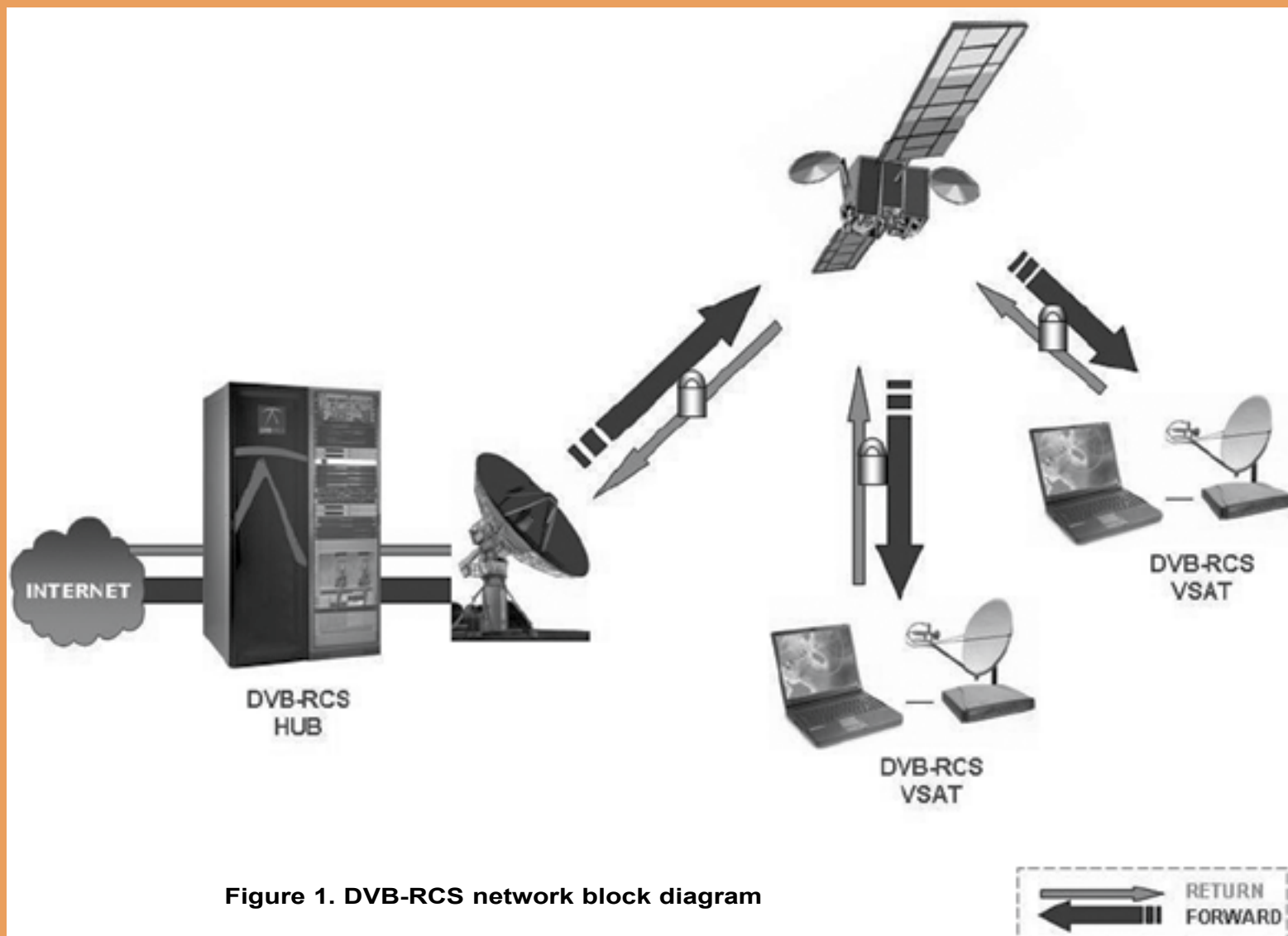


Figure 1. DVB-RCS network block diagram

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DVB-S2 *Adaptive Coding and Modulation (ACM)* offers rain fade countermeasures on the forward link and permits an optimum match of transmitter waveform to the channel conditions. In particular, the DVB-RCS standard has inherent support, as well as some “hooks”, for supporting such adaptation techniques. This article, then, discusses how DVB-S2 and DVB-RCS are married together. *Figure 1* shows a typical DVB-RCS network diagram.

ACM allows the transmission to change the strength of the FEC coding and the type of Modulation on a Frame-by-Frame basis. DVB-S2 frames are either 64k coded bits long (Normal Frame) or 16k coded bits long (Short frame). The coding and modulation used in any particular frame is signalled in a very ‘rugged’ header, which is inserted at the beginning of each DVB-S2 Frame.

DVB-S2 + ITS Benefits

— *The Physical Layer and its Performance*

Front and centre in the justification for DVB-S2 is the very high physical-layer performance. This is achieved through the use of

very powerful coding, combined with provisions for high-order modulation schemes that are optimized for use on nonlinear satellite channels. While there is nothing fundamentally new in either of these elements, the advancements in low cost digital processing power and the development of powerful decoding and synchronisation algorithms have made the use of these techniques feasible, even in low-cost applications such as direct-to-home (DTH) broadcast.

The power of DVB-S2 is illustrated in *Figure 2*. This figure shows the power/bandwidth trade-off of the modulation and coding combinations incorporated in the standard. The figure also shows theoretical performance bounds. When the modulation constellations and finite block sizes are taken into account, DVB-S2 is within a few tenths of a dB of the theoretically achievable. For all but the highest spectral efficiencies, it is actually quite close to the Shannon bound which, as far as is known today, represents the ultimate performance limit. The figure also shows DVB-S, for comparison. This comparison shows that DVB-S2 outperforms DVB-S by about 3 dB for the same spectral efficiency or by about 35 percent in spectral efficiency for the same link budget.

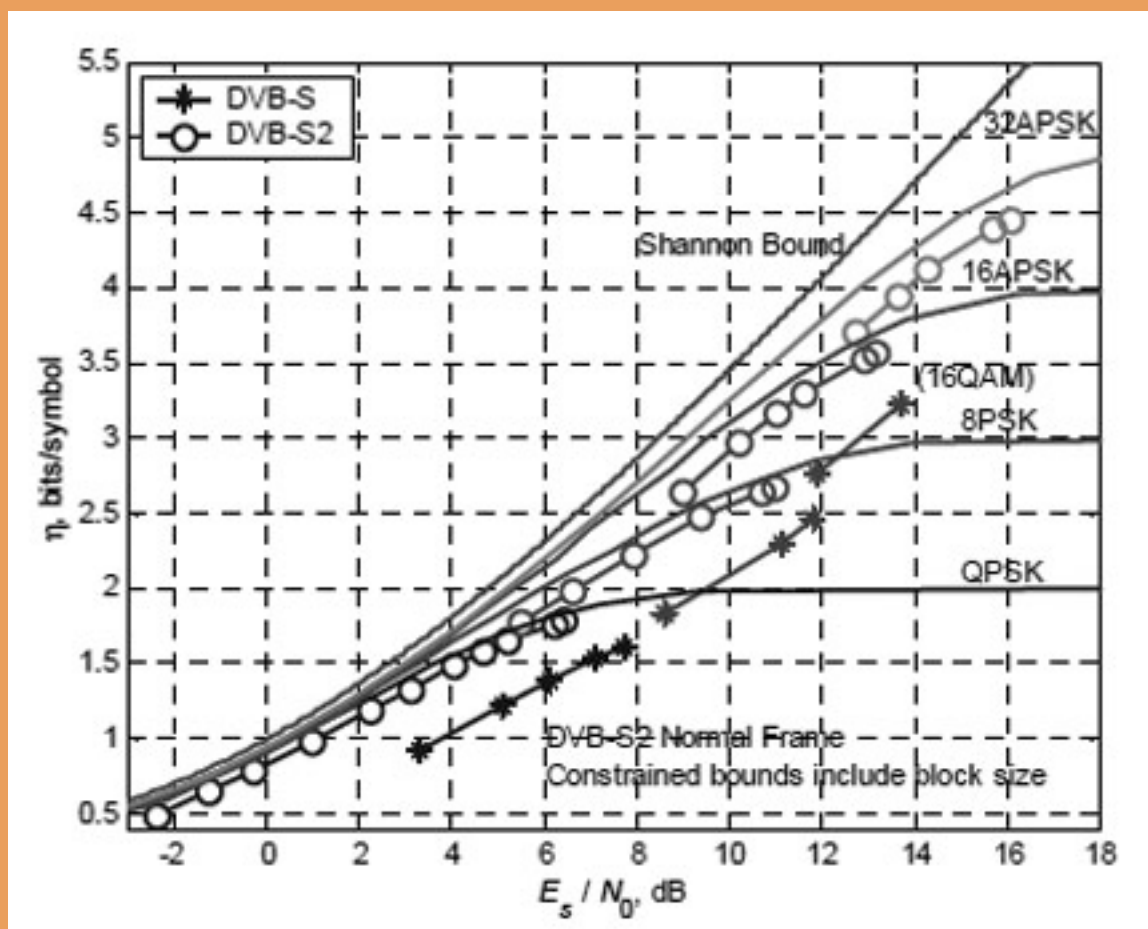


Figure 2: Theoretical Performance of DVB-S2 and DVB-S

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The DVB-S2 physical layer makes use of a powerful coding technique known as **LDPC** (*Low Density Parity Check*) coding, in combination with a small conventional block code (**BCH**). The main coding technique, also known as *Gallagher* codes, was first described in the 1960's. The complexity of decoding was however prohibitive until recently. Techniques inspired by those used for the more recent “Turbo” codes have been shown to work very well. For this reason, LDPC codes are sometimes described as a “cousin” of Turbo codes. The BCH code is included in DVB-S2 to mitigate the “flaring” of the error performance that is inherent in all high performance codes, including LDPC.

