Worldwide Satellite Magazine *October 2011*

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SatMagazine
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ILS launch of the DIRECTV 12 satellite
Photo courtesy of ILS

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ATLANTICB BIRD™ 7 Sea Launch lift-off

ILS Launch of Proton launch vehicle

Executive Spotlight

Frank McKenna, President, International Launch Services (ILS)

Frank McKenna became the President of International Launch Services (ILS) and board member in October of 2006, following two years as Vice President and Deputy of ILS. Additionally, in August of 2008, McKenna became the co-chairman of the Board of Directors of ILS. McKenna has more than three decades of experience in the aerospace and space launch businesses with Martin Marietta and Lockheed Martin Corporation, which was a partner in ILS until October of 2006. McKenna's background includes business management, business development and strategy, several CFO positions, and management of domestic and international joint ventures.

During the first year of McKenna's leadership, ILS won more than $1.2 billion in new orders serving customers across the globe. In August of 2007, the industry publication *Space News* honored McKenna as one of "*10 Who Made a Difference in Space*." After establishing a significant quality initiative, by August of 2008, ILS' backlog reached 24 *Proton* launches valued at more than $2 billion — a record high. In March of 2009, ILS celebrated a significant milestone — the 50th ILS Proton launch. In October of 2010, ILS and Khrunichev set the industry standard with 26 consecutive successful launches in 27 months — 18 commercial missions and nine Federal missions.

Proton being prepped for launch at the Baikonour Cosmodrome Photo is courtesy of ILS

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Executive Spotlight

ILS, a U.S. company with headquarters in Reston, Viginia, near Washington D.C., is a global provider of commercial launch services for satellite operators worldwide, and offers a complete array of services and support from contract signing through mission management and on-orbit delivery. The Company has exclusive rights to market the Proton and Angara vehicles, and has launched most commercial satellite platforms. ILS has worked with all major global satellite operators.

Khrunichev State Research and Production Space Center, which holds the majority interest in ILS, is one of the cornerstones of the Russian space industry and manufactures the Proton system and is currently developing the next generation Angara launch system. The Proton launches from facilities at the Baikonur Cosmodrome in Kazakhstan and has a history of more than 360 missions since 1965.

SatMagazine (SM)
Mr. McKenna, would tell us about your background leading up to your current role as president of ILS?

Frank McKenna
Prior to joining ILS in 2004, all of my career was in the U.S. aerospace and defense industry. I worked with Martin Marietta and Lockheed Martin Corporation (LMC), which was a partner in ILS until October 2006. For Martin Marietta and LMC, I held CFO positions, oversaw business development and strategy and managed domestic and international joint ventures. It has really been a great experience taking this background, combined with a talented management team at ILS and Khrunichev, to create a world-class commercial launch company.

Proton being moved to the launch pad at Baikonour, photo courtesy of ILS

SM
What are your thoughts on the launch market, given the predicted decline in satellite orders? How do you think new entrants or reentrants will fare in this environment?

Frank McKenna
We believe that the rationalization of the commercial launch industry has been very obvious and inevitable, driven by market forces for years. We have predicted and have been preparing for the decline in satellite orders to less than 20 per year for the GTO market by the end of this year. This dynamic does not fare well for new entrants or those who plan to reenter the market.

We believe that GTO satellite orders will remain low for the next few years, as replacement cycles for the FSS market have largely been met. ILS has built a solid financial and operational foundation with a robust business model to weather the storm and succeed.

Considering that peak demand has been satisfied by the two main launch providers over the last few years, creating additional supply in the commercial launch heavy lift market during a lull in demand will be detrimental to the market in the long term. Oversupply in the commercial launch market led to instability in the last decade resulting in rationalization by shareholders and market forces that drove other suppliers such as the ***Atlas*** and ***Delta*** vehicles to primarily serve a more profitable launch sector — the U.S. Government. **Sea Launch** and **SpaceX** entering the market now will inevitably result in a similar shake out. The two main commercial launch providers, **ILS** and **Arianespace**, have been more than able to supply 20 or more commercial satellite launches per year, which will be well in excess of demand for the next several years.

SM
How does a multinational company, such as ILS, manage to compete against other heavyweights in the industry to garner launch contracts? What sets ILS apart from other commercial launch services providers?

Frank McKenna
ILS competes and wins business based upon a total value proposition. There were some skeptics when we became a separate entity in 2006, spun off from **Lockheed Martin**, but we have spent the last five years building a formidable competitive global capability. So far this year, we have won seven new ILS ***Proton*** launch orders. Any competitor that comes up against us gets a fair, well fought competition — and they can attest to that. As for heavyweights, our parent company, **Khrunichev**, is a heavyweight, by any standard, as a primary supplier to the Russian Federal space program. It is crucial to have a substantial government business as a second leg to lean on, especially taking into consideration the forecasted low commercial market. What sets ILS apart are several different factors; the strong heritage and performance of the dedicated Proton vehicle, the flexibility of the Proton system to launch to customized orbits, and unmatched schedule assurance to meet customers' needs at fair value. All of those benefits, combined with a solid, sustainable business model with the ILS and Khrunichev partnership, is the total value package we offer.

SM
What was the result of the Russian State Commission investigation and inquiry made by ILS? And how does a company encourage its professional core of contributors to remain positive after an event such as anomaly with the Russian Federal Proton launch of the Express-AM 4?

Frank McKenna
The **Inter-Agency Commission** issued a statement on August 30th regarding their review of the failure of the Russian Federal Proton mission with the ***Express-AM 4*** satellite on August 18. The statement noted that the off-nominal orbital injection of the Express AM4 satellite was caused by the improper programming of "time interval to manipulate the gyro platform". This resulted in an off-nominal orientation of the ***Breeze M*** and injection of the spacecraft into an unintended orbit. All other Breeze M systems performed within specifications. According to the report, all other Breeze M systems performed nominally. ILS conducted its own *Failure Review Oversight Board* (**FROB**) on September 8 and 9 to review the detailed results of the Russian

Angara 1.1 Mockup (ILS) Vehicle

IAC investigation. ILS circulated the FROB's findings in mid-September.

The teams of dedicated professionals at ILS and Khrunichev want nothing more than a successful launch for all of our customers. When an anomaly of any nature occurs in our business, the ultimate goal of ILS and Khrunichev is to find out the cause of the failure, determine what corrective actions need to be implemented, and put measures in place to ensure that such issues will not occur on future missions. Our focus is on our customers and our performance. We are extremely grateful to our customers for all of the support we received throughout this timeframe and during our efforts to properly and safely return to flight.

SM
What does the rest of 2011 look like for ILS in terms of launches, given the Russian Federal Proton Mission on August 18th with the Express-AM 4 satellite, which resulted in an anomaly?

Frank McKenna
After the Inter-Agency Commission concluded its investigation of the Express-AM4 anomaly and determined that Proton was cleared for flight, we proceeded to work with our customer, **SES**, to determine a new launch date for ***QuetzSat-1,*** which is now the end of September. This is just two and a half weeks after the original launch date of September 12. There will be a Federal Proton mission prior to the ILS Proton launch of QuetzSat-1, with ***ViaSat-1*** for **ViaSat** to follow.

In total, we plan to conduct four ILS Proton commercial missions before the end of the year, along with three Federal Proton missions managed by Khrunichev.

SM
How can ILS accommodate such a busy schedule and manifest?

Frank McKenna
ILS and KhSC have proactively planned ahead to accommodate a rapid launch pace by maximizing production in the factory and building new facilities. The *Second Spacecraft Processing Facility* (**SSPF**) that was recently brought into service at the launch site allows overlapping campaigns, minimizing the required spacing between commercial launches from five to six weeks to three weeks. This facility allows ILS to accommodate our customers' spacecraft schedules when, as is the case this year, spacecraft deliveries are delayed or clustered within a short period of time. ILS/Proton continues to provide the best schedule assurance in the industry and the addition of the SSPF in Baikonur increases our ability to provide on-time launches for our customers.

SM
How are relations between Russian and Kazakhstan with respect to the launch site in Baikonur?

Frank McKenna
Relations between the two countries are strong and the partnership, with respect to the use of the Baikonur Cosmodrome, is on solid ground. In fact, immediately after the ILS Proton launch of the ***SES-3*** satellite for SES and the ***Kazsat-2*** satellite for the Republic of Kazakhstan in July, the heads of the two space agencies, **Roscosmos** and the **KazCosmos**, met to discuss launch site improvements at the Cosmodrome as well as future cooperation in advancements in space.

According to *Vladimir Popovkin*, in a recent statement to the press, the Baikonur Cosmodrome, which is under a long-term lease to Russia until 2050, will continue to be in full use for many decades to come as "the busiest launch site in the world".

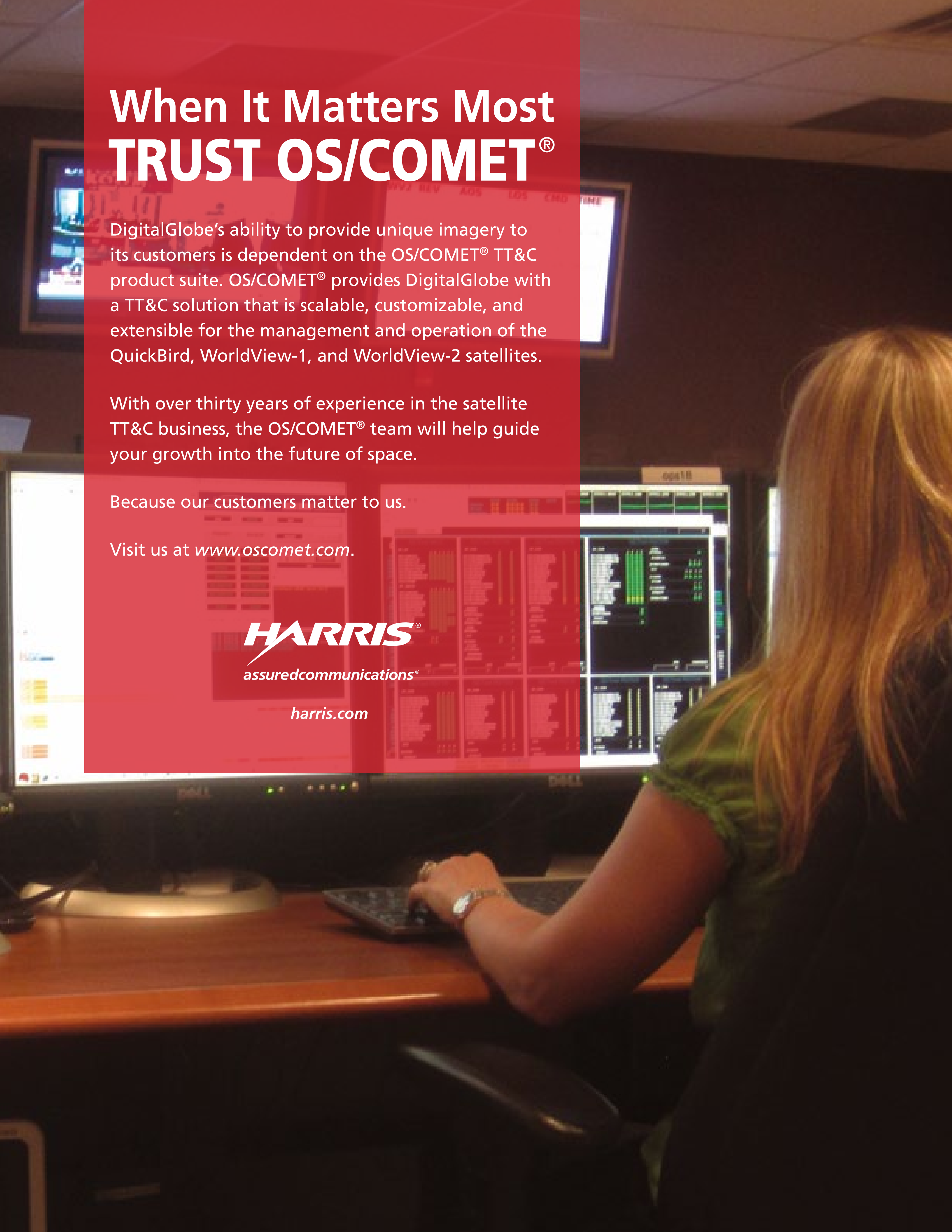
SM
Can you tell us about the next-gen Angara launch vehicle? Its capabilities? Milestones toward actual use?

Frank McKenna
The ***Angara*** launch system will initially support federal missions with first flight test anticipated in late 2013 or early 2014 on an Angara 1.2 vehicle. ILS is offering a commercial payload opportunity for the second launch of Angara family of launch vehicles using the heavy ***Angara 5***. The idea is to provide our commercial customers and the insurance community an early view of the Angara system. However this opportunity is a unique one, as we would consider commercial use of Angara only after it becomes fully flight-proven on Russian federal missions.

With 97 percent of the independent tests, as well as the comprehensive tests of the rocket's assemblies and bays now complete, the Angara system is on a steady development path. Angara engines will use an environmentally friendly liquid oxygen-kerosene mixture and the family of vehicles will have lightweight, medium, and heavy lift variants. The first stage of the Angara system has flown 100 percent successfully during the first two missions of KSLV in 2009 and 2010. The Russian Federation and Khrunichev are fully committed to the development and fielding of the Angara system as the next generation family of launch vehicles.

SM
Do you observe progress being made in the attempts by commercial launch companies to attract military and government payloads, as Hosted Payloads become more viable? Does ILS have plans in this area?

Frank McKenna
ILS is the leader in commercial launch for shared and hosted payloads. ILS has launched and we are contracted to launch several satellites with hosted payloads. We launched ***Anik F1R*** in 2005 for **Telesat**, which has a *Wide Area Augmentation System* (**WAAS**) payload for the **FAA**. Currently under contract we have ***Intelsat 22*** for **Intelsat**, which has a UHF payload for Australian and U.S. defense forces, ***Anik G1*** for Telesat with an X-band payload for **Paradigm**, ***Sirius 5*** for **SES** with a *European Geostationary Navigation Overlay Service* (**EGNOS**) application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for the **European Space Agency** (**ESA**) and ***Yahsat 1B***, which will have a dual use payload for **United Arab Emirates** (UAE) **Air Force**.

We expect there will be more opportunities for the commercial launch sector with hosted payloads for military, commercial and civil use, considering the economic and schedule advantages this has for governments and the financial challenges and constraints that exist in support of global space programs. The more that commercial satellite operators augment their business plan with hosted payloads, the more common it will become in the commercial launch market.

ILS Proton is ideally suited for satellites that include hosted payloads. With a dedicated, heavy-lift launch system, ILS Proton offers optimal performance and on-time delivery to orbit. We can offer an economical solution to governments who need to deploy their programs at a lower cost to orbit than if they built their own satellite.

SM
Where do you see the launch industry, in general, over the next year or two? Will there be more consolidation of various companies?

Frank McKenna
Consolidation is not likely, considering the strategic nature of launch vehicles in most countries. However, we do expect a shakeout of the commercial launch industry over the next several years as new entrants and reentrants to the market will be appearing at the same time as a decrease in demand for commercial launches. This follows the basics dynamics of market rationalization that occurred in the previous decade.

SM
When you look back over your career at ILS, what, in your opinion, has been the most significant achievement of the company during your tenure?

Frank McKenna
I would say more good fortune rather than an achievement for me, to be exposed to, and learn from, the talented people at ILS and Khrunichev to create a formidable force in the commercial heavy lift market. We have, together, secured more than $2 billion of business in our first year as a new entity in 2007, increased production and quality to launch a record eight commercial missions on a regular basis, sustained backlog of over 20 missions for the past four years, and have also created significant value for our heritage customers and new customers. This has fostered a streamlined and customer-focused partnership with Khrunichev to serve the global commercial launch market for many years to come.

For additional information regarding ILS, please visit their website at:
http://www.ilslaunch.com

Proton vehicle production in the Khrunichev factory — as many as 14 systems are produced annually.

International Launch Services 2011 Mid-Year Report

The continued support of our customers during a dynamic first half of the year in commercial launch has been absolutely essential for our success. The ILS Proton manifest, as with all launch providers, is dependent on the timely delivery of our contracted missions. This year, the first three commercial launches in our manifest were delayed due to satellite deliveries and after our first ILS Proton launch, there were further shifts in the launch schedule due to satellite in-orbit anomalies and technical issues. However, ILS was able to minimize the impact of these delays on our downstream missions due to several factors: The robust production in the Proton factory, responsiveness of the ILS mission teams, and the new facilities that have been put in place at the launch site to accommodate overlapping campaigns. We appreciate the patience and support of our customers.

Artistic rendition of the Telstar 14R satellite

Our first mission of the year was for **Telesat**, with a successful launch on May 21, with the ***Telstar 14R/ Estrela du Sol 2*** satellite. ILS was able to accelerate this mission for Telesat due to the delayed delivery of other satellites that were scheduled to launch earlier in the year. Unfortunately, the satellite suffered a deployment anomaly after separation, and the resulting review process delayed deliveries of Space System/ Loral spacecraft on our manifest. ILS Proton performed successfully on the mission and was exonerated during the anomaly review and cleared for future missions.

On July 16, ILS Proton launched the second mission for the year with a commercial first; a shared mission with the ***SES-3*** satellite for SES and the ***KazSat-2*** satellite to serve the Republic of Kazakhstan. SES-3 was the first Western satellite to be paired for launch with a Russian-built satellite. The SES-3 satellite was placed into geostationary transfer orbit, while the KazSat-2 satellite, built and managed by Khrunichev, was injected directly into geosynchronous orbit. This dual launch option was not previously available in the commercial market — and ILS was honored to have provided this attractive launch opportunity to our longtime customer, SES.

The successful launch of the SES-3 satellite for SES, with the KazSat-2 satellite, in July of 2011 — the first shared launch on an ILS Proton.

KazSat-2 satellite

In addition to the shared launch option, ILS also offers the ILS Duo capability, designed in direct response to satellite operators' demand for a lower cost solution for the delivering smaller spacecraft to orbit. The ***ILS Proton Duo*** capability is currently being marketing in conjunction with **Orbital Sciences Corporation** with two Orbital satellites stacked on a heavy lift Proton. Proton has a proven track record of launching multiple spacecraft to different orbits successfully (with the **Iridium**, **Glonass**, **Express**, **Cosmos** and **Raduga** spacecraft), and most recently, as a commercial first with the shared launch of SES-3 and KazSat-2 last month.

Strong Partners in Space: Russia and Kazakhstan
During the SES-3/KazSat-2 launch, high level dignitaries representing the Kazakh and Russian governments were in attendance to observe and offer support of this important milestone in the space industry for both countries. From Kazakhstan, the Prime Minister, *Karim Masimov*, the Minister of Defense, *Adilbek Dzaksybekov*, and the head of the Kazakh Space Agency, Kazkosmos, *Talgat Musabaev* attended, and from Russia, there were the head of the Russian Space Agency, Roscosmos, *Vladimir Popovkin* and Khrunichev Director General, *Vladimir Nesterov*. Immediately following the launch, the heads of the two space agencies met jointly to discuss future cooperation and other common goals and interests in developments and advancements in space, launch site improvements and enhancing their well-established partnership.

Plans for Expansion
ILS continues to be well received in the global commercial launch market. We have signed a contract with **Inmarsat** for ILS Proton launches of their ***Global XPress***™ constellation: ***Inmarsat 5 F1***, ***Inmarsat 5 F2*** and ***Inmarsat 5 F3***. In addition to the Inmarsat triple award, we recently secured another ILS Proton launch in 2013, to be announced at a later date.

Inmarsat Global XPress satellite

Earlier in the year, we announced the ILS Proton launch of the ***SES-6*** for SES in 2013, the sixth mission under the *Multi-Launch Agreement* (**MLA**) signed more than four years ago between ILS and **SES Satellite Leasing Limited** in the *Isle of Man*. One month later, we were awarded two launches from **Mitsubishi Electric Corporation** (**MELCO**) with the ***Turksat 4a*** satellite in 2013 and ***Turksat 4b*** satellite in 2014. Turksat 4a and 4b will serve MELCO's customer, Turksat, bringing direct TV broadcasting and telecommunications services throughout Turkey. This brings ILS to a total of seven new launch orders to date and a backlog of missions valuing nearly $2.5 billion dollars.

Maximized Throughput
The unique ability of ILS and our partner **Khrunichev**, to adapt to the evolving needs in the marketplace is critically important to our customers and we continue

Turksat 4a and 4b in orbit, artistic rendering

to work together to create flexible solutions to support their plans for growth, expansion and technological breakthroughs in the telecommunications industry.

Proton production has also contributed to our ability to serve and perform for our customers as demands require. With as many as 14 systems produced annually, the consolidation of key Proton suppliers under Khrunichev has contributed a steady production pace with maximized throughput to serve both the commercial and Federal Proton programs. To date, Proton has performed 31 consecutive successful missions since July of 2008; still the highest launch rate in the industry for a heavy-lift system.

The pace for the remainder of 2011 for ILS and Khrunichev will be rapid and robust. We plan to launch five to six additional commercial missions and three to four Federal Proton missions, with two commercial launches scheduled for September. ILS and Khrunichev are able to facilitate this rapid launch pace with the addition of the *Second Spacecraft Processing Facility* (**SSPF**) in *Baikonur*, completed this past spring. The SSPF allows overlapping campaigns, minimizing the required spacing between ILS launches from five to six weeks to around three weeks. Some of the upgrades include a new hotel for on-site personnel; two new spacecraft control rooms, new communications systems and several new offices. ILS Proton continues to provide unmatched schedule assurance and this demonstrated capability is strengthened with the addition of the SSPF.

While the marketplace is dynamic, the ILS and Khrunichev partnership continues to serve our customers' goals and objectives. We look forward to a very busy second half of the year and thank our customers for their ongoing support, confidence and trust in ILS Proton. ⇦

s/Frank McKenna

Sea Launch "On the Way Up"

by Kjell Karlsen, President, Sea Launch AG

Sea Launch is no stranger to bold ideas. Our concept of designing, building and owning our range and launching commercial spacecraft from a platform at the equator with minimal launch personnel is unique in the industry. The first launch of the *Zenit-3SL* in 1999 marked the culmination of four years of intense planning and development, performed by thousands of talented professionals around the globe through an international partnership comprised of RSC Energia, Yuzhnoye SDO/PO Yuzhmash, Boeing Commercial Space Company, and the Anglo-Norwegian Kvaerner Group. In that one successful launch, we broke the barriers of skepticism. We proved the concept worked — and worked well.

Through 30 missions launching from the ***Odyssey*** platform at sea and four missions at **Pad 45** at the **Baikonur Cosmodrome**, **Sea Launch** continued to provide innovation, flexibility, diversity of supply and choice to the industry's established launch providers.

However, problems originating with inadequate corporate capital structure, inefficiencies in the hardware production supply chain, and devastating price erosion in the launch services market, led to a Sea Launch decision in June 2009 to file for reorganization under Chapter 11 of the *United States Bankruptcy Code,* in the U.S. bankruptcy court for the District of Delaware. The Chapter 11 filing was commenced in order to enable the Sea Launch group of companies to restructure their business and to eliminate certain of their debts, as permitted under U.S. Bankruptcy law.

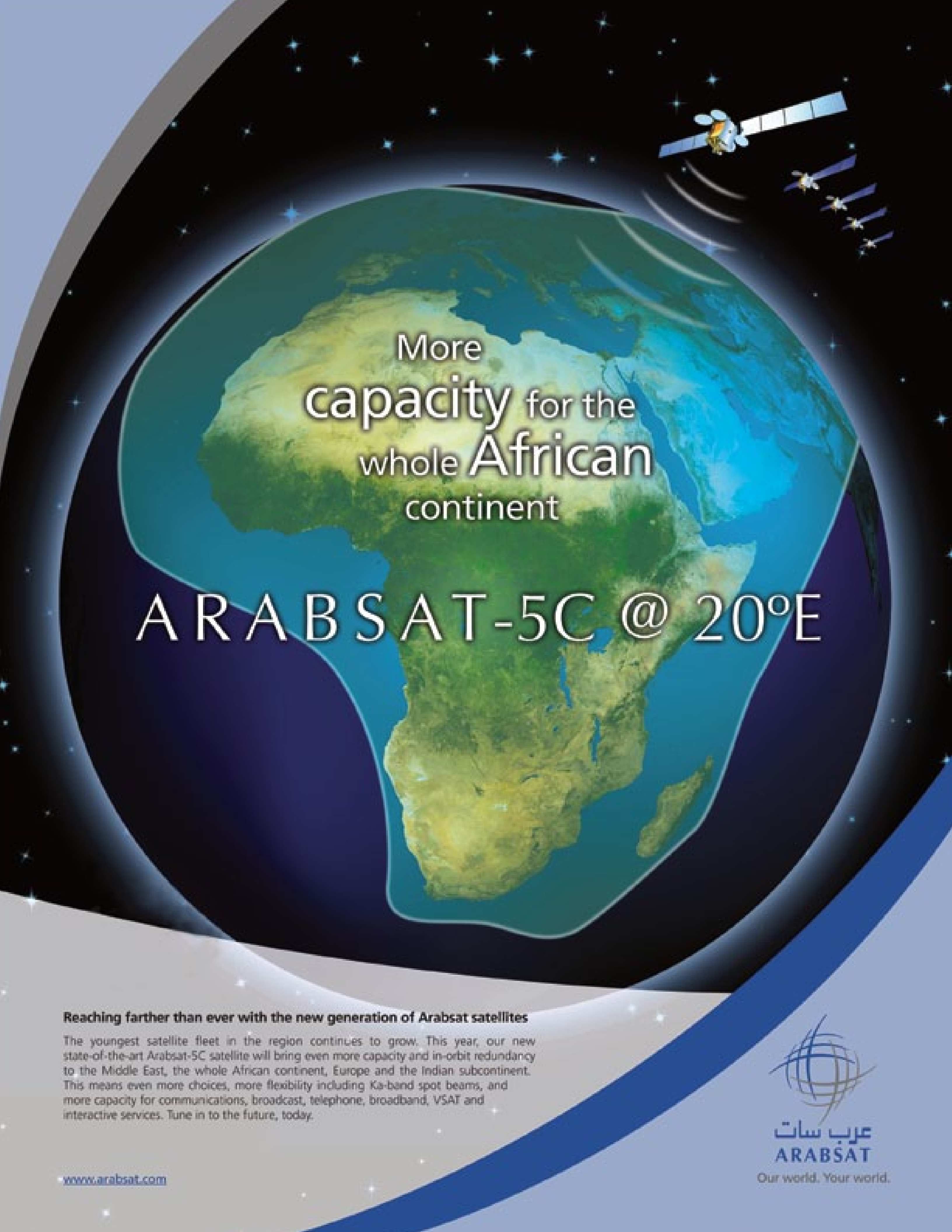
Challenges Faced During Restructuring

During the subsequent 16 months, Sea Launch had to set about restructuring our business in a way that made sense going forward for both our customers and stakeholders. This meant attending to the inadequacies in our original business plan, addressing organizational challenges, and restructuring operations. A number of issues needed to be focused upon such as:

- **New ownership structure**
- **Capital structure**
- **Supply chain restructuring**
- **Organization**
- **Roles and responsibilities**
- **New ownership structure**

Sea Launch Company, L.L.C. historically functioned as a five-party joint venture, with all the inherent complexities and inefficiencies associated with that structure. One of the objectives during restructuring was to transition the new **Sea Launch AG** organization into one having a more simplified structure.

Long-time Sea Launch partner and leading Russian Federation space integrator **OAO Rocket and Space Corporation Energia** (**RSC Energia**) stepped forward in October of 2010 when its subsidiary organization, **Energia**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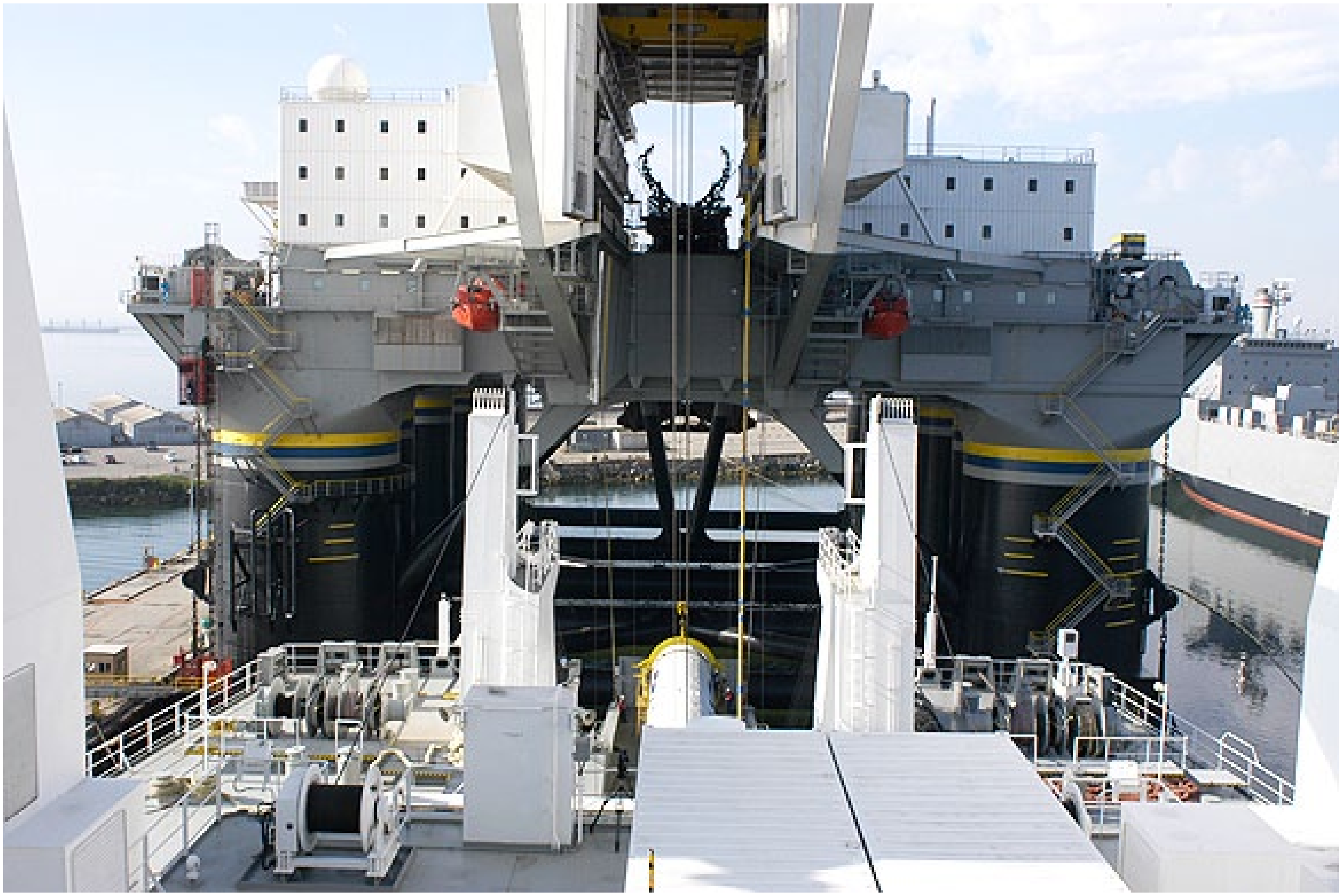


Overseas Limited (**EOL**) of Moscow, Russian Federation, became the primary shareholder of the newly formed **Sea Launch Aktiengesellschaft** (AG).

Founded in 1946, RSC Energia is a leader of the Russian and international space industry and one of the largest space integrators, receiving about 40 percent of the total Russian Federation space funding and employing approximately 18,000 people. As the prime contractor for all Russian Federation manned flights, RSC Energia receives a significant portion of its revenues from manned programs, **NASA ISS** station re-supply, and other federal contracts. Energia's lists of accomplishments reads like the history of Russian space exploration (***Sputnik-1***, ***Luna***, ***Vostok***, ***Mir***, ***Salyut Space Stations***, ***Buran***, ***Progress***, and ***Soyuz TMA*** spacecraft).

Capital Structure

Through the injection of EOL's $155 million in equity, EOL received approximately 95 percent of the common shares of reorganized Sea Launch AG. Boeing and Aker retained five percent of the newly formed equity. Under the approved Restructuring Plan, all of Sea Launch's debts incurred during the development phase and subsequent years were discharged in an agreed upon manner.

The end result is that Sea Launch AG has emerged with an improved balance sheet and no external debt, with sufficient equity, working capital and access to lines of credit to support its long-term growth going forward.

Supply Chain Restructuring

In the pre-petition organization, Sea Launch Company, L.L.C., from its Long Beach, California offices, acted as the prime contractor for all Russian, Ukrainian, Norwegian, and U.S. hardware and services contracts. This presented some challenges in the areas of manufacturing and production oversight, subcontractor payment flow-downs, and audits with the major sub-component manufacturers on the ***Zenit-3SL***, particularly in Russia and the Ukraine. Limited access to Russian sites and advance notification periods for non-Russian nationals contributed to a lack of transparency that has since been corrected.

Under RSC Energia's leadership, the organization has a renewed focus on strengthening all aspects of the Zenit-3SL hardware and services supply chain, including Russian oversight of all **Commonwealth of Independent States** (**CIS**) contracts for hardware and services, transparency in conducting customer audits and performance guarantees on key suppliers. In order to help accomplish this, Energia Overseas has formed two subsidiary organizations called **Energia Logistics United States** (**ELUS**) and **Energia Logistics Russian Federation** or (**ELRF**).

Upon the completion of restructuring activities in October 2010, Sea Launch AG has placed orders on the next 10 sets of flight hardware (Zenits #31 to 40) with our ELUS prime subcontractor. Since that time, Zenits #31 and 32 have shipped to support our 2011 launch manifest and production has resumed on the remaining eight vehicles supporting launches through 2013.

As part of a broader consolidation initiative currently taking place within the Russian Federation space sector, the head of the **Russian Federal Space Agency** (**Roscosmos**) recently confirmed RSC Energia as the leader of a new holding company integrating engine manufacturer **NPO Energomash** — followed by the planned future integration of ***TSKB-Progress*** and other Russian space companies. RSC Energia remains firmly committed to the success of the Zenit launch family going forward, its plans to integrate the supply chain and to serve the needs of the commercial satellite industry.