DVB-S2 offers a range of modulation schemes, starting with conventional QPSK and 8PSK. For higher spectral efficiency in applications that allow it, the standard also includes 16APSK and 32APSK schemes. These schemes use constellations that consist of a number of concentric rings of constellation points, rather than the square grids of points used in conventional high-order schemes such as **16QAM**. This makes the schemes better suited to the nonlinear transmission channels encountered in satellite systems, and offers the possibility of powerful, yet simple pre-compensation techniques. Overall, the range of possibilities offered by DVB-S2 cover a “dynamic range” of required signal-to-noise ratio of 18 dB.

These improvements form the prime justification for the development of DVB-S2, because of what they offer for broadcast services. There are, however, further features in DVB-S2 which have some very important properties for interactive services such as DVB-RCS.

— *Application Classes + Modes of Operation*

The basic mode of operation of DVB-S2 is often referred to as “**CCM**”, or *Constant Coding and Modulation*. The term refers to the fact that the modulation and coding does not change over time. This is the mode that will be used for broadcasting, where the same signal is sent to many receivers. As is the case for any transmission of this kind, properties such as code rate and symbol rate must be tailored to the worst-case situation addressed by the service offering. CCM mode can of course be used for interactive services and other non-broadcast applications, in exactly the same manner as DVB-S is used for this today. However, the standard allows the modulation and coding to change over time. This offers important advantages for non-broadcast applications, as explained in the following.

A DVB-S2 carrier is a continuous stream of channel symbols, transmitted at a constant rate. The carrier is organized in “frames”.

Each frame corresponds to one code word of the LDPC code, and contains between 3072 and 58192 information bits, depending on code rate and on which of the two frame size options (known as “normal” and “short”) has been selected. Each frame also contains a header, which identifies the modulation and coding used. The modulation and coding can therefore be varied on a frame-by-frame basis. Transmission modes that make use of this option are known as “VCM” (Variable Coding and Modulation”) and “ACM” (Adaptive Coding and Modulation”). VCM and ACM differ mainly in their intended use; they are virtually identical in terms of what is actually transmitted.

Transmissions that carry “*unicast*” data; *i.e.*, where each bit is destined for one receiver only, can take advantage of ACM to tailor the level of protection to the properties of that receiver. This can include “static” considerations of receiver sensitivity and location in the beam, but can also — and more importantly — be adapted dynamically to match the channel conditions existing for any receiver at any time. Doing this allows a very significant reduction of the propagation margins, compared to those that must be included in CCM systems. Depending on the propagation statistics, the use of ACM in this manner can provide improvements in spectral efficiency of 100 percent or more. The gain is obviously higher, the more severe the propagation conditions are. It will, therefore, typically be higher at higher frequencies, and in locations that experience intense rain.

At any one time, the total population of users in an ACM system will present a range of different needs for protection (*i.e.*, for particular modulation / coding combinations). The mix needed, and the amount of capacity needed for each combination, may vary in time. DVB-S2 caters for this in simple fashion. The header of each frame carries the information needed to demodulate it; there is, therefore, no need for any higher-level structures or for any pre-determined distribution of capacity among different protection modes. Frames can simply be made up as needed.

ACM (or its sibling VCM) can also be applied to professional services such as news gathering. In such point-to-point applications, the protection mode is typically varied slowly, and for the entire carrier, in response to variations in the channel conditions at either end of the link. For such applications, this variation may be combined for example with adjustment of the data rate generated by video encoders.

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— *Frame and Packet Structures*

The original DVB-S was developed specifically to transport an MPEG multiplex of several TV programs, known as a “transport stream”. Other applications had to adapt to this format. One example of this is the so-called *Multi-Protocol Encapsulation (MPE)*, which is used for example in DVB-RCS systems to transport *Internet Protocol (IP)* datagrams over a DVB-S carrier. Likewise, the DVB-RCS signaling in the forward link is formatted to mimic that used for control of MPEG-based applications.

DVB-S2 offers the flexibility to use other organisations of the data, including the possibility of varying the packet size. Potentially, these so-called “generic streams” allow much more straightforward encapsulation for example of IP traffic. This can also potentially reduce the overhead.

The standardisation of generic streams encapsulation is in progress. The first revision of the DVB-RCS standard with support for DVB-S2 is still based entirely on MPEG transport streams.

— *Benefits of Adaptive Coding + Modulation*

One way of describing the benefits of adaptive coding and modulation is that this technique allows the elimination of rain margins for most users, most of the time. This gain can be put to use in a number of different ways, chosen according to constraints and objectives.

In current systems, two large contributors to the total cost of service provision are the forward link bandwidth and the RF power amplifier in the user terminal. At the same time, most current systems are unbalanced in the sense that there is much more traffic in the forward link than in the return link. The cost of the return link bandwidth is therefore of lesser concern (This is starting to change as a result of developments in the types of applications used, but it is a valid assumption for most current systems).

The expectation is to use the “adaptivity gain” in the forward link, mainly to increase the spectral efficiency, and that in the return link largely to reduce the necessary size (and hence the cost) of the RF power amplifier. With the usage pattern changes alluded to above, it is probable that some of the return link adaptivity gain will in future be directed towards spectral efficiency improvements as well.

— *State Of The Industry*

When work commenced in 2004 to incorporate DVB-S2 in DVB-RCS, the industry was just starting to make DVB-S2 equipment available. Since then, most DVB modulator manufacturers have produced DVB-S2 product offerings. Most support the CCM profile and some manufacturers are starting to announce ACM profile offerings. However, there are large development risks associated with the demodulator aspects of DVB-S2.

It is clear DVB-S2 is being driven by the commercial needs form the marketplace. As with DVB-S, the major user of the demodulators for DVB-S2 is the commercial direct-to-home set-top box. Since the broadcast profile in the DVB-S2 specification only requires support for the CCM profile, this is the area where most of the ASIC chip development has occurred. Therefore, the chipsets existing today are supporting the CCM profile only. Typically these ASICs are only guaranteed to work at symbol rates of 10 MBaud and higher. Some RCS manufacturers have decided to implement a low cost CCM solution to provide a solution to the marketplace to take advantage of the increased forward link efficiency. Today, **SatNet** has a solution implemented using CCM and working at symbol rates down to 4 MBaud. The consumer *set top box (STB)* ASICs available today support only the larger Normal Frame as is required by CCM broadcasting. The Short (16k bit) Frame is useful in ACM as it reduces the granularity and hence the potential bandwidth waste and latency in an adaptive system.

There are also several developments underway for ACM receivers, which will include support for the low symbol rates required by many of SatNet’ customers. These developments will enable migration to the ACM profile when commercial ACM system solutions are available. These solutions are targeted to interactive services. Advantech Wireless is working on its own implementation solutions for near-term incorporation into its DVB-S2-capable Series 5000 terminal, whereas its Series 4000 is already available with DVB-S2 CCM capability.

The Company first publicly demonstrated ACM modem operation for satellite systems in September 2006, and has been shipping the technology as part of its point-to-point terrestrial microwave links since March 2006.