Organization

As proud as we are of our technical prowess, it is the Sea Launch people who are the core of our success. Sea Launch counts hundreds of experts in more than four countries, but each employee is dedicated to making sure every individual launch delivers maximum value to our customers. During the restructuring process, the core critical employees continued to keep the business and operations proceeding effectively. Established processes were preserved and experienced personnel were re-hired and retrained with respect to customer, insurance and spacecraft manufacturer interfaces, engineering and mission assurance oversight and authority, safety and regulatory requirements, contracts development and oversight, mission integration and operations skills (certified launch operators). This process has been very successful with the average experience of the retained Sea Launch engineering and operations team being greater than nine years, and 20 missions of direct Sea Launch experience.

Roles + Responsibilities

While the organization from which Sea Launch AG provides its launch services has changed with the restructuring, the people, parts and processes that have made us successful in our past 30 missions has not. The Zenit-3SL launch system maintains its original configuration and suppliers.

From its headquarters located in the Canton of Bern, Switzerland, Sea Launch AG provides the direct customer interface for the Sea Launch Zenit-3SL launch system. These services include not only all-inclusive launch services, but schedule assurance, financing, risk management, insurance, and creative contracting solutions to meet the changing demands of the commercial launch market. With an objective of providing an industry-leading launch experience for all of its customers, Sea Launch AG has a highly experienced group of executives and personnel to support these activities, with expertise in executive management, strategic planning, finance, contracting, legal, sales, marketing, communications, and customer relations.

Sea Launch AG owns and manages the primary technology, patent, and other intellectual property assets of the Company. These include the ***Odyssey Launch Platform*** and the Assembly and Command vessels located in the Home Port facility in Long Beach, California, and the unique know-how associated with launching satellites from an ocean-based launch platform located directly on the equator.

Sea Launch AG contracts directly and exclusively with ELUS as its technical partner for the delivery and execution of Sea Launch Zenit-3SL launch services.

Energia Logistics United States (**ELUS**) — is responsible for implementation and provision of launch services including ordering and payment of all flight hardware. ELUS delivers overall Mission Assurance and Systems Engineering oversight and verification including configuration control of flight hardware and software. This organization functions as a prime subcontractor to Sea Launch AG and is responsible for

providing all engineering oversight and mission assurance functions, launch operations and procurement of all Russian and Ukrainian hardware and services, as well as those from domestic and other international sources. ELUS manages the operations at Sea Launch Home Port, and also performs mission integration, and mission and range operations functions.

Energia Logistics Russian Federation (**ELRF**) — Acts as the agent for the purchase and sale of ***Block DM-SL*** and ***Zenit 2S*** flight hardware between ELUS and Contractors. ELRF provides regular factory insight and oversight of flight hardware fabrication and assembly at contractor and subcontractors facilities. It also manages payments originating from ELUS and made to Contractors and also monitors payments to subcontractors. Additionally, ELRF contracts for the transportation of flight hardware to Home Port.

ELUS is staffed mainly by existing long term personnel transitioned from Sea Launch Company L.L.C., The **Boeing Company** and **RSC Energia** as well as several key new-hires.

RSC Energia is responsible for fabrication and assembly of Block DM-SL, the overall launch operations of the rocket segment at Home Port, lead integrator for *payload integration, mission analysis* (**PIMA**) and the monitoring of related subcontractors' performance to schedule and providing technical services to ELRF.

PO Yuzhmash is responsible for fabrication and assembly of Zenit 2S hardware and monitoring of related subcontractors' performance to schedule.

Yuzhnoye SDO is responsible for Zenit 2S design and operations, engineering services and mission design.

Boeing Commercial Space Company (BCSC) is responsible for the *Payload Accommodations* (**PLA**) hardware and the PLA system integration and operation. BCSC provides analytical support to ELUS for PIMA, top-level launch planning functions, translation services, and marketing support for customers.

Looking Forward

The satellite communications business holds new and exciting possibilities, and we are constantly striving to anticipate and meet changing market demands. From increased lift capabilities, to exploring larger fairing sizes for even bigger satellites, we continue to drive innovation in the launch service industry, reliably and accurately delivering spacecraft to orbit for customers worldwide. Why? Because our customers are aiming high — and so are we.

Return To Launch Operations

At the time of writing this article, Sea Launch is in the midst of preparing for our 31st mission with the launch of the **Eutelsat *ATLANTIC BIRD*™ *7*** spacecraft in September 2011, launching from our equatorial launch site located at **154 degrees West**.

In parallel with this effort, Sea Launch is also conducting a launch campaign for the ***Intelsat IS 18*** spacecraft where mission operations and integration efforts are now underway. The launch of Intelsat 18 is scheduled for early October 2011 from the Baikonur Cosmodrome in Kazakhstan.

These launches are expected to occur from two separate launch facilities within 11-12 days of each other, demonstrating

the versatility, experience, and depth of the Sea Launch launch teams as well as the robustness of the ***Zenit-3SL/B*** system.

Building A Better Sea Launch

Sea Launch AG currently has a backlog of nine (9) launches valued in excess of $1 B. With a launch capacity of up to six to seven launches annually, Sea Launch AG plays a vital role in providing diversity of supply, affordability, and flexibility for the industry's satellite operators.

All of the restructuring efforts undertaken by Sea Launch would have been inconsequential without the dedication, vision, and commitment of the existing Sea Launch customers who played a large part in supporting a restructured Sea Launch and our employees, whose professionalism and experience were drawn upon continuously to build a better Sea Launch.

About the Author

Kjell Karlsen is the President of Sea Launch AG; the provider of the Russian, Ukrainian, and U.S. built Zenit-3SL heavy–lift launch service to the industry's satellite operators. Mr. Karlsen has been with Sea Launch since 1999, starting as the company's CFO and participating in all Sea Launch Zenit launches.

Mr. Karlsen received his Bachelor of Science degree in Business Administration from the University of Oregon and a Masters of Business Administration degree from Lehigh University. He is also a graduate of the Norwegian Air Force Training program. Prior to joining Sea Launch Company L.L.C., Karlsen was President of Kvaerner, Inc., and the Norwegian shipbuilder's U.S. headquarters in Philadelphia. Concurrently, he was Vice President of Kvaerner Financial Services, Kvaerner's U.S. treasury operation and also held executive positions with Den norske Bank of Oslo, Norway. Mr. Karlsen serves as a Board of Directors member for the Long Beach Grand Cru, benefitting the Legal Aid Foundation of Los Angeles. In 2011, he was named as one of Space News' "10 Who Made a Difference in Space".

Fiber Meets RF

by Dan Freyer, Principal, AdWavez Marketing

The consolidation of satellite uplink and antenna facilities as well as cable and DTH head-ends continues to be an industry trend, driven both by growth in channels and the opportunities to reduce overhead at 24/7 facilities. With this comes the need for robust, reliable and ever-higher capacity solutions for signal transport, switching, distribution and monitoring within the RF plant.

This article looks at an example of how the operator of one of the world's largest and most advanced satellite broadcasting centers was able to expand its facilities and connect two sites by fiber optics, to improve reliability for its L-band transmissions.

The new building of ASTRA Platform Services in the Unterfoehring Media Park, near Munich.

The Challenge: More and More Channels – One Uplink Center

ASTRA Platform Services GmbH (**Astra**), is a subsidiary of **SES ASTRA**, the leading *Direct-to-Home* (**DTH**) satellite system in Europe. Their ***ASTRA*** satellite system delivers services to more than 135 million DTH and cable households and transmits more than 2,500 television and radio channels. SES ASTRA is part of SES (Euronext Paris and Luxembourg Stock Exchange: SESG), which provides satellite communications solutions via a global fleet of 44 satellites.

From its broadcast center near Munich, Astra provides technical support to broadcasters and production companies, offering a comprehensive range of services for the preparation and transmission of content for TV and radio channels, including HDTV playout, interactive and data services, as well as preparation and transmission of content via satellite, over the Internet or to mobile reception units. Clients include

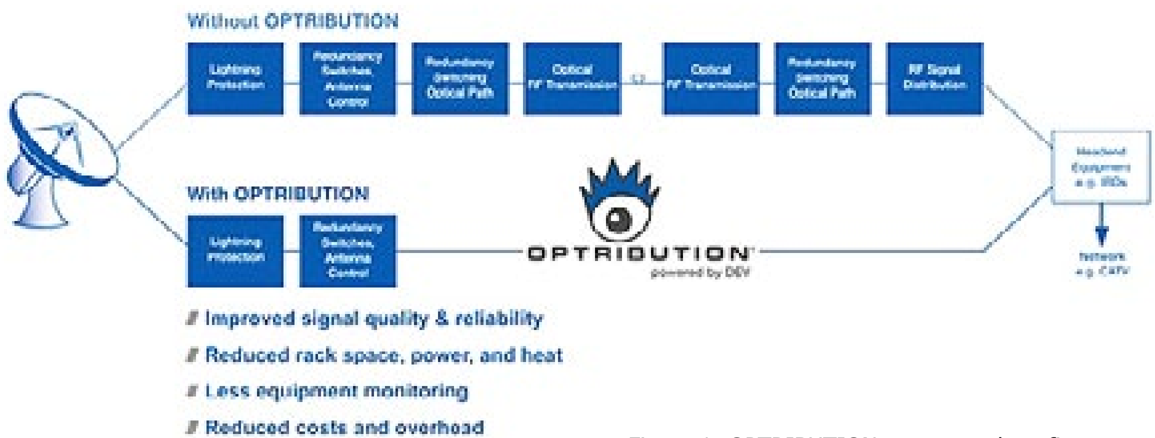


Figure 1: OPTRIBUTION concept + benefits

well-known broadcasters from the public and private sphere as well as Pay TV providers, rights owners, cable network operators, and global companies.

When Astra Platform Services GmbH needed to connect two facilities via fiber optic cables for transmission of L-band signals, they chose equipment from DEV Systemtechnik's OPTRIBUTION® product family. The result: Astra gained capacity to transport hundreds of programs over scores of optical links between buildings, with redundancy, signal quality and reliability, while freeing up valuable technical and rack space for other uses.

Making Two Facilities Into One

When physical space to grow at **ASTRA Platform Services**' broadcast center reached its limit, the company acquired a plot of land and facilities on the opposite side of the street, and decided to connect the two sites via fiber cables. For the transmission of L-band signals, Astra selected equipment from Germany-based **DEV Systemtechnik GmbH & Co. KG.** DEV develops and produces a complete range of leading-edge, high-performance products and systems for the optical and electrical transmission of *Radio Frequency* (**RF**) signals via coaxial cable or fiber for satellite, cable, and broadcast television head-ends. DEV products include distribution amplifiers, splitters and combiners, switching systems, distributing matrices, routing products, multiplexers, and fiber-optic RF signal transmission systems — all built to meet the highest standards of system availability, reliability and controllability. Subsidiary **DEV America** (www.dev-america.com) serves customers in North America from Newport Beach, CA.

"We have been convinced of the quality and high integration level of DEV equipment since the beginning of our cooperation. With the new OPTRIBUTION® chassis, DEV again increased packaging density, enabling us to realize optical signal transmission starting with three 3 RU chassis in the old building and four 4 RU chassis in the new one, which greatly relieved our spatial situation."

Adrian-Johann Grama, Senior Manager RF Services, ASTRA Platform Services GmbH.

"We do have to send and receive 24 hours a day, no matter whether there are technical interferences, scheduled maintenance tasks, or changes of components to update or expand the infrastructure," said *Adrian-Johann Grama*, Senior Manager, RF Services for ASTRA Platform Services. These conditions brought ASTRA Platform Services and DEV together. When *Grama* looked for replacement of distribution amplifiers no longer able to keep up with growing demands, he visited DEV's booth at the IBC trade fair in Amsterdam and discovered DEV's L-band signal distribution system, the ***DEV 2180***.

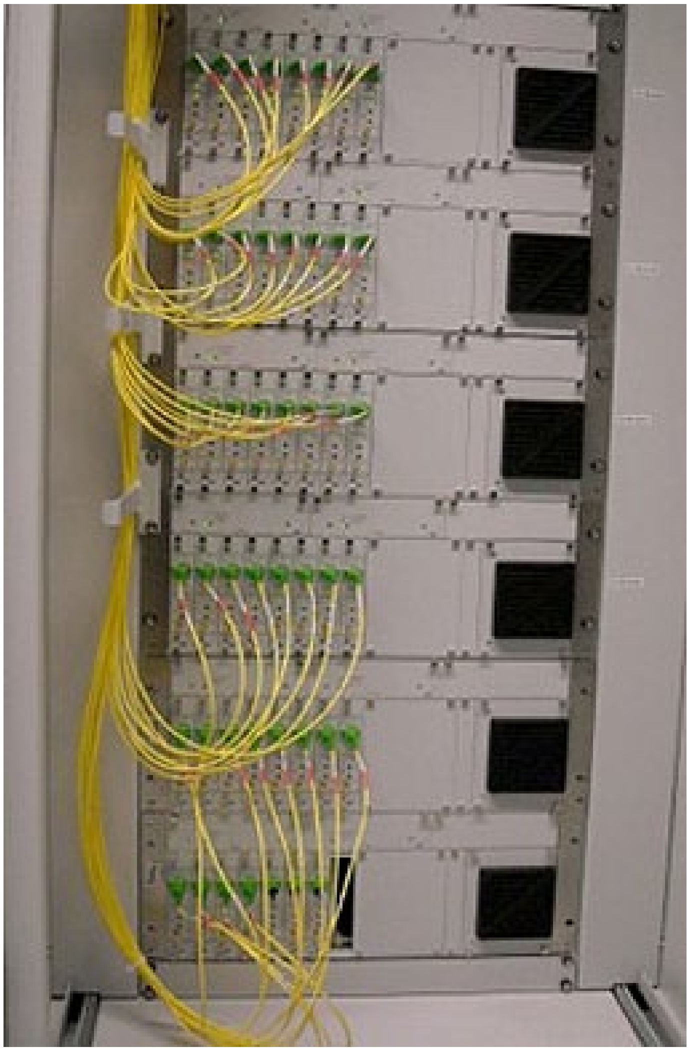
After field trials, *Grama* decided to replace the site's old distribution amplifiers with new equipment from DEV, accommodating up to eight modules 1:16 in one single 4 RU chassis. The change caused no problems. DEV pre-configured equipment was installed in only half an hour.

"We simply had to take the old hardware out and put the new one in." As a result, ASTRA gained excellent functionality in just one half the rack space needed before. It was no surprise that Grama thought of DEV first when it came time to equip Astra's new building with distribution amplifiers. Soon, the trusted DEV 2180 L-band distribution amplifiers were doing their job in ASTRA's new building as well.

"Benefits that satellite facilities can gain from integrated RF and fiber optic transport through OPTRIBUTION® include improved signal quality and reliability, as well as reduced rack space, power, and heat consumption. Additional benefits including the need to monitor less equipment, and the ability to do so with simpler user-friendly interfaces help satellite headends, teleports, and uplink facilities save on costs and overhead."

Inter-Facility Links

For signal connection between the two buildings, there was no viable alternative to opto-electronics. "300 meter run length in three dimensions through the city's sewage system created problems hardly solvable with coax cabling," explained Astra's *Grama*. While discussing distribution amplifier configuration topics with DEV consultants, he became aware of DEV's ***OPTRIBUTION®*** concept and decided to give



OPTRIBUTION® with DEV 7104 in the rack of ASTRA Platform Services

his L-band distribution technology supplier's offerings a try in the optical transmission field.

OPTRIBUTION® (*Optical Transmission and Distribution of RF Signals*) is DEV Systemtechnik's systematic approach to the ongoing development of the signal distribution infrastructure in satellite ground stations and CATV head-ends.

Four different form factors within the OPTRIBUTION® product line can meet a wide variety of signal transmission demands. Choice of the best-fitting OPTRIBUTION®product depends on the number of signals to be transported.

The 1 Rack Unit (RU) high ***DEV 4000*** series chassis, with two universal slots, accepts as many as four signals. The 3 RU ***DEV 7000*** series chassis with up to 20 optical slots can handle as many as 40 signals. The 4 RU DEV 7000 series chassis with 16 optical slots is additionally able to distribute (1:8, 16, 32, 64) or switch (4x8, 16, 32, 4x64) incoming signals. The new OPTRIBUTION® Outdoor Chassis can be installed near the antenna and converts the signals directly at that location. It offers four slots, enabling a 4+1 redundancy at the antenna. The wide operating temperature range from -30 to +60 °C allows for worldwide deployment even in extreme weather conditions.

To equip the OPTRIBUTION series chassis, DEV offers a multitude of modules featuring high packing density and application-oriented options: Four new transmitter cards with up to 12 options, four new receiver cards with up to three options, four new redundancy options, and optical **CWDM** mux/demuxes. The newly implemented CWDM technology allows the user to transmit up to eight independent channels over just one optical fiber.

More Bandwidth in Fewer Racks

ASTRA started with 32 fiber links for signal transmission between the two buildings. Capacity was later expanded to 48 links in total. The signal input interface in the old building is performed by an Intelligent Optical Signal Transmission System ***DEV 7103***, a 3 RU chassis providing a controller and accommodating up to 12 transmitter or receiver modules. ASTRA uses two of these chassis to convert the electrical to optical L-band signals.

Link termination in the new building is performed by a ***DEV 7104*** optical and RF transmission system. This 4 RU chassis combines signal transmission with distribution modules such as dividers and matrix switches. In the ASTRA Platform Services setup, the DEV 7104 receives the optical signals, amplifies them and distributes them into the system. The ***DEV 7103*** and ***DEV 7104*** optical transmission systems allow for integration of redundancy switches, offer redundant power supplies, and can be remotely controlled and monitored via a user-friendly web interface.

Discussing the project's success, *Grama* adds "We have been convinced of the quality and high integration level of DEV equipment since the beginning of our cooperation. With the new OPTRIBUTION® chassis, DEV again increased packaging density, enabling us to realize optical signal transmission starting with three 3 RU chassis in the old building and four 4 RU chassis in the new one, which greatly relieved our spatial situation. Since expansion to 48 links we operate four chassis in the old and six in the new part. The only open question in the whole process was availability. We were under enormous time pressure and had to confront DEV with a very tight delivery schedule. But everything arrived as it always should — just in time!"

The Payoff: Successful Growth

Demanding top-notch support and results from its technology suppliers like DEV and others has helped the talented team at ASTRA Platform Services successfully deliver high quality services for a growing list of customers. Over many years, Astra Platform Services has achieved a broadcast reliability in excess of 99.98 percent — the Company has been ranked continuously among the top playout centers worldwide, boasting more than 200 TV and radio programs.

About the author

Dan Freyer is the principal of AdWavez Marketing, a marketing firm serving the satellite industry, and can be reached at dan@adwavez.com. He is the author of *Liftoff: Careers in Satellite, the World's First and Most Successful Space Industry* (SSPI 2010), among numerous other publications and articles, and has helped top satellite manufacturers, operators, service providers, and equipment suppliers develop their businesses for over 20 years.

The Evolution Of Satellite-Based Communication

by Steven Boutelle, Vice President, Cisco Global Government Solutions Group

We are at a tipping point in the satellite industry. The Cisco Internet Routing in Space (IRIS) initiative extends into space the same Internet Protocol-based (IP) technology used to build the World Wide Web. The long-term goal is to route voice, data and video traffic between satellites over a single IP network in ways that are more efficient, flexible and cost-effective than are possible over today's fragmented satellite communications networks.

The IRIS Vision

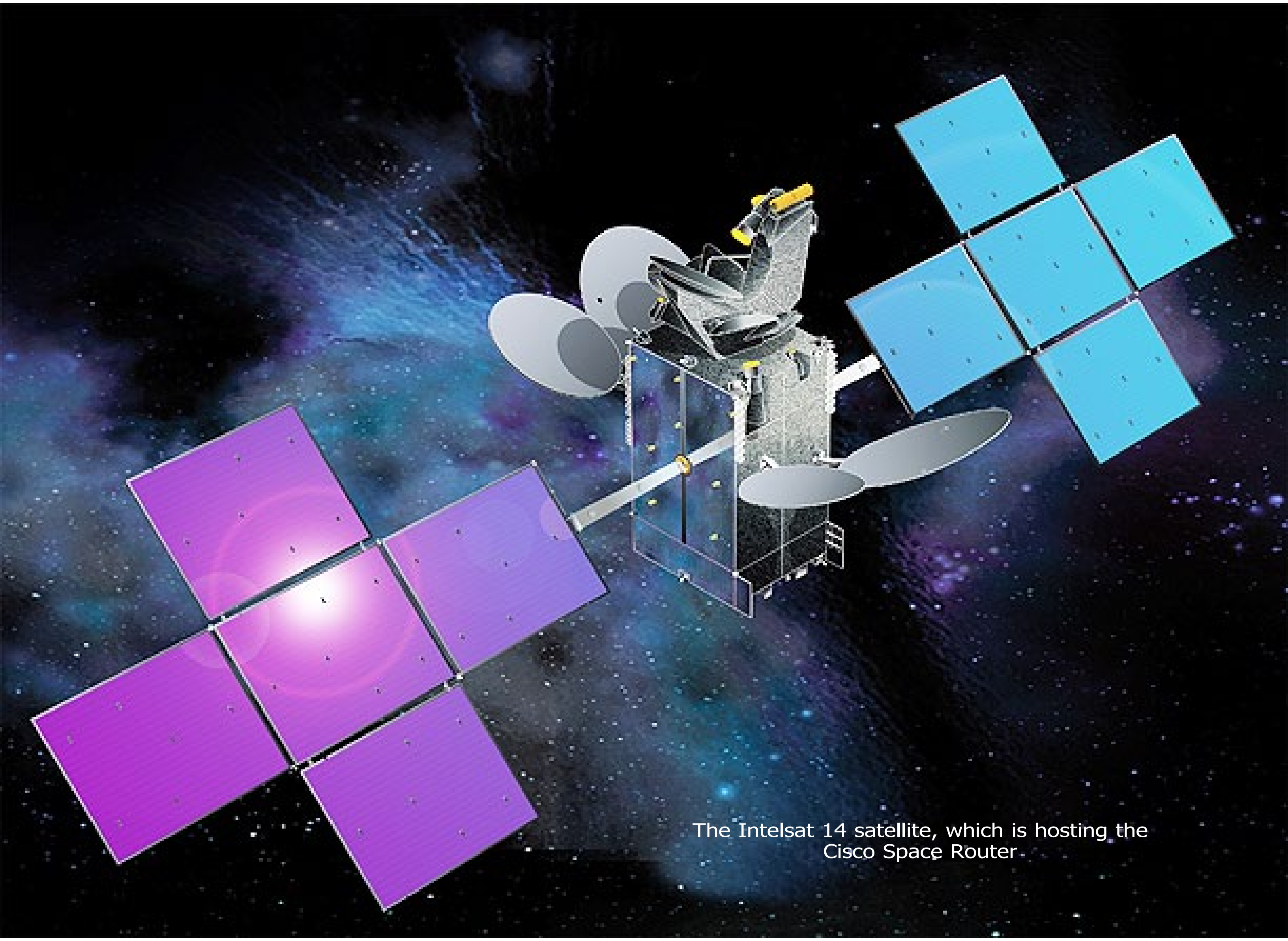
With a space router on board, it is possible to route traffic between satellites to provide better reliability and more sophisticated services to satellite customers, and not only to users on the ground. With this architecture, a small number of space routers provide a resilient network backbone in space. This backbone augments terrestrial networks and retains Internet connectivity even in the event of fiber cuts or natural disasters. This space network is not independent of the Internet — it is a natural extension of the Internet.

One key element of the ***IRIS*** vision is introducing standards across the satellite network and satellite industry to allow interoperability with terrestrial connections.

The IRIS testing phase is chock-full of firsts. While in orbit, the router has been uploaded with additional capabilities, such as ***Cisco Unified Communication Manager Express***, which provides telephone services throughout the network. Cisco recently updated the software in the space router aboard ***Intelsat 14***, effectively "turning on" a variety of capabilities already available for Cisco's terrestrial products and making them available in space. This is a revolutionary concept in an industry where satellite operators generally don't have the luxury of changing a payload post launch, and it opens IRIS to further changes, applications and upgrades.

Applications

Cisco designed IRIS as a commercial product that is available to both civil and government customers. Service providers and enterprises can make use of IRIS services to access the Internet anytime, anywhere and from any device.



The Intelsat 14 satellite, which is hosting the Cisco Space Router

The true power of IRIS is that it takes all of the capabilities and benefits that exist in the terrestrial Internet and allows them to be used over satellite networks. It makes satellites an intelligent part of the overall network, rather than just passive repeaters of radio signals. More importantly, IRIS allows the end user to take advantage of the reach of satellite bandwidth without needing to deal with the complexities of satellite access.

The ability to provide connectivity to support military personnel on the ground has become critical. Troops operate in environments ranging from the austere to the complex, from unimproved mountainous terrain to urban areas, in missions to combat terrorism and insurgency, provide natural disaster response, or engage in direct military operations. In such situations, the availability, robustness, and resiliency of connectivity and communications have the power to determine how such operations can be carried out, and whether some can be undertaken at all.

Law enforcement officers are another customer set that has critical needs for communication. They cannot anticipate where or when a situation will arise, so the network must be able to deliver communication services on demand, instantly. IRIS extends the on-demand service delivery model to include satellite communications. Bandwidth can be allocated to the most critical needs of users.

Security is another important aspect of law enforcement and defense, so IRIS extends terrestrial security policies and firewalls to the satellite components of the network.

One example of the way the technology will benefit users is how it assists emergency workers who are responding to a natural disaster. If a terrestrial infrastructure is destroyed, you can't get a cell phone signal to save your life — or anyone else's. The hurricane, earthquake or flood has leveled cellular towers for miles. What do you do?

With IRIS, the satellite can provision voice service for emergency workers and connect police with the fire department and the hospital, all through the satellite. No traditional telephone network is required to route the call.

Cisco had an opportunity to use IRIS to provide support for the Haitian relief effort. Together with partners, we set up ***Cisco TelePresence*** units in Haiti and in Miami. A number of injured children were airlifted into the **University of Miami** hospital for treatment after the earthquake. Unfortunately, their families were not able to travel with them, so IRIS and TelePresence enabled the families to stay connected.

Commercial Use

Cisco works with a variety of leading service providers in the commercial industry. These users are supporting the transition from the traditional telecommunications of the late '90s, when buying a T1 connection might cost around $1,000 dollars, to today's day-to-day Internet connection at $20/month. Cisco's goal is to make satellite services as easy as using a mobile phone, by changing the way services are accessed. This would allow a telecommunications company to combine satellite, wireless, and other featured services.

Cisco is working to create a standards-based approach to integrate satellite into day-to-day telecommunications. We want a combination that can reach out to all different signals. With a space router, you now have the dynamic of combining all these technologies for mobility management, data access management, and multiple access lines, including satellite, combined with the capabilities of IP.

Following the successful deployment of the industry's fastest commercial processor in space from **SEAKR Engineering** as part of the ***Cisco Space Router*** on board Intelsat's IS-14, Cisco recently announced an agreement with **TeleCommunication Systems** (**TCS**), who will be taking on the role of service provider for the Internet Routing in Space payload on IS-14 for global entities that include the **U.S. Department of Defense**. This marks a big step for the IRIS router, as it illustrates the commercial capabilities the program has to offer. Both Cisco and TCS foresee major opportunities to globally deploy these cost-efficient solutions through government and commercial markets.

The Challenges + Benefits Of Hosted Payloads

Launching IRIS as a hosted payload ensured a number of benefits as well as challenges for the IRIS team. "Hosted payload" refers to the use of available capacity on commercial satellites to accommodate additional transponders, network communications components, sensors, surveillance gear, or other important capabilities. Such "piggyback" or "hitchhiking" opportunities on commercial spacecraft provide users with a timely and cost-effective way of sending equipment into space.

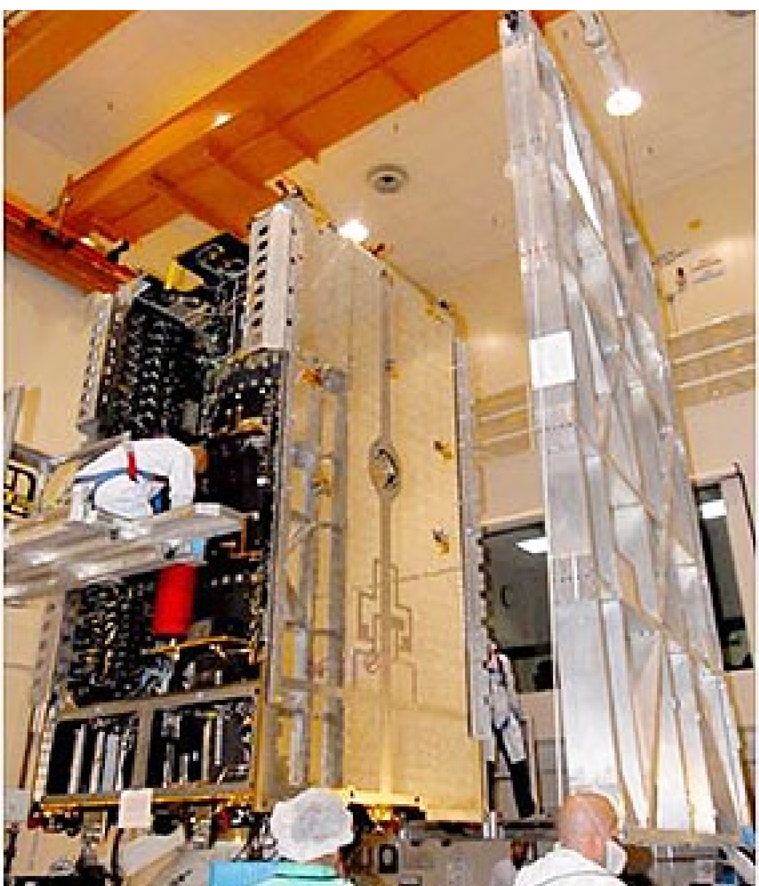
Placing a hosted payload on a commercial satellite costs significantly less than a defined firm fixed-price contract, and includes integration of the payload with the spacecraft as well as the marginal use of power, launch services, and other operating costs.

Based on IP networking, hosted payloads support the goal of accelerating convergence of ground, air, and space infrastructures into a single voice, data, and video network, while mitigating many of the interoperability issues between systems. Networking services are offered on demand via an IP-based full-mesh network from the satellite instead of "hop by hop" through terrestrial nodes. The satellite becomes an access point for the entire system, acting as a telecommunications office from space to serve the overall network.

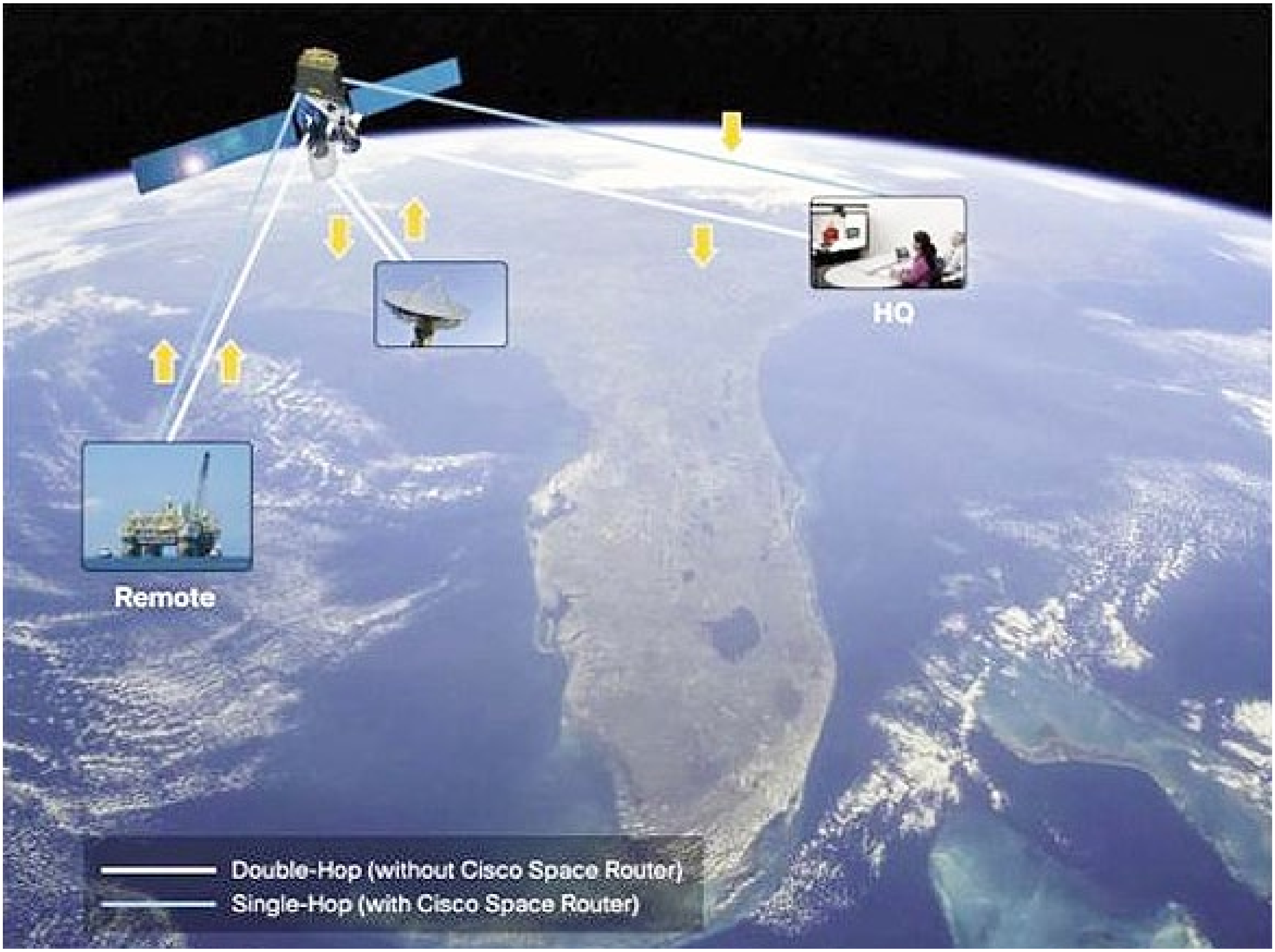
Timing is always a challenge for hosted payloads. IRIS was the first geosynchronous router as a hosted payload with a tight timeline; 22 months from start to finish. Military systems usually require decades to develop. If a hosted payload is going to be on a commercial satellite, there is a defined, and very brief, timeline from start to finish for launch.