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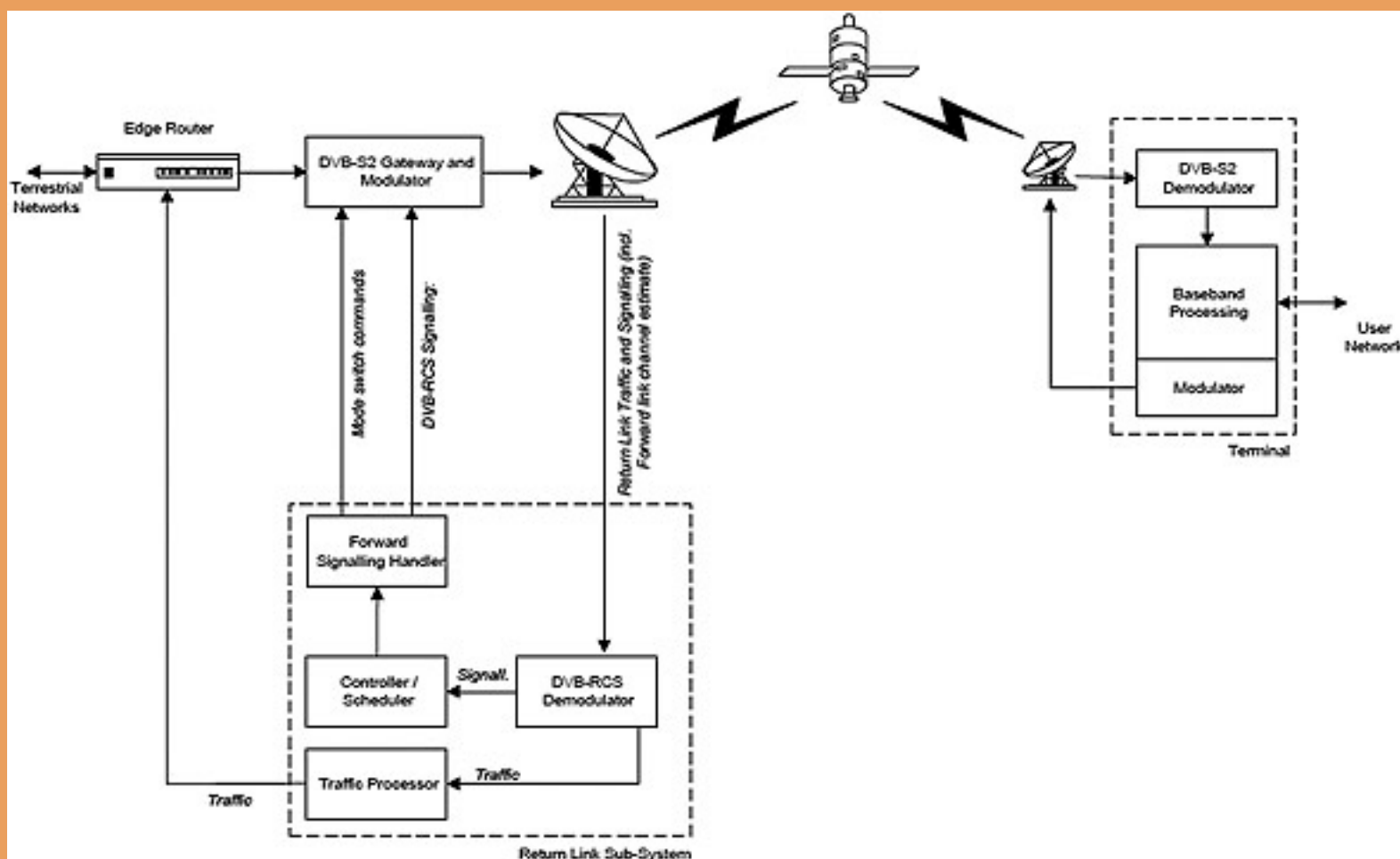


Figure 3. Top-level system architecture, with emphasis on forward link

Architecture Of DVB-RCS Systems Featuring DVB-S2

The top-level architecture of a DVB-RCS system with DVB-S2 is shown in *Figure 3*. Forward link traffic (IP datagrams) arrives from external networks. It is encapsulated and routed to parts of the forward link carrier with appropriate levels of protection for each destination terminal. Information about the mapping between terminal and protection level is provided by the Hub *Return Link Sub-System (RLSS)*. Also provided by the RLSS is the time-varying signaling information for the terminals; in particular, the return link capacity assignments and control messages. The resulting carrier is transmitted through the satellite to the terminal, which demodulates all the frames it can — the demodulator is not tied to any particular modulation/coding combination. Traffic and signaling are extracted in essentially the same manner as for a DVB-S forward link. The main new element is that the terminal reports back the received signal quality, in combination with an estimate of the least-protected mode it can sustain.

Return link transmissions also use adaptation to the channel conditions. For forward link adaptation, the RLSS uses the received signal quality information to select an appropriate mode for each terminal, and signals this to the forward link equipment. This signaling closes the loop for the adaptive operation of the forward link. Return link adaptation decisions are also made within the RLSS; they are communicated to the terminals as part of the signaling already generated there.

In a comprehensive system, the mode switch “decisions” made in the RLSS and based solely on the link conditions will be routed to the *Network Management System (NMS)* before being implemented. Here, they will be treated as “recommendations”. Final decisions will be made in the NMS, and will include higher-layer considerations such as load balancing and conditions of service level agreements. This resource management function is extremely important for the overall performance of the system and for the provision of quality-of-service guarantees to individual users. It is also a highly complex function, in particular because it manages a transmission resource that has a time-varying total capacity: The information carrying

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ability of a DVB-S2 ACM carrier depends on how it is made up of frames with different protection level and therefore different spectral efficiency. The remainder of this paper is focussed on the physical and MAC layer aspects directly related to DVB-S2; we do not have the room here to treat the resource management and quality-of-service issues in any detail.

Major System Components

— Overall Gateway and Network Management

The main gateway components are the edge router, the forward link subsystem, the return link subsystem and the network management system. The edge router is a conventional IP router; it serves as the bi-directional traffic interface to the outside world. In some system configurations, it also performs the re-assembly of IP datagrams from ATM cells in the return link. The network management system is not shown in *Figure 3*, but network management functions are being developed for SatNet's ACM product.

The remaining elements of the gateway are described as follows...

— Forward Link Subsystem

The *Forward Link Subsystem* (FLSS) serves to process the IP traffic to all terminals, to generate some parts of the signaling, and to transmit it all towards the satellite. An important new function of the FLSS in a DVB-S2 system with ACM is the switching/routing of traffic and/or signaling to appropriate protection modes.

The Company has concluded that switching at MPEG level is the most attractive option. The ACM switching is a result of events at the physical layer; restricting the implication to the lowest layer possible reduces impacts elsewhere in the system¹. For the arrangement of the MPEG switching, a multi-stream architecture has been chosen for the forward link; that is, the DVB-S2 carrier is made up of a number of multiplexed transport streams.

¹ *For completeness, we mention here that it is in principle possible to implement adaptive coding and modulation without varying the properties of individual carriers over time. This requires a multi-carrier arrangement. Such arrangements have been considered previously, but have now been superseded by the features offered by DVB-S2. Some of the multi-carrier techniques may find application in other areas; e.g., implementations of DVB-RCS adapted for mobility.*

— Return Link Subsystem

The Return Link Subsystem is not modified fundamentally by the introduction of adaptive operation / rain fade countermeasures in the forward link. Advantech Wireless has selected to implement the basic detection and decision algorithms for forward link adaptation in the RLSS.

— User Terminal

The user terminal requires a DVB-S2 demodulator and decoder. Other functions include modification of the system 1 For completeness, we mention here that it is in principle possible to implement adaptive coding and modulation without varying the properties of individual carriers over time. This requires a multi-carrier arrangement. Such arrangements have been considered previously, but have now been superseded by the features offered by DVB-S2. Some of the multi-carrier techniques may find application in other areas; e.g., implementations of DVB-RCS adapted for mobility. timing synchronisation method, to adapt to the mechanism adopted for DVB-S2 ACM, and handling of multiple transport streams on one carrier. In addition, accurate measurement of the received signal Carrier to Noise Ratio and the reporting of the measure are vital to the operation of the ACM system.

Design Of Key System Components

— Forward Link Subsystem

The forward link subsystem consists of two main components: The **IP-DVB encapsulator**, which transforms a stream of IP datagrams into one or more MPEG transport streams, and the **modulator**, which generates the actual transmitted carrier. These elements are described next...

- **General Functionality of the IP-DVB Encapsulator** — The operation of the IP-DVB encapsulator differs somewhat, depending on whether or not the system employs adaptive coding and modulation. These two cases are described separately in the following.