A hosted payload allows current commercial technology to be placed in space very quickly to provide 80 to 90 percent mission capability to today's warfighter. However, the government prefers to pursue the development of 100 percent coverage solutions that could take decades to deploy — another challenge to consider. The benefits of IP-based routing in space include...

- **Cuts the transmission double hop in half, allowing IP-based signals to interconnect in a single hop for more immediate communication**
- **Provides greater effective throughput on demand to support more signal than traditional systems, such as real-time video from unmanned aerial vehicles (UAVs), or to support more users**
- **Multiplies the benefits of advanced spot-beaming technologies (on the Ka-band)**
- **Improves interoperability through cross-beam communications to upload to Ku- and down on C-bands**
- **Routes traffic to intended recipients asynchronously, using one uplink and one downlink, keeping the signal stronger**



Cisco's space router being bolted onto the Intelsat 14 satellite

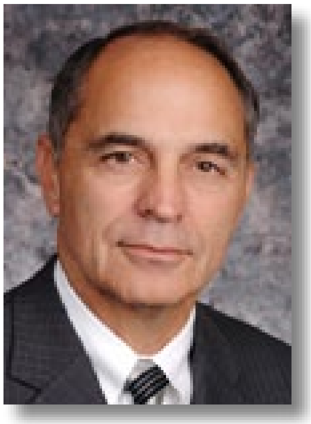


- **Uses multiple waveforms to support connectivity across joint operations without the inefficiencies of "cross- banding" (resending the signal across radio bands to achieve connectivity)**
- **Regenerates the signal to provide a power increase, reducing the size of antennas on the ground, a feature that is particularly important for mobile**
- **Greatly simplifies management of satellite terminals under the IRIS footprint with zero touch deployment**

Over the coming years, IRIS will support the deployment of a truly mobile network that allows users to connect and communicate how, when and where they need to, and that continuously adapts to changing needs without depending on a fixed terrestrial infrastructure. This significant inflection point is not different from what the telcos in 1995 experienced, and will converge voice, data and video over IP. This technology will transform how government agencies and commercial organizations use IP-based network services to accomplish their missions.

For more information on Internet Routing in Space, visit **www.cisco.com/go/iris**.

About the author



Steven Boutelle leads a business development team that advises government customers on business practices and technology solutions. Boutelle's team focuses on defense, space and intelligence markets. Before joining Cisco, Boutelle served as the Chief Information Officer of the U.S. Army, responsible for the Army's worldwide use of information technology. He introduced converged voice, data, and video to the Army, building an enhanced network infrastructure to serve 1.9 million users.

He established the Army Knowledge Online portal and the Defense Knowledge Online portal to provide streamlined access to content for six million defense users. Through an IT portfolio management program, he reduced the costs of IT systems and applications by half. Boutelle is a recognized leader, technology evangelist, and mentor. His career in the U.S. Army is marked by a consistent record of adopting new technologies and streamlining processes to improve productivity and enhance collaboration.

The Delta Heritage

by Jos Heyman, FBIS, CEO Tiros Space Information

Thor booster rocket launch

The Delta launch vehicle, that currently places many satellites into orbit possesses a long heritage that can be traced back to the *Thor* missile development of the early 1950s. In this article, the development path that led to the current *Delta 4* launch vehicle will be summarized.

Thor Missile

In response to the threat posed by USSR long range missiles, in 1954 the U.S. Air Force initiated the development of a tactical ballistic missile. This missile would be capable of delivering a nuclear warhead over a distance between 1,850 and 3,700 km, a range that would allow Moscow to be attacked from a launch site in the United Kingdom.

On November 30, 1955, **Douglas**, **North American** and **Lockheed** were invited to bid for the project and on December 27, 1955, Douglas was awarded the prime contract for the airframe. At the same time, **Rocketdyne** was awarded a contract for the missile's engine.

This was a single-stage missile with a length of 18.40m and was powered by a single **Rocketdyne** ***LR79-NA-7*** engine fueled by Lox and kerosene, providing a thrust of 758,7387N. The first successful flight of a Thor missile occurred on September 20, 1957.

Within three years, the first of 60 missiles were deployed in the United Kingdom as part of the **Royal Air Force**. The missiles were based at above-ground launch sites and a missile could be launched within 15 minutes. Ten minutes into its flight the missile would have reached an altitude of 450 km, and after 18 minutes, it would impact its target.

A total of 224 missiles, designated initially as ***SM-75*** and later as ***PGM-17***, were constructed. Of these, 64 were used for test flights, including training flights. There were 12 launch failures. The majority of these flights were from **Cape Canaveral,** while a few took place from Vandenberg. No missiles were launched from their bases in the United Kingdom.

The Thor was always considered a temporary solution. When **ICBM** missile sites in the United States became operational, the Thor based missiles were withdrawn from duty. The 60 missiles deployed in the United Kingdom were returned to the United States and were placed in storage, along with other remaining missiles.

These surplus vehicles became a ready source for sub-orbital programs of a scientific and technological nature. There were eight launches in the ***Dominic*** program between May 2, 1962, and November 1, 1962 — all were conducted from **Johnstone Island**. Also flown from Johnstone Island were 13 anti-satellite tests between February 14, 1964, and November 12, 1968. Six flights from Cape Canaveral in the ***Asset*** program were conducted between September 18, 1963, and February 23, 1965.

Although the basic Thor missile (also identified as ***DM-18***) was never used for space launches, it was combined with various other upper stages to produce a number of variants that allowed the surplus missiles to be used as space launch vehicles. New first stages were constructed when the stock of surplus missiles was depleted. The various variants were:

- **The Thor Able and further derivatives**
- **The Thor Agena and further derivatives**
- **The Thor Delta, now more commonly known as Delta; and minor other variants**

In addition to the military missile designation ***PGM-17***, the basic Thor first stage received military designations in the ***LV/SLV,*** while the ***Delta*** received designations in the ***SB*** series. The following table lists the known designations and the cross references to the launch vehicle types, however, there remain discrepancies in this list. It is probable that these designations were only used for flights carrying military satellites.

Designation	Type
SLV-2	Basic Thor missile
SLV-2A	TAT 1st stage for Agena B + D upper stage
SLV-2B	??
SLV-2C	TAT 1st stage for Agena B + D upper stage
SLV-2D	Thor 1st stage on Asset flights
LV-2C	Thor 1st stage for Delta upper stage on Asset flights
LV-2D	Thor 1st stage for Altair (Burner I) upper stage
SLV-2E	??
LV-2F	Thor 1st stage for Burner II upper stage
SLV-2F	Thor 1st stage for Burner II upper stage
SLV-2G	Thorad 1st stage for Agena B + D upper stage
SLV-2H	Thorad 1st stage for Agena D upper stage
SLV-2J	??
SB-3A	Delta II

Military Thor launch vehicle designations

Initially the civilian designations included ***DM*** (probably meaning **Douglas Missile**) and ***DSV*** (probably meaning **Douglas Space Vehicle**), as described with the individual launch vehicles. The post 1971 designations systems are discussed later in this article.

Thor Able

The ***Thor*** missile was mated with the ***Able*** two stage upper stage, which was built by **Space General** and was originally used for the ***Vanguard*** launch vehicle. The first stage of the Able was powered by an ***Aerojet AJ-101*** engine and the second stage by an ***ABL X-248 Altair*** engine.

Thor Agena prior to a Pacific coast launch

This missile appeared in various configurations. The ***Thor Able I*** combination, which carried the two stage Able; the ***Thor Able II*** version, which possessed no Able second stage; and the ***Thor Able III*** version, which added an upper stage powered by an ***Atlantic 1KS 420*** engine, making this a four-stage vehicle. The ***Thor Able IV*** was a three-stage version with improved engines. The ***Thor Ablestar***, initially known as ***Thor Epsilon***, combined an improved, basic Thor vehicle, designated as ***DM-21***, with a new second stage based on the Able first stage.

Thor Agena

Originally known as ***Hustler*** after the **Bell** motor, the Agena upper stage, was developed by **Lockheed** and included a Bell liquid fueled motor. It was fitted with the basic Thor first-stage to create the ***Thor Agena A***, ***Thor Agena B*** and ***Thor Agena D*** combinations, while the upper stage was also combined with the improved developments incorporated into the Thor first-stage. This resulted in the ***Thrust Augmented TAT Agena B***, ***TAT Agena D*** and ***Thorad Agena D*** versions. The TAT versions had three strap-on ***Thiokol Castor TX-345*** solid boosters.

The final version of the Thor combined with an Agena D upper stage with the ***DSV-2L*** long tank first stage with either three, six, or nine solid fueled strap-on boosters. The combination has been referred to as ***Thorad-Agena D*** or ***Long Tank Thrust Augmented Thor*** (**LTTAT**)-***Agena D***.

Thor Burner

The Thor vehicle was also matched with the ***Altair*** upper stage as the ***Thor-Burner I***, sometimes also referred to as ***Thor Altair***. Further versions were the ***Thor Burner II*** and the ***Thor Burner IIA***, which introduced an additional burner stage.

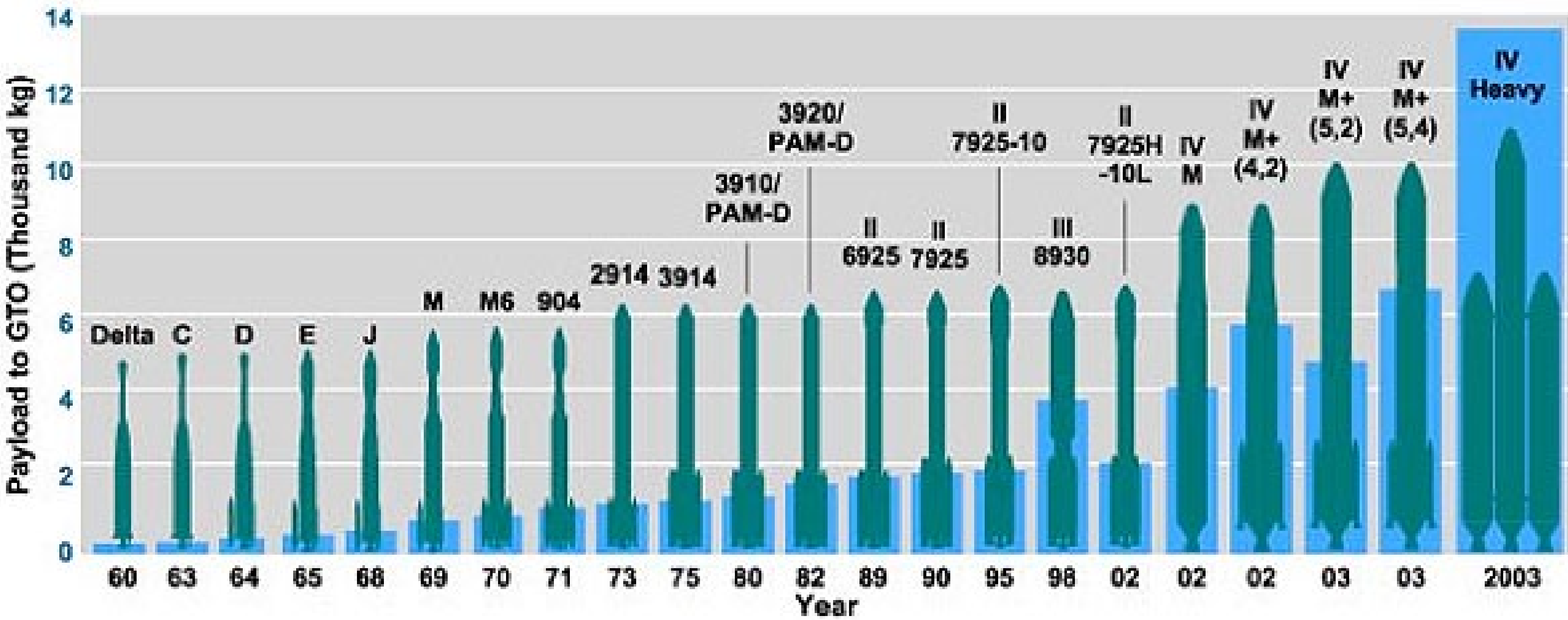
Type	First flight	Sub-orbital	Orbital	Failed
Thor Able I	23-Apr-1958	3	1	2
Thor Able II	23-Jan-1959	6	1	1
Thor Able III	7-Aug-1959		1	
Thor Able IV	11-Mar-1960		1	
Thor Ablestar	13-Apr-1960		14	5
Thor Agena A	21-Jan-1959		10	6
Thor Agena B	26-Oct-1960		38	9
Thor Agena D	2-Aug-1962		17	3
TAT Agena B	29-Jun-1963		2	
TAT Agena D	28-Feb-1963		61	4
Thorad Agena D	9-Aug-1966		36	2
Thor Burner I	19-Jan-1965		5	1
Thor Burner II	16-Sep-1966		16	
Thor Burner IIA	16-Mar-1974		8	1

Thor + Upper Stage Flights

Delta Introduction

The ***Thor Delta*** series of launch vehicles was developed starting in April of 1959 by the **Douglas Aircraft Corporation** as an interim launch vehicle. It evolved, however, into a distinct series of launch vehicles known simply as Delta, which are still being used to this day and are expected to be further developed in the years to come. The current design has, however, little in common with the original Thor missile due to the continuous, incremental development process.

By combining the basic Thor first-stage and a number of its improvements, with a wide range of upper stages as well as solid boosters, the Delta launch vehicle is configured in a broad range of versions to accommodate specific payload requirements. The designation system is, to say the least, complicated — several changes in the designation systems have added to the vehicle's complications.



Development of the Delta launch vehicle (Boeing)

The basic ***Thor Delta***, or ***Delta DM19***, consisted of a Thor first-stage with a second-stage propelled by an ***Aerojet AJ-10-142*** liquid fuelled motor and a third stage with an ***Allegheny Ballistics Laboratory X-248 Altair***.

The ***Delta DSV-3A,*** or ***Delta A***, was similar to the basic Thor Delta vehicle but possessed a ***Rocketdyne MB-3-II*** first-stage motor as well as a second stage re-start capability. Subsequent versions differed in configurations, depending upon the launch requirement determined by the payloads to be carried. The various configurations are shown in the accompanying tables.

Similar to the Delta ***DSV-3A***, these versions were known by alternative designations that dropped the 'DSV-3' component. For instance, the ***Delta DSV-3N*** was also known as ***Delta N***. Some of the following listed versions were not built. (*See tables on the previous page*.)

Delta 300 + 900

In 1972 and 1973, a new designation system was used in which the first character following the name ***Delta*** indicated the number of ***Thiokol TX-354-5*** strap-on boosters (3, 6 or 9), the second character indicated the second-stage (with '0' meaning the ***Aerojet AJ-10-118F***), while the third character indicated either that no third-stage was carried ('0') or a ***Thiokol TE-364-4*** ('1') third-stage was in place. The system was used only briefly and the only known designations are ***Delta 300*** and ***Delta 900***.

Type	First flight	Orbital	Failed
Delta 300	15-Oct-1972	2	1
Delta 900	23-Jul-1972	2	

Delta xxx Flights

Delta 2

By 1974 the Delta had evolved into a launch vehicle that had little relation to the original Thor missile. A new launch vehicle designation system was modified (with later modifications, as required) that identified the Delta launch vehicles by a four digit number which indicated the configuration of the launch vehicle. It is also considered that this four digit numbering system represents the ***Delta 2*** series of launch vehicles.

Delta 0900 prior to the launch of *Nimbus E*.

Type	Stage 0	Stage 1	Stage 2	Stage 3
Delta DM19	---	1 Rocketdyne MB-3-I	1 Aerojet AJ-10-142	1 ABL X-248 Altair
Delta DSV-3A	---	1 Rocketdyne MB-3-II	1 Aerojet AJ-10-118	1 ABL X-248 Altair
Delta DSV-3B	---	1 Rocketdyne MB-3-II	1 Aerojet AJ-10-118	1 ABL X-248 Altair
Delta DSV-3C	---	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118	1 ABL X-258 Altair
Delta DSV-3C1	---	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118	1 ABL X-258 Altair
Delta DSV-3D	3 Thiokol TX-345-5	1 Rocketdyne MB 3-III	1 Aerojet AJ-10-118	1 ABL X-258 Altair
Delta DSV-3E	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 ABL X-258 Altair
Delta DSV-3E1	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 United Tech FW-4D
Delta DSV-3F	---	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 ABL X-258 Altair
Delta DSV-3G	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	—
Delta DSV-3H	---	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	---
Delta DSV-3J	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 Thiokol TE-364-3
Delta DSV-3K	---	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	Cryogenic stage
Delta DSV-3L	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 United Tech FW-4
Delta DSV-3L-II	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 United Tech FW-4
Delta DSV-3M	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	1 United Tech FW-4
Delta DSV-3N	3 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	—
Delta DSV-3N6	6 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	---
Delta DSV-3N9	9 Thiokol TX-345-5	1 Rocketdyne MB-3-III	1 Aerojet AJ-10-118E	---

Delta DSV configurations

Type	First flight	orbital	failed
Delta DM19	13-May-1960	11	1
Delta DSV-3A	2-Oct-1962	2	
Delta DSV-3B	13-Dec-1962	8	1
Delta DSV-3C	27-Nov-1963	9	1
Delta DSV-3C1	25-May-1966	2	
Delta DSV-3D	19-Aug-1964	2	
Delta DSV-3E	6-Nov-1965	6	
Delta DSV-3E1	1-Jul-1966	18	
Delta DSV-3F	Not built		
Delta DSV-3G	11-Dec-1966	2	
Delta DSV-3H	Not built		
Delta DSV-3J	4-Jul-1968	1	
Delta DSV-3K	Not built		
Delta DSV-3L	27-Aug-1969	1	1
Delta DSV-3L-II	3-Feb1971	1	
Delta DSV-3M	18-Sep-1968	12	1
Delta DSV-3N	16-Aug-1968	6	
Delta DSV-3N6	11-Dec-1970	2	
Delta DSV-3N9	Not built		

Delta DSV flights

In the designation system, the first digit identifies the core stage and the strap-on boosters, while the second digit indicates the number of strap-ons used. The third digit identifies the second stage, while the final digit identifies the third stage. Not all combinations were used.