◊ Systems Employing DVB-S and DVB-S2 with CCM

— In current systems, the forward link gateway (IP encapsulator, IPE) implements the functions shown as a conceptual block diagram in *Figure 4* on the next page. Incoming IP traffic packets are encapsulated over MPEG packets using the MPE protocol. This is the primary function of the gateway. In addition, the

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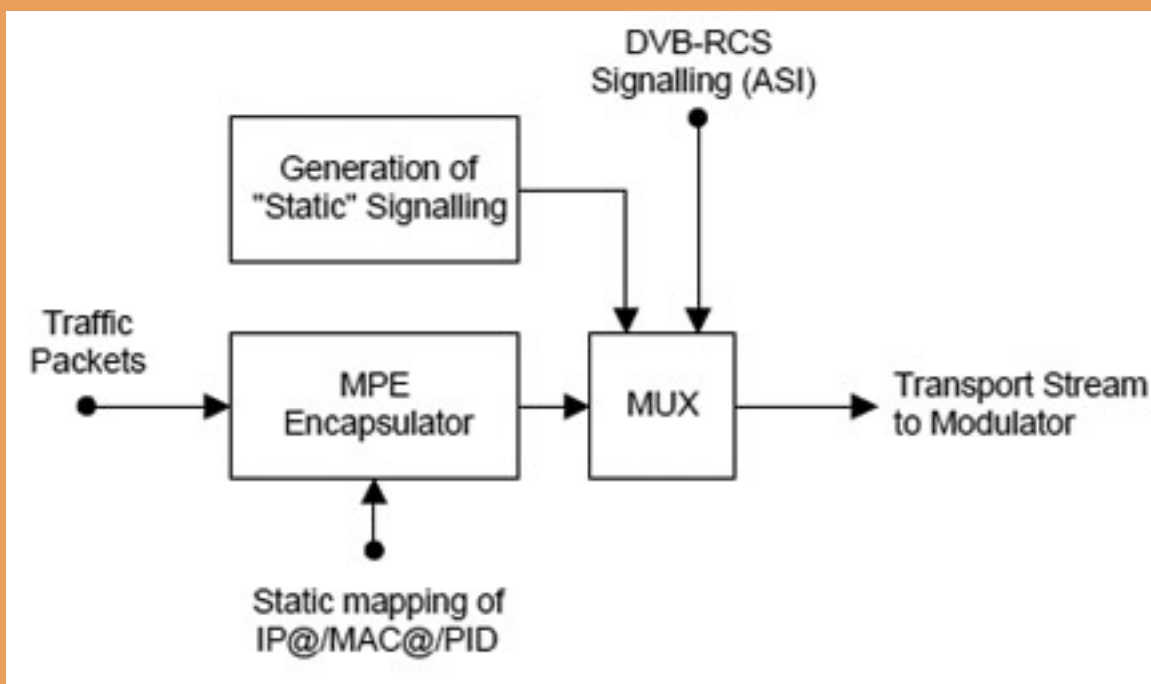


Figure 4: Gateway Architecture for DVB-S and DVB-S2 CCM Systems

encapsulator generates the DVB *Service Information (SI)* signaling “tables” describing the characteristics of the network and the physical organisation of the transport streams. Encapsulators optimized for DVB-RCS networks have expanded this table generation feature to produce a number of tables that are specific to this application. These tables are relatively static; they describe top-level characteristics of the system and the return link air interface. One of the few differences between DVB-S and DVB-S2/ CCM is in the format of these tables; there are slight differences between DVB-S and DVB-S2 forward links in this respect. A further function of encapsulators for DVB-RCS is the inclusion of an MPEG multiplexer port. This port allows the inclusion in the transmitted stream of the more “dynamic” signaling. This signaling contains all real-time information needed for operation of the terminals, notably return link capacity assignments and correction messages for timing, power and transmit frequency. The arrangement shown in *Figure 4* on the next page is also applicable to systems employing DVB-S2 in CCM mode. Aside from the above-mentioned differences in the SI tables (and the much better physical layer performance), there is no fundamental difference between the operation of DVB-S and DVB-S2/ CCM.

• **Systems Employing DVB-S2 with ACM** — In ACM mode, the encapsulator performs a number of functions in addition to what it does in CCM mode. *Figure 5* shows a conceptual block diagram of the IP encapsulator for ACM operation. The Company emphasizes that this is a conceptual diagram; there are many possible ways of implementing functionality equivalent to that described here.

◊ **Basic Function** — In the selected architecture, the traffic is distributed among a number of transport streams,

as opposed to the single transport stream used in CCM. The transport streams are quasi-statically configured; each corresponds to a particular protection level in the transmitted signal.

◊ **IP Encapsulator** — The IP Encapsulator device packages IP datagram packets on top of the MPEG packets that constitute the transport stream, using a protocol known as **MPE (Multi-Protocol Encapsulation)**. In non-ACM/VCM implementations, this is a conceptually straightforward process: The IP packets are segmented as necessary (because they are in general larger than MPEG packets), equipped with header information and error detection (CRC) necessary for the re-construction in the receiver and mapped to a particular **PID (Program Identifier)** within the transport stream. A PID can be seen as a destination address or as a logical sub-division of a transport stream. The packets are then sent out of the encapsulator as a transport stream. Practical IP encapsulators used in DVB-RCS systems include a multiplexing function near their output, in which the encapsulated traffic is multiplexed with DVB-RCS specific signaling. This signaling can include capacity assignments and control messages to terminals and is generated in the Return

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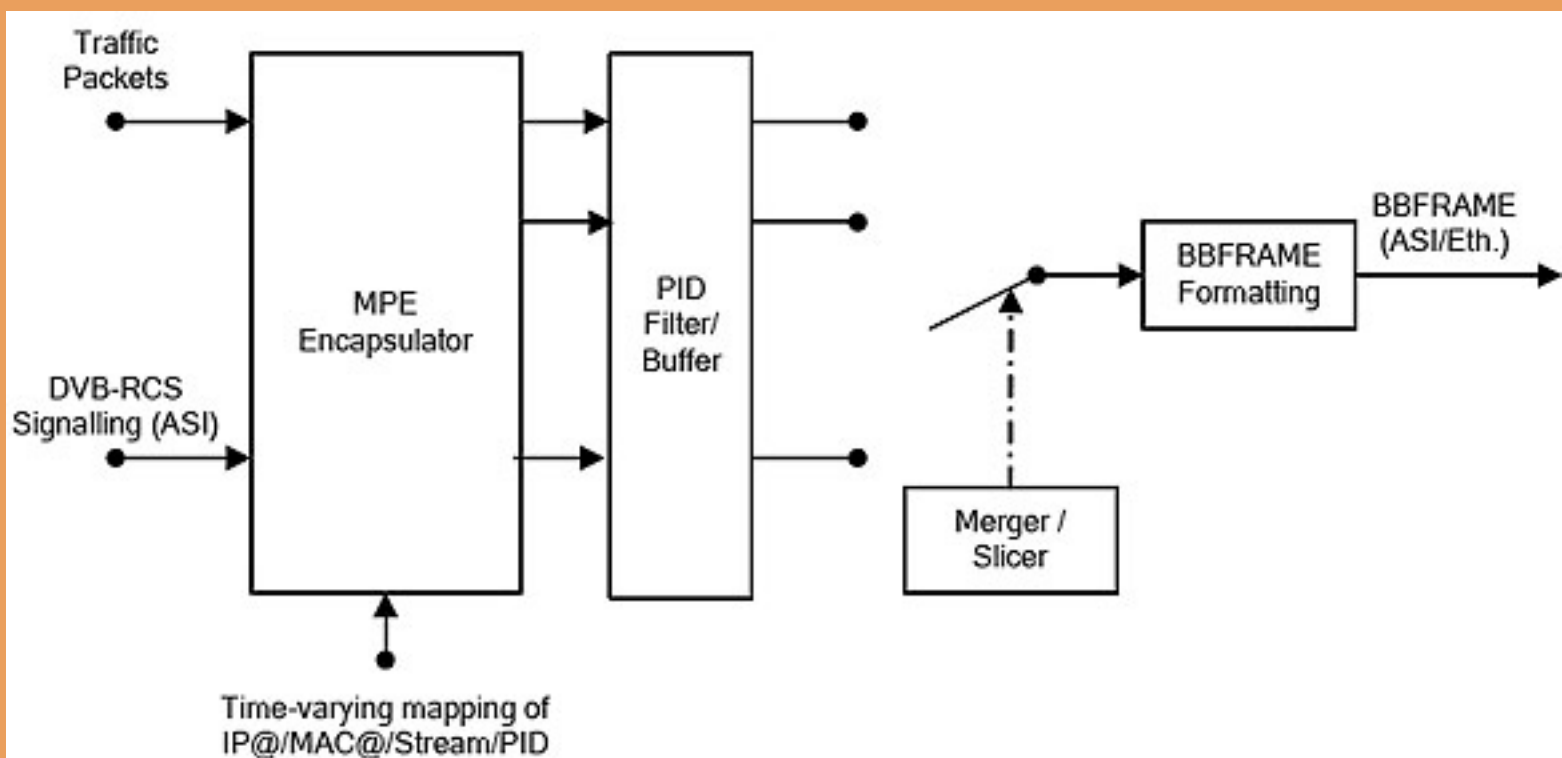


Figure 5: Gateway Architecture for DVB-S2 ACM Systems

Link Subsystem. It is delivered to the encapsulator as a transport stream. It makes sense to maintain this basic organisation for VCM/ACM operation, in order to enable the continued use of encapsulators designed for systems in which all transmitted information is handled in the same manner (*i.e.*, those using DVB-S or DVB-S2 in “CCM Mode”). There are however some small, but significant differences in the way this device is configured. All IP encapsulators offer the possibility of selecting the PID used for each IP flow. This selection is usually made on the basis of the IP destination address and/or the destination MAC address of the terminal. The IP encapsulator has a user-defined table that specifies this mapping. In SatNet’s architecture, the selection of the protection level (known as “**MODCOD**” in DVB-S2 parlance) to be used for each IP packet is done indirectly at this stage, by defining rules that map each supported MODCOD to a particular **PID2**. In other words, rather than an explicit mapping of terminals (IP addresses) to MODCOD’s, IP addresses are mapped to specific PID’s within the transport stream. The rationale for this method is that it allows the use of a conventional IP encapsulator, which is not aware of MODCOD’s.

All traffic to all terminals is still contained within one transport stream at the output from the IP encapsulator. As will be explained, these PID’s are used down-stream in the *Mode Adaptation Unit (MAU)* to get the data to the correct modulation and coding scheme. VCM is implemented by a static table in the encapsulator, which always maps data destined for a particular terminal to a particular PID. ACM is in principle implemented in the same fashion, except that the table is updated in real time when the MODCOD required for a particular terminal changes. DVB-RCS signaling is handled in the same manner as traffic. The source of the signaling information (the RLSS) is aware of the MODCOD/PID mapping and generates the signaling MPEG packets with the appropriate PID values for the MODCOD on which they will eventually be transmitted. A properly implemented IP encapsulator does not alter the order of the incoming IP packets. Some delay and delay variation is introduced, due to the necessary processing in the device and because the signaling is usually given priority over traffic in order to meet system timing constraints.

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❖ **Table Generation** — The generation of System Information (SI) tables is similar to that performed in the CCM IPE. Of course, those tables that are specific to a transport stream must be generated for each stream. The DVB-RCS specific tables common to some or all terminals need only be generated once, and can be quasi-statically mapped to and multiplexed into one particular transport stream. This will ordinarily be the one with the highest level of protection. As mentioned above, the format of some tables differ slightly between DVB-S and DVB-S2.

❖ **Mode Adaptation Unit** — The primary function of the *Mode Adaptation Unit* (MAU) is to re-organize the incoming packets into DVB-S2 frames and to deliver these to the modulator. The main functional elements of the MAU are shown in *Figure 5*. The MPEG packets contained in the transport stream delivered by the IP encapsulator are routed to a number of different buffers, based on the PID value. There is one buffer per supported MODCOD. A device known as the “merger/slicer” controls a switch which guides packets off the buffers and into a device which formats them into DVB-S2 frames; at this point known as Baseband Frames (BBFRAMEs). The BBFRAME formatting consists largely of adding a header. Complete BBFRAMEs are delivered to the modulator.

❖ **Data Rates** — Each of the generated transport streams can carry a data rate that is likely to be far in excess of what the eventual DVB-S2 carrier can support. Note that, due to the time-varying demand on the different protection levels, combined with the fact that there is no pre-determined make-up of the DVB-S2 carrier, the total capacity of the carrier will vary over time. This may have an impact on the services and, in a fully managed system, requires traffic shaping. Traffic shaping is a complex matter, which involve the Edge Router (and possibly other IP network components) intimately. The policy of the merger/slicer is a key point in the architectural considerations surrounding the mode adaptation; in particular because it can have a significant impact on the *Quality of Service*, in the form of packet re-ordering and excessive delay. Typically, the

algorithm used to select the MODCOD to serve for any particular frame is a form of a weighted round-robin scheme, which ensures that all MODCOD’s get served reasonably often, but gives priority to those with the highest traffic load. A fully optimized merger slicer needs to be aware of the Quality-of-Service attributes of individual packets. It is no trivial matter to make this information available to the merger/slicer algorithm. However, simpler (QoS-agnostic) algorithms can be used with only a modest impact on either quality of service or bandwidth utilization.

❖ **Other Considerations**

- **Multicasting:** The IPE can support multicasting. It is expected that, at least initially, all multicasting traffic will be carried in the most protected mode available.

- **Quality of Service:** Quality-of-Service provisioning in networks with a variable physical layer is a complex process, which has not yet been addressed in the context of interoperability between manufacturers. In any case, QoS aspects are outside the scope of this paper. We just notice here that one possible way of propagating QoS to the MAC/physical layers of DVB-S2 with multi-stream ACM is to arrange for the grouping of packets with different service requirements / priorities within each protection mode (similar to the classes of the service of the DiffServ model at IP level). Such an arrangement will tend to increase the number of streams that must be supported.

— **Modulator**

A modulator for DVB-S2 does more than the actual encoding and modulation. It must also create the framing structure and insert the corresponding physical-layer signaling in the stream.

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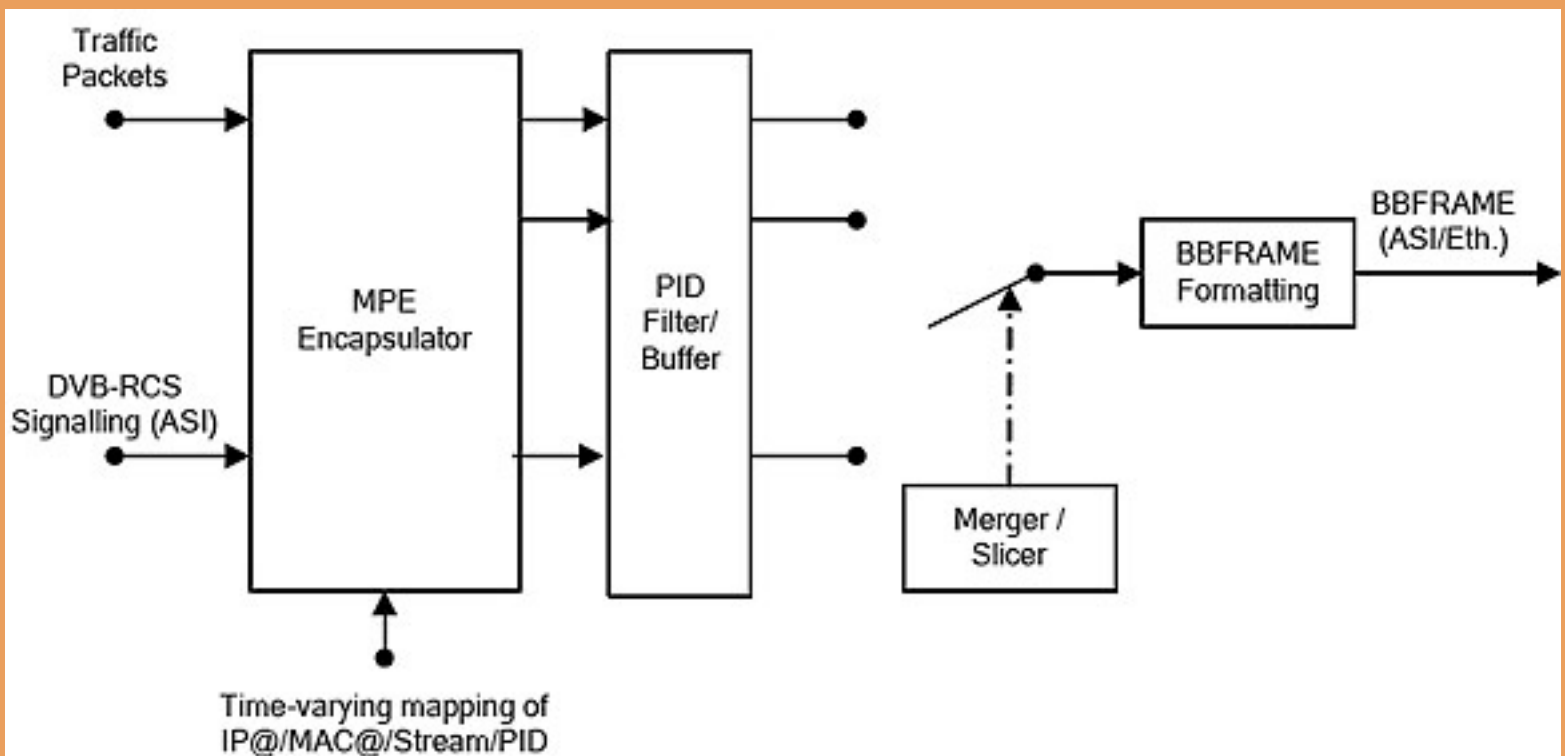


Figure 6: Functional Block Diagram of ACM Modulator

When operating with adaptive coding and modulation (ACM), the modulator must also perform certain timing functions that actually modify the transmitted data. Top-level block diagrams for the two versions of the modulator defined in this document are shown in *Figure 7* and *Figure 6*. The two versions are described in the sequel. The CCM functionality is a strict sub-set of the ACM functionality.

The descriptions are based on transmission of *MPEG-2 Transport Streams*. It is however noted that the operation may eventually be extended to cater for other types of input packets in so-called “generic streams”.

- **CCM Modulator** — This modulator performs a single, sequential chain of operations, see *Figure 7*. The input consists of an MPEG Transport Stream. If the input data rate is too low for the symbol rate, Null packets are inserted in the stream. If it is too high, packets are discarded, for example using a leaky-bucket policy. Aside from the differences in the actual modulation and coding schemes used, this modulator is functionally very similar to a DVB-S modulator. The “mode adaptation” and “stream adaptation” blocks serve to create DVB-S2 BBFRAME’s and FECFRAME’s from the input MPEG packet stream; these terms are defined in the DVB-S2 standard. Following that, channel encoding (FEC) is added,

channel symbols are created (QPSK, 8PSK etc.) and the physical-layer frames are completed by addition of physical layer headers and pilot symbols. The final stage of processing in the modulator consists of pulse shaping and up conversion to the desired intermediate frequency.