In the late 1990s, occasionally additional digits were added to the designation to indicate the diameter of the payload bay fairing in feet. There were 8', 9.5' and 10' fairings. The 10' fairing came in a 10 version (metal skin and stringer) a 10C (composite) as well as a 10L (lengthened composite) version.

#	Stage 1 engine	Strap on engine
0	1 Rocketdyne MB-3-III	none
1	1 Rocketdyne Thiokol Castor 2	MB-3-III TX-354-4
2	1 Rocketdyne Thiokol Castor 2	RS-27 TX-354-5
3	1 Rocketdyne Thiokol Castor 4	RS-27 TX-526-2
4	1 Rocketdyne Thiokol Castor 4A	MB-3-III TX-780-1
5	1 Rocketdyne Thiokol Castor 4A	RS-27 TX-780-1
6	1 Rocketdyne Thiokol Castor 4A	RS-27A TX-780-1
7	1 Rocketdyne Hercules	RS-27A GM 40
8	1 Rocketdyne Hercules	RS-27A GM 46

First + Second Digit — First Stage + Strap Ons

#	Engine
0	1 Aerojet AJ-10-118F
1	1 TRW TR-201
2	1 Aerojet AJ-10-118K
3	1 Pr & Wh. RL10B-2
4	1 Pr & Wh. RL10B-2 with 4 m tankage
5	1 Pr & Wh. RL10B-2 with 5 m tankage

Third Digit — Second Stage

#	Engine
0	No third stage
1	1 Thiokol TE-364-3
2	1 Thiokol TE-364-4
3	1 Thiokol TE-364-3
4	1 Thiokol TE-364-4
5	1 Thiokol Star 48B (PAM-D)
6	1 Thiokol Star 37FM

Fourth Digit — Third Stage

In 2006, Boeing proposed to re-designate the Delta 7xxx versions to Delta 2xxx. The re-designation was, however, short-lived as the Delta 7xxx format continued to be used in official documents.

Type	*First flight*	*Orbital*	*Failed*
Delta 1604	23-Sep-1972	2	
Delta 1900	16-Dec-1973	1	
Delta 1913	10-Jun-1973	1	
Delta 1914	10-Nov-1972	2	
Delta 2310	15-Nov-1974	3	
Delta 2313	19-Jan-1974	3	
Delta 2910	22-Jan-1975	8	
Delta 2913	9-Aug-1975	2	
Delta 2914	13-Apr-1974	30	
Delta 3910	14-Feb-1980	11	
Delta 3913	3-Aug-1981	1	
Delta 3914	13-Dec-1975	10	2
Delta 3920	16-Jul-1982	9	
Delta 3924	28-Oct-1982	5	
Delta 4925	27-Aug-1989	2	
Delta 5920	18-Nov-1989	1	
Delta 6920	1-Jun-1990	2	
Delta 6925	14-Feb-1989	15	
Delta 7320	24-Jun-1999	10	
Delta 7326	24-Oct-1998	3	
Delta 7420	14-Feb-1998	13	
Delta 7425	11-Dec-1998	4	
Delta 7426	7-Feb-1999	1	
Delta 7920	4-Nov-1995	29	
Delta 7925	26-Nov-1990	71	1

Delta xxxx flights (to 1 August 2011)
Two more Delta 7920-10Cs will be launched later in 2011

Delta 3

In 1995, **McDonnell Douglas** proposed to enlarge the family of Delta launch vehicle with the introduction of the Delta 3.

The ***Delta 3*** used the Delta 2 first-stage in combination with a cryogenic upper stage powered by a ***Pratt & Whitney RL10B-2*** engine. The basic version had nine strap-on solid fueled boosters built by **Alliant Techsystems,** of which six were ignited during the launch and another three during the flight. Other versions considered, but not built, carried three or six solid fueled strap-on boosters.

The Delta 3, also referred to as ***Delta 8930***, was launched three times between August 26, 1998, and August 23, 2002, of which one failed, while the other two launches provided unacceptable results. A number of vehicles had been built to meet orders for 18 launches but, with the poor results and the ***Delta 4*** coming into use, the remaining Delta 3s were scrapped and used as spares.

Delta 4

The ***Delta 4*** was **Boeing**'s successful response to the **U.S. Air Force**'s ***Evolved Expendable Launch Vehicle*** (**EELV**) program. Initially intended also for the commercial market, the weakness of that market made Boeing decide to concentrate on the military market only.

In the Delta 4, the first stage of the Delta 3 was replaced with a new *Common Booster Core*, driven by a *Boeing Rocketdyne RS-68* engine. This core is augmented with strap-ons and upper stages. The basic ***Delta 4*** Medium version, also known as ***Delta 9040***, has a 4m fairing and was capable of placing a 1300 kg payload into a geostationary orbit. The upper stage is powered by a ***Pratt & Whitney RL10B-2*** engine.

The *Delta 4 Medium+* ***(4,2)*** is similar to the Delta 4 Medium but with two ***Alliant Tech S GEM-60*** strap-ons. It is also known as ***Delta 9240***.

The ***Delta 4 Medium+ (5,2)***, or ***Delta 9250***, is similar to the Delta 4 Medium+ (4,2), but has a 5m diameter payload fairing for larger payloads and a modified second stage. This version has not yet flown.

The ***Delta 4 Medium+ (5.4)*** is similar to the proposed Delta 4 Medium+ (5,2) but with four strap-on boosters. This latter version is also known as ***Delta 9450***.

The first Boeing Delta 3 sits atop pad 17B at Cape Canaveral. Photo: Boeing

A United Launch Alliance Delta 4 rocket blasts off from Space Launch Complex-37 at 2:41 a.m. EDT on July 16, 2011 with the Air Force's Global Positioning System (GPS) IIF-2 payload. This launch marks the 50th successful GPS launch on a Delta vehicle. CREDIT: Pat Corkery, United Launch Alliance

In the ***Delta 4 Heavy***, also known as ***Delta 9250H***, the two strap-on boosters are the same as the Common Booster Core stage.

Type	First flight	Orbital	Failed
Delta 4 Medium	11-Mar-2003	3	
Delta 4 Medium+ (4,2)	20-Nov-2002	8	
Delta 4 Medium+ (5,2)	Not yet flown	0	
Delta 4 Medium+ (5,4)	6-Dec-2009	1	
Delta 4 Heavy	21-Dec-2004	5	

Delta 4 Flights to 1 August 2011

Further variants, which have not yet been built, are the ***Delta 4 Medium+(5,6)*** and ***(5,8)***.

There is also the proposed ***Delta 4 Small*** version which will consist of the Common Booster Core and the upper stage and, with a 3m fairing.

These new versions mean that the launch vehicle that evolved from the Thor missile will be around for quite some time to come...

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.

IP Over Satellite: Going Where Cables Can't Reach

by Simen K. Frostad, Chairman, Bridge Technologies

TV distribution over satellite to date has been primarily a linear, one-way service. As with traditional broadcasting over terrestrial networks, the linear model was enough to keep viewers satisfied — until there was an alternative. Now that viewers have shown such a strong preference for interactivity in their media consumption habits, the writing is on the wall for providers of linear services.

The rapid development of **Netflix** in the short time since its launch is the big wakeup call. Its growth has been astounding and it now accounts for as much as a third of all network traffic in the U.S. With streaming media services such as these rapidly gobbling up bandwidth on the web, and the research indicating that it does not take Netflix users long to switch the majority of their viewing time over to the service in preference to traditional

media services, consumers are demonstrating that the market has moved on and media providers are scrambling to react.

Part of the success and rapid take up of Netflix is due to the high quality of the images. This means that, even over a relatively slow link, users can receive broadcast quality video.

Artistic rendition of the Nilesat-201 satellite

When you connect that quality with IP-everywhere distribution you have a huge shift in paradigm from transporting broadcast media over all the different network formats like DVB-T, satellite, and cable. The attractions of 'any media, anywhere', combining real-time and on-demand content supply, and occasional media or OTT services, and full access to the web, are compelling.

Consumption of streaming, two-way services is rising rapidly, while growth in traditional media delivery services is static, or possibly even negative. Satellite service operators are keen to exploit the potential, and adventurous **IP-over-satellite** operators may even come up with a better business model than traditional media suppliers.

IP-over-satellite throws open most of the potential of two-way communication, making it possible to deliver real-time linear broadcasting, on-demand content and OTT services via satellite. The technology creates an opportunity for satellite providers to use their capacity to deliver a user experience that is comparable to what's available via wired broadband.

National infrastructure projects in the Middle East and the launch of new satellites such as Egypt's ***Nilesat 201*** indicate the growth potential of satellite networks for remote areas, widely-dispersed communities, or even urban areas that lack a developed cable infrastructure. In locations such as these, the digital access gap is already large and growing, and while in the remote areas there is no possibility of creating a cost-effective cable infrastructure, there is still vast potential in more populous urban areas where cables may eventually be laid: Here, the satellite providers have the ability to jump the gun and deliver comparable services now, rather than wait years for the cables to be laid and meanwhile risk falling farther behind.

Governments are keen to ensure that their populations do not miss out or become polarized between connected and unconnected communities. The priority for them is to ensure widespread access both to digital media and to the Internet. For those countries with significant proportions of the population in rural areas, it's important to ensure those communities have access, to encourage the development of connected businesses as well as the sense of social connectedness.

It's not just in the 'developing' countries that the potential lies for satellite providers: Many European nations have large areas of relatively inaccessible terrain where cable infrastructure is lacking. The mountainous regions of countries such as Greece and the interior of Spain are both benefitting from government-sponsored IP-over satellite programs aimed at bringing remote communities into the connected world.

The other great IP-over satellite growth area is the mobile market, both consumer and professional. Sectors of industry such as mining and exploration, renewable power generation, and transport all require, as any business does today, to be connected to the net, and when employees are in remote locations access to entertainment is increasingly seen as a requirement rather than a luxury. The mobile hospitality industry, too, is under pressure to match the facilities its customers enjoy at home, giving cruise and airline passengers more of a connected and interactive experience.

About the author
Simen K. Frostad is the Chairman of Bridge Technologies.

Remote Fault Resolution

Reaching remote and dispersed audiences via satellite is one challenge, but providing the right quality of service is another thing altogether. What happens for example, when a cruise ship in mid-ocean reports a service-affecting problem with its Internet access and media service? Or when an oasis village in the Egyptian desert experiences loss of audio? Engineers can hardly pay a timely visit to the subscriber to resolve the problem, and the potential cost of maintaining service quality to remote communities is a serious obstacle to the growth of the sector.

There is now a technological solution for this too, in the form of Bridge Technologies' microVB, a miniature monitoring probe that can be user-installed at the set top box and that allows operators to remotely gather complete 24/7 information on the all data streams at the set top box. This gives operators the ability to analyze every packet passing through the STB and gives a better view into every factor influencing service quality than the traditional site visit by an engineer. The ability to remotely diagnose any service-affecting problem in the subscriber's home network — when that may be hundreds or even thousands of miles from the provider's nearest base — means that maintenance can be cost-effective and problems can be resolved quickly. Zero-touch installation, network self-registration, and non-intrusive operation make the microVB the first viable solution for monitoring at the STB, and helps deliver end-to-end monitoring as a practical reality. All data on parameters such as packet loss and jitter statistics are gathered with one-second granularity, using standards-based protocols, and when the data is correlated with information from other probes in the delivery chain it offers operators complete trail for fault tracking. The live data can be analyzed at any remote location, allowing the operator to see exactly what the viewer sees, and enabling alternative forms of analysis, capture and store, and other uses such as presentation to provider partners for use in SLA agreements.

Mobile Satellite Services

Mobile Satellite Services (MSS) is a sector with tremendous growth potential, and this is reflected in market data that shows the sector emerging from the recession faster than the rest of the satellite market, according to NSR (www.nsr.com). Providers in the sector have taken their lead from consumers and are racing to deliver the killer app — data. The global MSS market is expected to grow to $10.2 billion in 2020, more than doubling from its current volume. MSS operators have grown more than 8 percent in the past year while FSS VSAT operators have seen their share of the satellite mobility revenues top the 20 percent mark. MSS targets include the maritime market, where both industrial and leisure shipping needs Internet access and media services. The airlines, outdoor consumer and professional markets are the other main growth areas, in addition to the base of military and governmental users.

Monitoring Broadband, IPTV + OTT

The complex nature of the services that can be provided via IP-over-satellite means that the task of monitoring quality of service is more of a challenge that it is for simple linear satellite services. When the service includes linear broadcast, content on demand, and OTT services together with net access, providers need a solution that can deliver comprehensive monitoring data on all the streams. The Bridgetech system is available with a Traffic Analysis option that provides in-depth advanced monitoring and analysis of IP protocols and services, combining detailed monitoring and analytics of broadcast/IP streams and all OTT services under a single unified Bridgetech environment with consistent display and reporting features.

Executive Spotlight

Stuart Daughtridge,Vice President, Integral Systems

Stuart C. Daughtridge is Vice President of Advanced Technology and Business Development for Integral Systems, a Kratos Company. Daughtridge joined Integral Systems in 1999 and has been instrumental in developing the Company's full line of satellite communications products and services. Before joining Integral Systems, he held several management positions in the spacecraft engineering and satellite operations division of Orion Satellite Corporation (acquired by Loral Space & Communications), including Director of Satellite Operations. Prior to Orion, Daughtridge was a spacecraft engineer at Intelsat, and Contel Spacecom. He holds a Bachelor of Science degree in Electrical Engineering from Lafayette College.

SatMagazine (SM)
Mr. Daughtridge, you have enjoyed a number of management positions with leading companies, such as Intelsat, Orion Satellite Corp, and Contel Spacecom where you worked on NASA TDRSS system as a spacecraft engineer. What drew you to Integral Systems (now Kratos Integral Systems) in 1999?

Stuart Daughtridge
I actually first encountered Integral Systems as a part of an acquisitions process I was involved with earlier in my career. I remember being extremely impressed with the quality and expertise of the people. As I remember it, Integral Systems actually wasn't selected for that project, but the class they showed afterward in some additional discussions we had with them really impressed me. Some time later, when Loral bought Orion, I decided, for personal reasons, to move on in my career. Frankly, I was not really looking for a job in the ground systems side of the business, however I met with executives from Integral Systems and came away impressed again, primarily due to the Company's people and their approach to business.

SM
In July, Kratos Defense and Security Solutions announced the acquisition of Integral Systems. Now that the acquisition is complete, how have things changed?

Stuart Daughtridge
Kratos is a leader in a number of technologies highly related to what we do at Integral Systems. The Company has reached into organizations, especially government and defense organizations, where Integral Systems did not have access. Now as Vice President of Advanced Technology and Business Development I have a new role that works to capitalize on both of those strengths. My primary responsibility is to look across our solution sets to coordinate the research and development and new product development efforts for our existing markets and to help in development of new markets.

By the way, in just three months, we are already seeing the benefits of the merger. We have better aligned our products and services to meet the specific needs of our various customer groups and are working closely with Kratos engineers and business development teams on a variety of opportunities.

SM
For some time now Integral Systems has been working actively on the satellite interference problem. How is the battle going?

Stuart Daughtridge
Satellite interference, or RF Interference (RFI), is a major problem. Not only is it a burden on the end user in terms of lost productivity and service, but it also has a direct impact on the revenue and profits of satellite operators, broadcasters and service providers. To combat the growing problem, we are constantly enhancing our Monics®, SAT-DSA® and satID™ RFI analysis, detection and geolocation product lines. Some of the latest enhancements include:

- **Monics is now able to detect and characterize RFI on carrier-in-carrier service such as DoubleTalk, even with the newer modulation types.**

- **Greater integration of our products to provide a lower cost, all-in-one RFI mitigation system that monitors, detects, characterizes and accurately geolocates signals that the customer can use as product or a managed service.**
- **Improved accuracy and ease-of-use in our industry-leading satID geolocation product line.**

SM
On a number of occasions in 2011 you have discussed the issue of managing remote sites. Why is this important to our readers? What specific steps can they take to help cut costs and increase efficiencies?