- **VCM/ACM Modulator** — The VCM/ACM modulator performs many of the same operations as the CCM version, plus some additional ones. The most fundamental difference is that the processing is not a simple, uni-directional sequence of operations. A typical block diagram of the VCM/ACM modulator is shown in *Figure 6*. VCM and ACM are practically equivalent in terms of modulator functionality. For brevity, we therefore refer to this device in the sequel simply as an ACM modulator. As described above, the generation and sequencing of baseband frames (BBFRAMES) is a non-trivial process in an ACM system. It involves considerations of data content properties above the physical layer, ideally all the way up to Quality-of-Service aspects. In most cases, the nature of this processing will therefore be at least somewhat dependent on the application. The initial version of the DVB-S2 standard nevertheless includes the mode adaptation function (generation of BBFRAME’s) inside the modulator. Many implementers have realized that this advanced and specific mode adaptation

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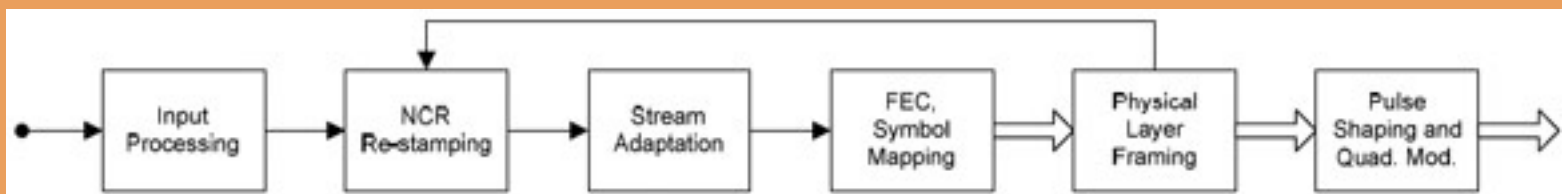


Figure 6: Functional Block Diagram of ACM Modulator

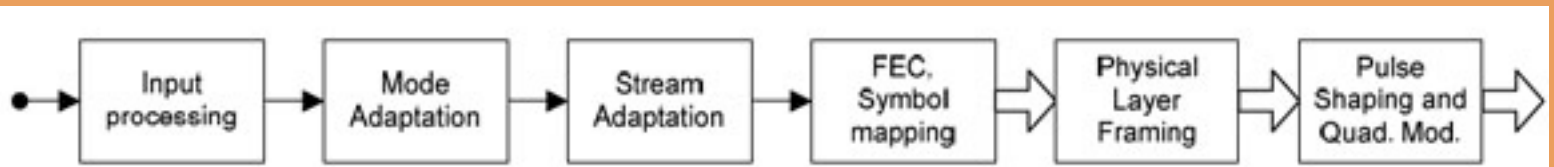


Figure 7: Functional Block Diagram of CCM Modulator

functionality is not in its natural home as an integral part of the modulator, which is generally seen as a generic, physical-layer device. An alternative architecture has therefore been adopted, in which the mode adaptation function is handled separately, so that the input to the modulator is a sequence of BBFRAME's, each tagged with the MODCOD to be applied to it³. The modulator's job is then reduced to transmitting the sequence of BBFRAME's in the order they arrive. The processing proper in the ACM modulator therefore starts with the stream adaptation; i.e., the creation of FECFRAME's. The rest of the processing follows essentially the same sequence as in a CCM modulator. If the rate of arrival of BBFRAME's is lower than that supported by the carrier, the modulator generates "dummy" frames. If the frame rate is too high over an extended period of time, the modulator has no choice but to drop frames. This is approximately equivalent to the null packet insertion and packet dropping performed in the CCM modulator. Because of the asynchronous nature of the up-stream processing, in particular the buffering and selection operations of the mode adaptation function, the method adopted for distribution of timing information (Network Clock Reference packets) in ACM

systems is different from that used for DVB-S and DVB-S2 CCM. In ACM, the timing is related to the transmission time of the physical layer DVB-S2 frame header. It is therefore in practice necessary to insert ("stamp") the timing reference values inside the modulator. This stamping is done before the stream adaptation, but based on time values only obtained downstream. This is illustrated by the feed-back connection shown in *Figure 6*. The remaining functions of the ACM modulator are equivalent to their CCM counterparts.

Depending on equipment design, it is of course possible to locate the mode adaptation function within the same physical enclosure as the modulator; for example as an optional circuit board.

Return Link Subsystem

As mentioned above, the detection functions for forward link adaptivity (*Rain Fade Countermeasures*, **RFCM**) are implemented in the RLSS. This will complement the already existing support for RFCM on the return link. The goal is to provide a full integration of both Forward Link and Return Link Adaptive Coding and



Figure 8. SIT Appearance (Featuring Series 5000 IDU)

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Modulation (ACM) in the RLSS. This integration consists of the addition of forward link measurements to the RFCM detection algorithm, and the addition of RFCM modes to the Control of the terminal. Finally, this includes the interface to the IP Encapsulator and the adjustments required to the signaling to cover forward link protection modes. In the forward link, decisions about appropriate protection are based mainly on the E_s/N_0 and/or required protection level reported by the terminal. A mode switch decision generates a routing command to the encapsulator. The forward Link E_s/N_0 is reported by the terminal.

User Terminal

The *Satellite Interactive Terminal (SIT)* is used as part of a DVB-RCS network to exchange traffic data and signaling information with a centralized Hub. There are two transmission paths; the Forward Channel from a central Hub to the user terminal, and a Return Channel from the user terminal to the central Hub. The terminal is composed of two main elements, an *Indoor Unit (IDU)*, and an *Outdoor Unit (ODU)*. The **Series 5000** IDU from Advantech Wireless is shown in *Figure 8*; the Series 5000 IDU features CCM/, VCM and ACM functionality. Refer to *Figure 8* for the **Series 4000** IDU which has CCM only functionality. The Host PC is also not considered to be part of the terminal; it is assumed to be part of the user's equipment.

The main features required in the terminal for support of DVB-S2 are the following:

- DVB-S2 receiver with an L-band input interface and a baseband digital output interface consisting of demultiplexed streams and a control interface
- Handling of re-assembly of IP packets from multiple logical streams
- Operation with the adopted DVB-S2/DVB-RCS timing distribution method
- Signaling of forward link E_s/N_0 and supported modulation/coding combination in the SYNC burst
- Extension of SNMP operation to cover ACM-related configuration parameters

Acknowledgements

Thanks go to the Canadian Space Agency and Telesat for their participation and support on Canadian R&D programs developing and demonstrating a DVB-RCS system featuring DVB-S2 capabilities.

Reference

- [1] ETSI EN 301 790, v1.4.1, "Digital Video Broadcasting (DVB): Interaction Channel for Satellite distribution Systems"
- [2] ETSI TR 101 790, V1.2.1, "Digital Video Broadcasting (DVB): Guidelines for the use of EN 301 790"
- [3] ETSI EN 302 307, v1.1.2, "Digital Video Broadcasting (DVB): Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications"

Author contacts...

* Mark Lambert



Achieving Major Sat Status — Spacecom's AMOS Fleet

by Hadass Geyfman

After successfully breaking into the playground of the commercial satellite giants, with *AMOS-1*, -2 and -3, the Israeli satellite industry is now moving forward with new satellites, more innovations and new target markets.

Israel's first observation satellite, launched in 1988, and their first commercial communication satellite, *AMOS-1*, was launched in 1996. They served as the ticket to the prestigious group of countries that build satellites that included the U.S., Russia, France, India, China, Japan, and most recently, Iran.

The soon-to-be launched *AMOS-5*, will position the Israeli satellite operator **Spacecom** as a multi-regional player. It will be followed by *AMOS-4*, scheduled to be launched next year, and *AMOS-6* which will replace *AMOS-2* in 2014. Both are expected to expand the range of Spacecom's various offerings and markets.

Israel Aerospace Industry (IAI), which planned, developed, designed, and built the first three of the AMOS satellite fleet, is now in the integration stage of *AMOS-4*, which will cover East Asia, the Middle East and a large part of Africa. *AMOS-4* will enable Spacecom to achieve a breakthrough with unique services, innovative concepts, new features and unprecedented capabilities that, in addition to other elements, will contribute to America's defense and security.

AMOS-6, scheduled for a launch in 2014 to its orbital spot at **4 degrees West** (to replace *AMOS-2*), will cover Central and East Europe and the Middle East. Spacecom is readying the *AMOS-6* satellite for pan-European coverage, Ka- broadband and additional capacity for the Middle East. One of the most prominent services that will be provided by *AMOS-6* is broadband Internet via small Ka-band beams. Many regions around the world, including some

parts of Europe, lack terrestrial broadband Internet. Satellites can provide an efficient solution to broadband Internet with Ka-band.

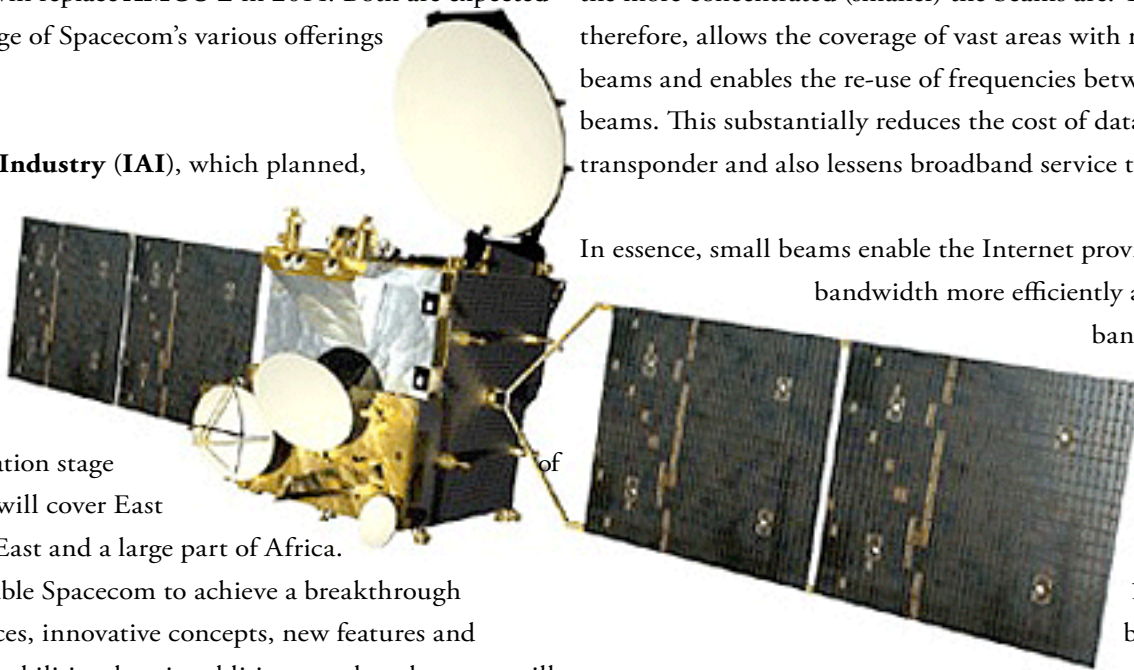
AMOS-6 would provide its Internet services via many small Ka-band beams, as each beam covers a city or a district. Ka-band can provide service through many small beams that are inherent, because of its high frequency, relative to Ku- and C-bands (that are being used in common commercial satellites). For a given antenna and specific level of performance, the higher the frequency, the more concentrated (smaller) the beams are. The Ka-band, therefore, allows the coverage of vast areas with many small beams and enables the re-use of frequencies between non-adjacent beams. This substantially reduces the cost of data throughput per transponder and also lessens broadband service through satellites.

In essence, small beams enable the Internet provider to allocate its bandwidth more efficiently and provide high

bandwidth Internet to all users in different areas without overloading the network. In fact, 10 to 20 small beams, or even several dozen small

beams, are expected to become the future of broadband Internet by satellite.

Another advantage of Ka-band for Internet services is its high bandwidth. It is a low cost/free frequency that is also susceptible to weather conditions, — transmission disruption can occur even with the lightest of rain. While TV broadcast is highly sensitive to any disruption (and not ideal to be transmitted over Ka-band), the Internet is more tenable.



The Ka-3's third advantage (for Internet transmission) is that it requires very small antennas at the customers' homes. Transmission via the Ka-band can be received by antennas with diameters of 8 to 12 inches.

While AMOS-6 is scheduled for a launch in 2014, AMOS-5 is scheduled to be launched in the coming months to its orbital spot at **17 degrees East**. This launch, from the **Baikonur Cosmodrome** in Kazakhstan, will be conducted by the Russian company **ISS Reshetnev**, which also built the satellite.

AMOS-5 will be launched directly into *geostationary orbit* (**GEO**), using the same method that launched AMOS-3 in 2008. This Russian method of direct launch is significantly different than launching satellites into the **GTO** (*GEO Transfer Orbit*), after which the satellites are transferred to GEO orbit. The direct launch to GEO orbit allows the satellite to be smaller and more economical to build and operate. Plus, it significantly extends the satellite's lifespan. In addition, solving malfunctions relating to its initial orbit position can be accomplished, if needed, more efficiently.

Satellites launched directly to the GEO don't need to be equipped with a propulsion system to push them to the final orbit. With fewer and smaller fuel tanks than satellites launched to the GTO, the direct launched satellites can add more room for transponders, antennas, and for larger solar panels. This means more bandwidth, covered areas, and energy for the beams. Moreover, the launch to GTO requires more ground support equipment, more tests and trials, and more procedures than satellites launched directly to GEO.

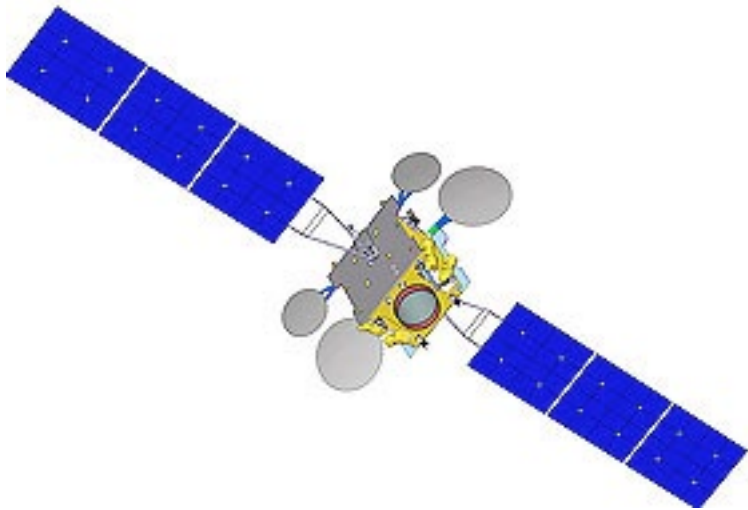
"AMOS-5's fixed pan-African C-band beam and three steerable Ku-band beams will cover Africa with connectivity to Europe and the Middle East," said *Gil Ilany*, Spacecom's VP of Marketing. "AMOS-5's 14x72 MHz and 4x36 MHz C-band transponders, coupled with 18x72 MHz Ku-transponders, will position Spacecom as a source of capacity for a variety of African and African-related businesses, including telcos, cellular operators, broadcasters and others. AMOS-5 is debuting into these markets at an opportune time, as operators from around the world are expanding into the region."



Photo: The Amos-3 launch
Image on the previous page: The Amos-3

The African market is extremely rural in many areas, making satellite technology the optimal, most reliable, and least expensive method, to reach clients in far-flung villages and towns. In fact, revenues from transponder leasing in Africa and Asia are currently stronger than ever. This industry's most important drivers — VSAT, DTH television, broadband Internet and intercontinental video transmissions — enjoys strong growth and service demands. Communication operators, TV and Internet providers, and enterprises using VSAT, in these regions, are depending on satellites as a vital service to their success.

AMOS-5's position (at **17 degrees East**) enables its beams to reach everywhere in Africa, including islands such as Mauritius and Madagascar. The steerable antennas enable the beams to reach the Middle East as well as all European regions. The Pan-African



Artistic rendition of AMOS-5 satellite

C-band antenna will cover the entire continent, from north to south and west to east. The same C-band beam, also covers southern Europe as well as the Middle East through the Persian Gulf region.

The three steerable beams can each reach a specific population or provide language needs. Antenna Ku-1 provides the French language beam, reaching from Senegal and Guinea on the West Coast, to Nigeria and Cameroon to Mozambique and Madagascar on the East Coast. In Europe the beam reaches France as well as Lebanon in the Middle East.

The Ku-2 antenna (the Southern beam) covers South Africa, Namibia and Zimbabwe in the south, to Zaire and the Congo in the center of Africa; plus western and southern Europe, as well as other parts of the Mediterranean Basin.

The last steerable antenna, Ku-3, covers a wide swath at the center of the continent reaching Nigeria and Cameroon in the west to South Sudan, Chad and Uganda in the center, to Kenya, Tanzania, Ethiopia, and Eritrea in the east.

AMOS-5's beams also connect Europe to Africa. The C-band beam reaches from Turkey in the west to southern Spain and France in the East. In the north, the beam hits all of the United Kingdom as well as Denmark, Germany and Poland.