Stuart Daughtridge
Most satellite operators and their customers have remote site operations (manned and unmanned). Effective management of these remote sites is important because it can reduce operating costs and outage times, as well as improve Quality of Service (QoS). To address these issues and increase total network efficiency, many satellite operators have deployed Newpoint Technologies' COMPASS Network Management System (NMS) and its recently introduced Mercury G3 Remote Site Manager. Mercury G3 with COMPASS provides complete visibility and control into the entire remote site, including all site equipment (antenna, RF equipment, modems, routers, UPS, generators, door status, security systems including video feeds, etc.). The visibility and control capability reduces the impact of equipment failures, since most problems can be resolved remotely, thus eliminating the need for unscheduled visits.

COMPASS also provides intelligent alarming and recovery capabilities that allow operators to quickly, and in many cases automatically, recover services after a failure at the remote site. In addition, COMPASS Service Manager understands what services are being provided by the system and their value. This information gives operators the ability to focus on recovery of the service, instead of having to focus on the recovery of the failed equipment. By focusing on the services and not on the hardware, COMPASS Service Manager gives operators the tool they need to maximize revenue and control achievement of SLA (Service Level Agreement) requirements. COMPASS also provides other advanced capabilities to drive down operating costs, such as being able to operate over very low data rates links and by supporting multiple in and out-of-band communications methods, including Internet and satellite phones.

SM
What technologies will play the most important roles in the SATCOM industry over the next year or two? Why?

Stuart Daughtridge
One key trend in the industry is the growth of, and transition to, small, light weight transportable Comms-on-the-Stop and Comms-on-the-Move (COTM) solutions. Integral Systems is working on technologies that are key to the realization of these capabilities:

- **We have recently released a line of powerful and ultra efficient Solid State Power Amplifiers (SSPAs) that have the lowest size, weight and power requirements of any amplifier in the industry. These units can be configured as form, fit and function replacements for less reliable, low power Traveling Wave Tube Amplifiers (TWTAs).**
- **Our line of Raptor USAT deployable communications systems can be hand carried onto an aircraft and fit into an overhead bin providing over eight Mbps of Ku-band throughput.**
- **To further meet the needs of first responders and the military, we also have introduced a full line of cased products that range from LAN/WAN network solutions to Small End Office (SMEO) systems.**

It is the integration of Information Technology (IT) from the terrestrial network with Operations Technology (OT) of the satellite network. Typically, terrestrial network management systems like HP OpenView do not have visibility into the status of the satellite portion of integrated terrestrial/SATCOM networks. With our integrated solution, we will be able to provide full visibility and management of the entire network, from the terrestrial cloud, through the teleport and the satellite RF links themselves on a single consolidated network management system. The data display can then be customized to the display the level of information each organization needs to most effectively manage their systems. That is real situational awareness with a true 360 degree view that will drive cost efficiencies and improve QoS to customers.

The transition of the maritime SATCOM COTM market from relatively expensive Inmarsat L-band services to far more cost effective C- and Ku-band fixed satellite services has been a major COTM trend in the industry. It creates an order of magnitude cost savings for maritime operators. Our SATCOM Solutions Division (formerly CVG/Avtec Systems) provides small 1.2m terminal solutions to both the U.S. Navy for the CBSP program and the U.S. Coast Guard for their large cutter fleet.

Another trend builds on something I mentioned earlier, the importance of effectively managing remote sites. This can be applied to COTM network environments as well. End users should be able to achieve the benefits without losing focus on their primary job or mission. After all, these users typically don't know much about SATCOM or the remote system, nor do they want to, frankly. For example, our COMPASS product is currently being used to automatically set-up, configure and remotely manage VSAT systems in Iraq. All the warfighter has to do is deploy the antenna and push a button. COMPASS then takes over, establishing a low data rate out-of-band connection with the NOC. System experts are then able to remotely configure (and troubleshoot if necessary) the system and set up the high data rate communications network.

SM
Are there any upcoming Integral Systems projects you are at liberty to discuss that would offer readers a sense of the Company's direction over the next year?

Stuart Daughtridge
A lot of my focus will be on continuing to improve on our offerings, especially by leveraging expertise and technologies from one area to innovate solutions in others. An integration project that we recently kicked off is particularly exciting. It involves the integration of our COMPASS NMS and Monics carrier monitoring systems with Kratos' NeuralStar Enterprise Network Management product. This integration allows us to create an end-to-end network monitoring capability beyond anything that currently exists in the industry.

SM
Given the international scope of business these days, how does Integral Systems successfully compete and operate in this environment?

Stuart Daughtridge
You are absolutely right. Ours is truly a global market and Integral Systems has always been fortunate to have a significant part of our business come from international markets. We stay visible and responsive to our global customers especially through our Integral Systems Europe (ISE) division, and we are well established in Asia and Latin America where we have seen strong growth. Satellite operators and services providers in all regions continue to see already tight margins squeezed by market pressures. They need technologies that cut costs, increase operational efficiencies, enhance QoS and enforce SLAs just to survive. Our commercial-based products, solutions and services are well positioned to meet these demanding requirements.

We recently expanded our international footprint by adding a subsidiary to ISE in England and opening an office in India. The team in England provides us a strong RF and antenna integration capability that we were lacking for the international market. This helps round out our capabilities to be able to provide our customers' end-to-end, fully integrated ground segment solutions.

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Disruptive Changes in the Satellite Space
Monday, 16 January 2012 / 1400 – 1530

Moderator:
SUSAN IRWIN, President, Euroconsult USA, Inc., *USA*
Panelists:
MARK DANKBERG, CEO & Chairman, ViaSat, *USA*
LEO MONDALE, Managing Director, Global Xpress Program, *Switzerland*
(more panelists to be confirmed)

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Interorbital Fosters Small Satellite Research Surge

by Randa Relich Milliron, Interorbital Systems CEO + Founder

Since late 2009 when rocket manufacturer Interorbital Systems (IOS) introduced its low-cost ($8,000) TubeSat Personal Satellite Kit and Launch package to the academic world, an unprecedented number of experimenters — many of whom would never have hoped to find the means to conduct on-orbit research — are now finishing the orbital applications, experiments, and the completion and testing of their own 40+ spacecraft. All these payloads — both TubeSats and CubeSats — are projected to launch on IOS' *NEPTUNE 9* (N9) rocket in the Spring/Summer window of 2012.

"It's a whole new, wildly expanding market. We had planned to conduct our first orbital effort with our five-module 30kg-to-LEO rocket, but that payload space sold out so rapidly that we've moved to a nine-module, 60 to 70kg-lift configuration, the NEPTUNE 9 or N9. We saw the pressing need for a dedicated and adaptable small sat launcher emerging over four years ago and are now meeting that need with our NEPTUNE family of modular rockets," Interorbital Systems CEO/Founder *Randa Milliron* stated.

One of the keys to making this groundswell of entry-level satellite developers possible is IOS' line of low-cost modular rockets. In terms of new rocket and satellite design, modular is the hot new buzzword — not only in creating flexible and affordable space launch architectures, but also, in the design, deployment, and new uses of satellites. Instead of relying exclusively on monolithic, multi-ton, billion-dollar satellites, both satellite service providers and manufacturers are now taking the small satellite phenomenon seriously. CubeSats and Interorbital TubeSats, a subset of small satellites, are relative newcomers in the world of satellite design and manufacture.

They are a disruptive satellite technology that represents not only drastically reduced mass and size, but also a change in mindset: A new design philosophy about what kinds of technologies are needed to perform a space mission. Constellations of nano-and picosats, and distributed and 'fractionated' satellites are thought to be the next big innovation wave. The science, research, and military space communities faced with downsizing budgets are looking for new satellite architectures to complement the existing massive satellite designs to reduce costs, development time, and mission risk. In commercial space there are active constellations using microsatellites weighing in at just 12 kg performing merchant ship monitoring services. In military space, DARPA and other DoD organizations have dedicated programs for using groups of on-orbit small-sat modules as fractionated systems, platforms for distributed computing, and networked nodes in mobile arrays. There are new satellites in town, and unlike their "big iron" cousins, they can be held in the palm of your hand. What is needed to fully realize the potential of small and particularly nano-and-pico satellites is a new low-cost dedicated rocket to launch them, on-demand… Enter the ***NEPTUNE***!

NEPTUNE-Series (N-Series) Rockets

Interorbital Systems, based in Mojave, California, since 1995, is developing a family of responsive modular, low-cost, orbital and interplanetary launch vehicles — the NEPTUNE or N-Series — that enable access to space for the private, government, military, and academic sectors. The primary design criteria for these rocket systems were minimized development and manufacturing

Image copyright Bryan Bersteeg

costs, maximum robustness and reliability, and a nimble adaptability of form that could meet nearly every type of space launch mission requirement. The IOS design methodology required eliminating unnecessary, expensive, complex, failure-prone, or performance-limiting systems such as turbopumps and stand-alone pressurant systems. The key building block of the N-Series is the *Common Propulsion Module*, or **CPM**. A minimum of nine (9) CPMs is required for IOS' first three-stage modular launch vehicle.

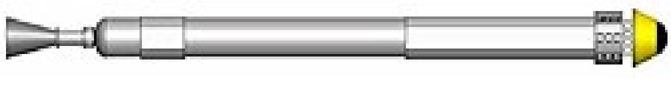
N-Series rockets are powered by high-density storable propellants (white fuming nitric acid, turpentine, and furfuryl alcohol; this combination results in compact launch vehicles that are easy to transport, store, and hold in a state of readiness. Because the N-Series storable rocket propellants are hypergolic and ignite on contact, a separate ignition system is not required, increasing the overall reliability of each module's propulsion system through an ensured, instantaneous chemical ignition.

For the last 15 years, Interorbital Systems sought ways to create a rocket and launch system that could deliver true launch-on-demand. The elements in this system include:

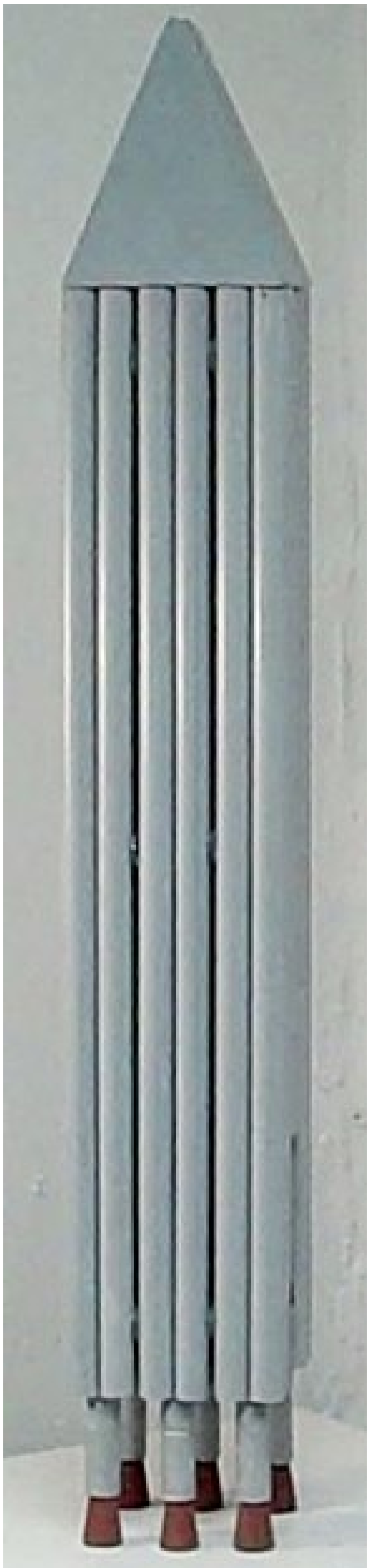
— One, or more, private spaceports
— Assembly-line production methods that allow quick construction of the individual CPMs (modular rocket building blocks), resulting in the ability to rapidly assemble low-cost multiple-CPM launch vehicles
— Introduction of a small satellite developer's kit (linked to a guaranteed launch opportunity) that serves as a gateway for a constantly expanding launch-customer base. At present, Interorbital has all components in place and is about to begin its pre-orbital flight test program.

Orbital launch plans include ocean-based services off the coast of California, followed by land-based operations in the South Pacific kingdom of **Tonga**, once launch services are sanctioned by US export control. Potential U.S. ranges for satellite launch activity include **Kwajalein**, **Kodiak**, and **Wallops Island.** IOS' California-based launch operations will take place from several possible staging areas: Either from one of two ports in Northern California, or from the **Port of Long Beach** in Southern California. To mitigate risk of systems failure without the expense of a full-up launch vehicle test flight, Interorbital will launch test vehicles adapted from individual CPMs in a series of low-altitude flight tests under *FAA Class 3 Waiver* to verify the function and robustness of both hardware and software. Three test flights are planned for 2011-2012.

What will the entry of IOS' disruptive new rockets into the launch market mean? Dr. *Dino Lorenzini*, a pioneer in the micro- and nanosat markets with his satellite and space hardware manufacturing company **SpaceQuest** — known for rapid turnaround of spacecraft and ***AprizeSat*** constellation of AIS monitoring microsatellites — commented on the advent of Interorbital's N9. "I believe Interorbital Systems can fill a critical need in the small satellite launch market as there are



Common Propulsion Module (CPM)



no other U.S. companies with a viable plan to place 45 to 100 kg in low Earth orbit. The opportunity to book dedicated launches to specific orbits on a given schedule, and do it from US territory at an affordable price, is the Holy Grail for the small satellite launch industry."

Interorbital Systems Test Vehicles

IOS suborbital test launches using single CPMs will verify all rocket systems before an orbital launch is attempted. By using these individual inexpensive modular testbeds, rather than the full-up launch vehicle, development and debugging costs are substantially reduced.

CPM TV Common Propulsion Module Test Vehicle is the flight test vehicle for a series of low-altitude (25,000-50,000 ft) rocket and launch systems tests, including recovery. This first CPM TV is unguided and fin-stabilized. The tandem-tank version of the CPM TV (pictured right), and the four-tank CPM TV II system (illustration shown above) are currently under development. The four-tank CPM TV II will initially be used in the second set of flights to test the guidance system, engine start/stop capabilities in flight, satellite ejection system, and other hardware and software in-flight tasks. At present, there are five payloads booked for these suborbital test flights: The **Naval Postgraduate School**, **Morehead State University**, and **KAUST** (**King Abdullah University of Science and Technology**).

Interorbital Suborbital Launch Vehicle

A single CPM launch vehicle can be used as a stand-alone sounding rocket or as a target drone. The CPM SR145 is a full-performance CPM capable of carrying 145kg to 310km in a ballistic trajectory.

Orbital Launch Vehicles

IOS orbital launch vehicles consist of three or four stages. The parallel method of staging is utilized. Each stage peels off the outside of the rocket, revealing the other stages nested inside the outer cluster. This results in a rocket with lower length-to-width aspect ratio making it less susceptible to wind shear and bending moments. Since all the launch vehicle's engines are positioned side-by-side, air-starting of the stages is simplified by allowing the next stage to ignite while the previous stage is still burning, eliminating the need for propellant settling rockets. The minimum configuration for a three-stage version is 9 CPMs. Several versions will be available to match specific mission requirements. The number of CPMs can vary from the minimum nine to as high as 36.

IOS N9 is a nine-module, three-stage rocket with a 60-70-kg lift to 310 km LEO. (N9, 9-CPM rocket, pictured left). The Stage-3 CPM has start-stop capability (using the auxiliary control system), allowing the N9 to deliver 20 kg to a 2,000 km circular orbit. Each N9 has six Stage 1 CPMs, two Stage-2 CPMs, and one Stage-3 CPM. The six Stage-1 CPMs generate 60,000 pounds of thrust; the two Stage-2 CPMs generate 14,400 pounds of thrust; the single Stage-3 CPM generates 7,200 pounds of thrust. This orbit was chosen to mitigate space debris — all satellites will re-enter Earth's atmosphere and burn up after an orbital lifespan of from three weeks to three months, depending upon solar activity.

It was Interorbital's President/Founder and CTO *Roderick Milliron* who decided to go one step beyond designing a new launch vehicle: He also provided a satellite kit that would serve as a gateway for those citizen scientists and academics who wanted to build a spacecraft that would not just become a fancy paperweight, but could be expected to be launched and to do important scientific work in space.

Rod explained, "I realized that not everyone wants to, or is able to do, the engineering required to build a satellite from scratch; nor do many people feel up to the challenge of entering the launch industry labyrinth and fighting for a nearly non-existent payload space or launch opportunity. I decided to streamline the process for them, and created the TubeSat Personal Satellite Kit and Launch concept."

After interfacing with the small sat community he found that people and organizations would much rather do the work of creating applications for a pre-existing orbital platform. IOS has simplified the process through the one-stop-shopping aspect of its TubeSat Kit and Launch program.

While many single-unit (1U) picosats have signed up for IOS launches, more elaborate small-sat configurations are being added to future manifests. The N9's deployment unit can accommodate up to triples (3U) in both Tube and Cube form-factors. Kirk Woellert, Head of Washington DC Operations for IOS, said, "The three-unit CubeSat is a popular form-factor, since at current payload technology levels it provides the most utility for that standard. Many of the current U.S. launch providers quote rideshare prices in terms of one CalPoly P-POD delivered to orbit. At the 2011 NRO-NASA Small Payloads Rideshare conference, several of the current launch providers quoted their prices and the average for a P-POD was about $325K. We launch CubeSats for a fraction of that price. We think this will spur new nanosatellite developers to enter the nanosatellite market."