The fact that AMOS-5 will provide coverage between Africa and most of continental Europe means that Earth stations (teleports) from the U.K., Denmark, Germany, Hungary, Greece and other countries, can send and receive signals to, and from, the satellite, which then sends them directly to Africa. From the Middle East, stations as far as Iraq and Saudia Arabia, as well as those closer to the Mediterranean Sea, are able to work with the satellite. Technically, the C-band is a better option for providers in these countries, as C-band is not affected by adverse weather conditions.

However, communication providers in Europe, looking to reach specific areas in Africa, can use the Ku-bands' beams. French speaking Africa can use Ku-1 from France, Austria, Germany, Italy and even Norway, for telecom, broadcast or data transmissions. The Ku-2 beam enables collaborations between European and southern African projects. The Ku-3 beam reaches the Middle East and parts of Europe, particularly France, Germany and Italy, and in Africa its focus is Central and Western Africa.

“AMOS-5 will provide telecom and cellular backhaul, VSAT, broadcast, broadband and data communications,” said *Ilany*. “The African market is growing and service expansion is an important part of this, as well as the introduction of new services over time. Africa includes rural areas, urban, cities and villages, and each has different needs. We have already pre-sold capacity on the satellite to a number of communication providers and teleports that will anchor our operations over the continent.”

Both AMOS-5 and AMOS-4 use shaped (designed) beams (instead of the usual round-shaped beam). These beams are designed in a way that enables each beam to cover only the areas where the service is provided, — they do not waste energy on areas where Spacecom is not providing service. This method saves resources and enables maximum use of the beam and its energy.

To achieve this designed beam, the antenna's reflector is being curved in some places to create concaves and arches that create a beam that reaches only the targeted areas.

Scheduled to be launched in 2012 to its orbital spot at **65 degrees East** (over the Indian ocean region), AMOS-4 will further expand Spacecom's coverage. It will cover several regions; from central Africa to the Philippines and India (without Japan). This includes South East Asia, the entire Middle East from Israel in the west to Pakistan and Afghanistan in the east, and East and South Africa.

"AMOS-4 is one of the most advanced satellites of its kind in the world," says *Giora Eyrar*, project manager of the AMOS-4 satellite in the *Space Division* of Israel Aerospace Industry's *Systems Missiles and Space Group*. "It has 10 antennas, which, in terms of commercial satellites, is unprecedented. All of the antennas are steerable automatically. One of them is a multi-beam antenna (MBA), and two of the others are dual band, wideband antennas, which can transmit and receive communication at two frequencies.

"AMOS-4 is highly cost-effective for the optimal platform, which allows more width for the payload or, alternatively, more fuel, either of which improves the return on the investment. The satellite also has redundancy subsystems to ensure high quality and continual service for its lifespan. We have integrated into the AMOS-4 a unique, systematic, solution that meets the challenge of continuity and stability of beam coverage during orbit, the MBA antenna, which includes innovative elements in both the ground station and the satellite itself. The payload allows for immediate, effective, management of wideband antennas via the ground control station and according to customers' varying needs. The greater flexibility that comes with operating the satellite's payload provides the customer with important marketing advantages."

AMOS-4's Middle East coverage is among others designated for the U.S. Government. All communications between the Pentagon and the troops in the Middle East is transmitted through the U.S. Army's missions' center in central Europe. Due to lack of fiber between Europe and the Middle East, the U.S. Army is leasing capacity in commercial communication satellites.



Artistic rendition of the AMOS-4 satellite

AMOS-4 will provide additional coverage of central Europe and will be able to connect the missions' center with every spot in the Middle East. Furthermore, as the U.S. Army is currently the primary operator of the Ka- band (and sometimes uses the Ku-band for backup), AMOS-4's Ka-beams and Ku-beams will accommodate their needs. In essence, AMOS-4's Ka-band, in conjunction with its coverage of the entire Middle East, and the additional coverage of central Europe, are important advantages for the needs of the U.S. Army.

In example this combination of features, the Pentagon will be able to transmit orders (via the satellite) to an UAV (an Unmanned Aerial Vehicle), to take off and film a specific area over Iran, Iraq, Afghanistan and other locales, with the footage then transmitted to the Pentagon as a live broadcast, as well as to the commanders on the ground. Every squad can be equipped with a small satellite-terminal.

In addition to AMOS-4's advanced technology, it includes some conceptual innovations. One of them is a feature that will enable governments, enterprises, telcos, cellular providers and others, to lease capacity and independently operate and manage the system, as if they were the owners of the satellites. For each such customer, Spacecom would allocate capacity in the satellite and would set up a control center at the customer's site. This would allow countries that don't have their own satellite, as well as large enterprises and communication operators, to enjoy the benefits of their own satellite, while saving the costs of developments and maintenance.

Focus

“The systemization of the ground segment, allows an automatic command and control of the satellite, as well as the operation of an architecturally multi-layered payload, which, in turn, allows the allocation of resources and automatic control for every customer that the payload covers,” *Eyran* explained. “Each customer can independently plan its missions, and privately control its resources from its own control station. Every antenna is steerable to the relevant service area, as determined by the customer, which lets it tilt accordingly, providing the maximum coverage and operations.

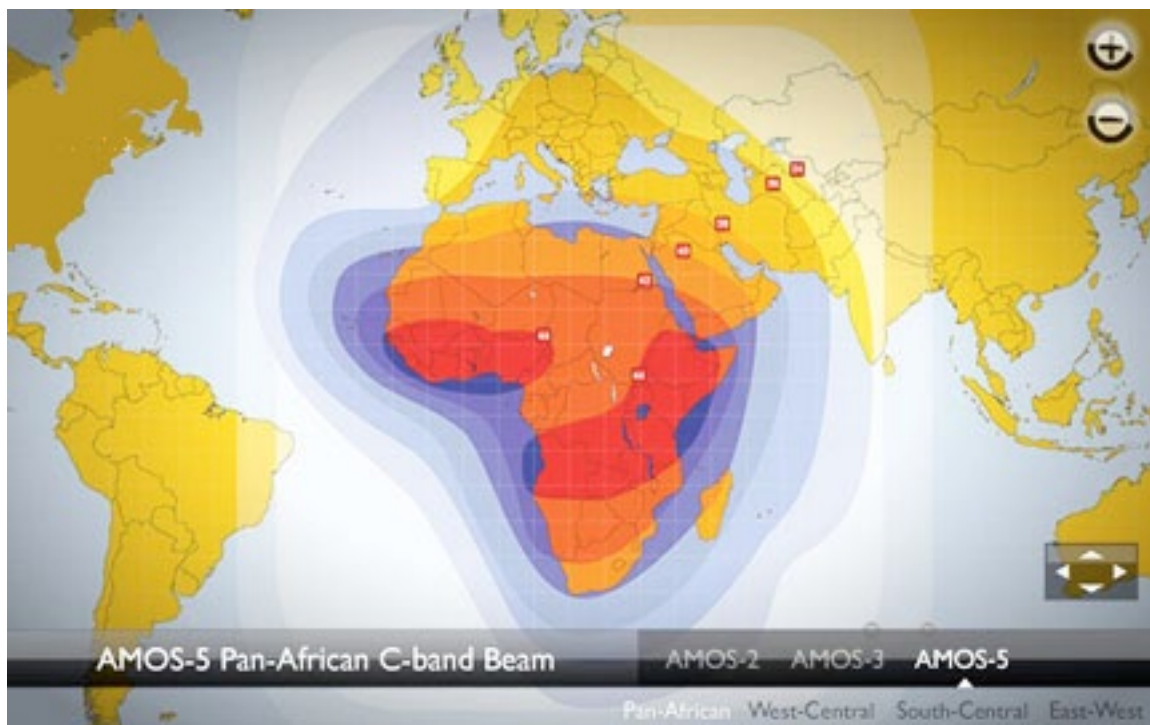
“In addition to managing resources from the ground control station,” said *Eyran*, “the customer can monitor the services, solving any potential problems more rapidly than ever before, and ensuring continuous high-quality service.”

The growing need for on-demand content on various devices, the 3D technology that is already around the corner, and the outspread demands for broadband Internet via satellite, as well as the increasing communication needs of enterprises, communication operators, and governments, are positioning satellites as an attractive solution, particularly in emerging markets. Furthermore, due to costs and issues of technical service to fiber, satellites provide an efficient solution for reaching rural areas and the large swaths of non-urban areas in Africa and Asia.

The AMOS satellite fleet is positioned to provide coverage over many of the world’s fastest growing and highest-demand satellite markets.

About the author

Hadass Geyfman has been a journalist for 18 years, covering technology and technology innovations, business/finance/capital market, telecom and other topics - features, news and news analyses. She currently freelances, writing articles on a range of subjects for trade and consumer magazines, as well as writing corporate white papers and marketing articles. Prior to that she was the Middle East editor at the U.S. technology magazine “VON magazine”, following on from a position as senior finance and technology reporter for the financial newspaper “Globes”. Before that she was Editor In Chief of “Electronica” magazine, covering future technologies in all fields of electronics. Contact her at hadass.geyfman@gmail.com



AMOS-5 Satellite Coverage Map