As of August, Interorbital introduced its new CubeSat Kit: Academic pricing per a 1U CubeSat Kit and Launch is $19,125. As there is high risk on the first launch, all payloads will fly at the academic rates. A two-tiered (academic and non-academic) price schedule will go into effect later this year. IOS is committed to keeping student project launch costs low and will strive to maintain the $8,000 academic price of its TubeSat kit and launch package.

Tubesat with sample ejection cylinder

So, now, just who's on-board?

The list of confirmed co-manifested CubeSat and TubeSat payloads on Interorbital Systems' first NEPTUNE 9 orbital launch follows:

CubeSats:

- **UC Irvine, UCISAT1**
- **Google Lunar X PRIZE (GLXP) Team EuroLuna, Romit 1 (2U from Denmark)**
- **FPT University, Vietnam, F-1 CubeSat**
- **Nanyang Technological University, Singapore**
- **King Abdullah University of Science and Technology (KAUST), Saudi Arabia/US (2**
- **IOS CubeSat Kits)**
- **Google Lunar X PRIZE Team PLAN B (Canada)**

TubeSats (constructed from Interorbital Systems TubeSat Kits):

- **Morehead State University (Kentucky Space), TubeSat plus 2 payloads on suborbital test flights**
- **InterAmerican University of Puerto Rico**
- **University of Sydney (Australia) iINSPIRE Program (2)**
- **Aslan Academy (Private Los Angeles, California High School)**
- **Project Calliope (Space Music Project)**
- **Universidad de Puerto Rico / Marcelino Canino Canino Middle School: Micrometeoroid impact study**
- **GLXP Team SYNERGY MOON: Communication Hardware tests**
- **GLXP Team Part-Time Scientists / Fluid & Reason Software (2)**
- **Naval Postgraduate School (3) (Ad hoc orbital communication nodes) plus 2 payloads on suborbital test flights**
- **Defense Science and Technology Lab (DSTL, U.K.)**
- **Austrian arts program from mur.at with MURSAT United States Military Academy at West Point (2)**
- **Brazilian Space Institute/ 108 5th-7th Grade Students, Ubatuba, Sao Paulo, Brazil**
- **Mexican Satellite Project: ULISES / Soccer Opera from Space**
- **TriVector Services, Huntsville**
- **AKQA (All Known Questions Answered) Advertising, San Francisco**
- **La Despensa (The Pantry) Advertising Agency/Iniciativas en Idiomas (Madrid, Spain)**
- **Earth to Sky's Project: The Golden iPod-Voyager Updated! Bishop, California (2)**
- **KAUST Saudi Arabia/US, TubeSat plus 1 payload on suborbital test flight**
- **University of Sao Paulo, Brazil (2)**
- **Institute of Advanced Media Arts and Sciences/The Science Project, Inc., Japan (7)**
- **NASA IV &V Facility, West Virginia (2 TubeSats; 1 CubeSat)**
- **Galaxy Global, 1 TubeSat, donated to NASA Educational Program**

Twenty additional projects with committed payloads are in various phases of arranging funding. These include academic, arts, private-sector, military, and corporate groups from the U.S., Peru, Mexico, Singapore, Chile, India, Hungary, Germany, Pakistan, New Zealand, the Dominican Republic, Holland, South Africa, and France. The list of those seeking passage on a dedicated launch grows daily.

The payloads and applications of these small sats are truly many and varied, ranging from academic, to arts, to military, to pure space science, to music, even projects that are destined for the moon! Four ***Google Lunar X PRIZE*** teams have test payloads on Interorbital's maiden launch: Canada's ***PLAN B***; Denmark's ***EUROLUNA***; Germany's ***PART-TIME SCIENTISTS***; and IOS' official team: *SYNERGY MOON*.

Confirmed N9 Payloads

Other payloads on the IOS Mission I manifest include both TubeSats and CubeSats from the *NASA Independent Verification and Validation* (**IV&V**) *Facility* in West Virginia. *Marcus Fisher*, Associate Director of IV&V, is interested in getting multiple spacecraft into orbit so his team members can explore **SWARM** concepts and robotic applications, including creating software that runs as an intelligent fault manager/in-flight decision maker, and in another set of experiments, remotely controls manipulators and attitude control systems.

- **FPT University, Hanoi, Vietnam, will fly its F-1 CubeSat, an educational picosatellite being developed by the University's FSpace Laboratory, to provide students training in aerospace engineering applications. The satellite measures 10x10x10cm and weighs 1kg, and carries a low-resolution camera (640x480 pixel) to take photos of the Earth, as well as a magnetometer and several temperature sensors to study the space environment. Team leader: Thu Vu Trong**
- **The Golden iPod is a modern version of Voyager's Golden Record, with a 16GB storage capacity. It is a project of Earth to Sky, spaceweather.com, a group of Bishop, California, middle school and high school students, and Dr. Tony Phillips.**
- **Mexico's Space Opera: Juan Diaz Infante's PLAY Festival brings the world ULISES I Sat, the platform for a Space/Soccer Opera Project, Mexico City**
- **TRACsat – TriVector Radiation and Attitude Control Satellite from TriVector Services, Inc., Huntsville, Alabama. Fundamental to many satellite missions is positioning the satellite in a desired orientation in orbit. The TRACsat aims to use simple electronics to determine the attitude of a nanosatellite in orbit.**
- **The University of Sydney will fly the i-INSPIRE (initial - INtegrated SPectrograph, Imager and Radiation Explorer) satellite, which is intended to be Australia's first University satellite to be launched and operated in space. It will carry a novel photonics-based spectrograph, an imaging camera, and a radiation detector. The team is led by Dr. Xiaofeng Wu and Iver Cairns. Scientific goals include (1) analyzing the first spectra from a space-borne, photonics-based spectrograph, and identifying features related to the Earth, Sun and radiation events, (2) obtaining first images of Australia from an Australian satellite, and (3) obtaining radiation maps of the Earth to compare with space weather events and spectrograph data.**
- **The Ultimate STEM programs: Brazil's Ubatuba-Sat and University of Puerto Rico/ Marcelino Canino Canino Middle School. Both programs give hands-on training to children in the design and manufacturing of satellites. In Ubatuba, the 108 students, average age 11, compete to build the best TubeSat mock-up. The team with the best mock-up gets to build the actual spacecraft. Their program is the brainchild of Emerson Yaegashi and Candido Osvaldo. The Puerto Rican group is already known in NASA circles for the launches they've already conducted in partnership with the agency. Their aggressive spaceflight program, which will use a TubeSat to measure micro-meteoroid strikes in the 310km orbit, is led by Gladys Munoz and Oscar Resto and is part of the Puerto Rican Space Grant Consortium.**
- **Military payloads from the U.S. Military Academy at West Point, the Naval Postgraduate School in California and the U.K.'s Defense Science and Technology Lab**

GLXP Confirmed N9 Payloads

- will conduct on-orbit tests and experiments that encompass many communications functions using small sats in creative ways such as ad hoc orbital nodes for ground-to-space communication links, Earth imaging/ surveillance, and software/hardware viability testing.
- **Arts-Meet-Science payloads from Austria's MURSAT and Dr. Sandy Antunes' Project Calliope add satellites with art, music, and photography as their core missions. Sandy wants to sonify the ionosphere and send back sounds for composers to freely use in musical works. MURSAT will serve as an Earth imaging system for the Austrian teams' art project.**

The other projects on-board encompass military, communication, pure science, formation flying, tethering, propulsion system testing, advertising/social media experimentation, and many more exciting areas of on-orbit research. Please visit www.interorbital.com for links to all satellite projects on the current IOS manifest.

Customized Missions

Interorbital is currently in negotiations for dedicated launches using the ***N9*** ($695,000 academic) ($995,000 nonacademic) and the follow-on ***N36*** ($15-$20 million) variants of the modular rocket system.

N36 is a 36-CPM, three-stage satellite launcher with a 1000kg lift capability. A four-stage (*Lunar Transfer Stage*) version will be used for lunar missions (CPM with lander/payload is *Stage 4*) and the Google Lunar X PRIZE. ***N36 Heavy*** is IOS' modular evolution to heavy-lift. It will consist of 36 modules with larger diameter and higher thrust engines — second-generation CPMs. This launcher is currently in the planning stages.

Interorbital Systems' Related Projects

Interorbital Systems is currently an official entrant in the $2 million ***NASA NanoSat Challenge***, and the $30 million ***Google Lunar X PRIZE*** as launch provider for, and team member of, SYNERGY MOON. Agreements with other GLXP teams are already in place for flying LEO test payloads, with several TLI missions pending.

The Future

Using nanosats and picosats at all levels of space research has been found to be effective and affordable, and as a result of many successful missions worldwide, both interest and participation in using these form-factors are growing. In 2009, the task at IOS was to drive the costs of space-access down to an entry point at which a parent with a credit card could buy a child his or her own personal satellite and launch. That price level has been achieved. The future of the small satellite is bright. Interorbital Systems is an active player in this revolution.

CEO Milliron stated, "The level of excitement and anticipation of our first full-scale launches is almost impossible to describe. We, and the launch partners flying with us, can see and feel the effects of our efforts: Scores of new science and arts payloads readying for lift-off; affordable LEO launch-on-demand becoming a reality; orbital access for all — these are the inestimable rewards of re-shaping the future of the space launch and satellite industry!"

MODULAR ROCKET SYSTEMS

Each member of the NEPTUNE Modular Series of launch vehicles is assembled from multiple Common Propulsion Modules (CPMs). Payload capacity can be varied by increasing or decreasing the number of CPMs.

COMMON PROPULSION MODULE

Each Common Propulsion Module is composed of two tandem propellant tanks and a single throttleable, ablatively-cooled rocket engine. Depending on the configuration, the modules can operate in either blowdown or pressurant tank-fed modes. The capacity of the propellant tanks is regulated by varying their lengths. Construction costs are kept low by utilizing many off-the-shelf components and state-of-the-art assembly line methods.

LIQUID ROCKET ENGINES AND PROPELLANTS

A single fixed, throttleable, low-thrust, liquid rocket engine powers each CPM. When the CPMs are clustered in multiples of three or four per stage, differential throttling of opposing rocket engines provides pitch, yaw and roll control. Stand-alone CPMs will be steered by four small gimbaled vernier rocket engines. Storable, high-density white fuming nitric acid (WFNA) and turpentine/furfuryl alcohol are the CPM's primary propellants. These low-cost, storable, environmentally friendly propellants provide reliable, efficient, hypergolic ignition.

AERODYNAMICS

The aerodynamic properties of the uniquely configured NEPTUNE Modular Series rockets have been extensively analyzed. Data shows the thrust to drag ratio is acceptable with values less that that of the Space Shuttle. In general, the rockets follow a slow build-up of velocity in the region below 10 km (32,800 ft.), reaching Mach 1 at between 25,000 ft. and 35,000 ft. with the rocket's velocity just rising above Mach 4 at an altitude of 33 km (110,000 ft). At this altitude, the atmospheric pressure is extremely low (only 0.125 psi) (sea level pressure = 14.7 psi). Since orbital velocity is around Mach 25, the majority of the acceleration (90 percent) takes place outside of the denser parts of the atmosphere where the drag is extremely small.

MULTIPLE ENGINES

Launch vehicles with multiple engines have been in use since the beginning of the space age. The Saturn 1B had 8 booster engines, 6 stage two engines, and 2 stage three engines (a total of 16 engines). The Soyuz three-stage rocket has a total of 34 engines, with the upper stage engines included.

CPM TV on Mobile Launcher during lift test at Mojave Air and Space Port

When looking at the the engine view of the NEPTUNE Modular series rockets, one sees not only the booster engines, but also all of the upper stage engines. This is due to the parallel staging configuration. With the standard stacked stage configuration, the upper stage engines are not visible. On the previous page is an engine view of the Soyuz launcher with 32 booster and vernier engines. The Soyuz rocket is one of the most reliable rockets in the world.

NEPTUNE 9 (N9)
The modular NEPTUNE 9 or N9 is a three-stage (parallel-staged) dedicated small-satellite launch vehicle capable of lofting a 60-70kg payload into polar low-earth orbit. It is a 9-Common Propulsion Module (CPM) rocket. (The flight configuration engine and module count breaks down to six CPMs = Stage 1; two = Stage 2; and one CPM = Stage 3). N9 is designed to support TubeSat, CubeSat, and all other small-sat community requirements. Plans for the rocket include "batch" launches of 40+ picosats at a time beginning in 2012.

NEPTUNE 36 (N36)
The NEPTUNE 36 or N36 is a four-stage (parallel-staged), medium-lift launch vehicle capable of placing a 1000-kg payload into polar low-Earth orbit or accelerating a 200-kg payload to Earth-escape velocity. The rocket is composed of 36 Common Propulsion Modules. In its four-stage form, the NEPTUNE 36 is slated to launch the Google Lunar X PRIZE SYNERGY MOON lander/ rover (Stage 4) to the Moon. It will also be used to launch a two-person crew module (CM-2) into low Earth orbit for short orbital tourism missions. The crew module (CM-2), presently in development, is Stage 4 in the space tourism configuration.

NEPTUNE 36 Heavy (N36 Heavy) in planning phase...
The Neptune 36 is a four-stage (parallel-staged), heavy-lift launch vehicle capable of placing a 4000-kg payload into low-Earth orbit or accelerating 760-kg payload to Earth-escape velocity. The rocket is composed of 36 higher-performing, second-generation Common Propulsion Modules. It will serve as IOS's primary six-crew Orbital Expeditions space tourism and heavy–lift launcher.

Rocket flight test roll-out at sunset, Mojave

CREW MODULE 6
The CM-6 is designed to accommodate five expedition crew members and one command pilot. The six-person crew will be seated radially around a centrally located service compartment access hatch. Each crew member has a window providing excellent visibility. The CM (*photo at top of next page*) is attached to the forward section of the rocket and has the following primary components: Emergency escape system, life-support system, electric power system, docking collar, retro-rocket de-orbit system, attitude control system (ACS), parachute recovery system, and an aft heat-shield for reentry.

CREW MODULE ESCAPE SYSTEM
The CM is equipped with set of four aft-mounted liquid rocket engines. In the event of a catastrophic failure of a major rocket system at the launch site, or anywhere along the launch trajectory, the escape rockets will boost the CM away from the launch vehicle. In this event, the CM is designed to land in the ocean by parachute and to be recovered.

COMMON PROPULSION MODULE STATIC ENGINE TEST
Click on this direct link to see an excerpt of a static throttling test of a Common Propulsion Module altitude liquid rocket engine. The test was made at Interorbital's Alpha Test Site, located at the Mojave Spaceport. Rocket engine ignition is hypergolic. When the propellants exit the rocket engine's injector, they ignite on contact. Nozzle expansion ratio is ambient.

Interorbital Systems will be carrying out further static rocket engine testing as well as at least three low-altitude (50,000 ft) flight tests of a single Common Propulsion Module. A photograph of a Common Propulsion Module Test Vehicle (CPM TV) on its Mobile Launch Trailer (MTA) is shown below. A full-performance CPM SR145 flight test will complete the flight test program before the first orbital launch in 2012.

NEPTUNE MODULAR SERIES TEST PROGRAM

NEPTUNE Modular Series rocket components have been undergoing ground and flight tests since 1999. Testing includes ongoing static rocket engine firings as well as launches of the IOS Neutrino sounding rocket. The IOS Neutrino sounding rocket has provided valuable data on rocket engine and hypergolic propellant performance in flight, Inertial Measurement Unit and Guidance Computer operation under high acceleration and vibration conditions, data logging and telemetry systems, and payload recovery systems. The Neutrino's 500-pound thrust, liquid rocket engine will also be used as an upper-stage kick engine. It will provide on-orbit start/stop capability for interorbital transfer operations. (*Link to a Neutrino Rocket launch video*.)

The Life, Death + Rebirth Of The Teleport Industry: A 30 Year Reflection

by Richard Hadsall, CTO, MTN Satellite Communications

Thirty years ago, the state of the global teleport industry looked like this: Every teleport was owned and operated by either a government or large monopoly, providing basic telephony, video and data landing point services that linked major carriers from one continent to another. Profit margins were high and prices held steady, at easy-to-maintain levels.

In other words — life was good.

Today, life is still good, but you need to be nimble to make it so.

True, we're seeing annual compound growth rates of seven percent and the combined global teleport sector is now worth more than $19 billion in annual revenue. However, a sense of commoditization has set in. Every customer is asking for more and more bandwidth at requested prices that seemingly get lower with every conversation. How does a teleport operator prosper? By deriving new, value-added services and opportunities for customers that can be competitively priced to make up for the deficit. That means satisfying the ever evolving needs and wants of Internet Cafes, VoIP, VPN data, wireless applications for smartphones, streaming media services and other communications essentials that allow the user's device experience to present the same kind of access and seamless ease-of-use they experience at home.

This is all part of the evolutionary nature of our industry. Market trends and regulatory structures shift, and companies must anticipate them well in advance and respond accordingly to survive. Today, as **MTN Satellite Communications** celebrates its 30th anniversary, I wanted to take this moment to look back at the sweeping changes that have redefined our industry over the past three decades.

In the beginning, regulatory initiatives in the 1980s impacted the entire way teleport operators did business. Before deregulation, anytime I required additional global capacity for international traffic, I would have to deal with COMSAT and pay whatever the going rates were at the time. But then deregulation broke COMSAT up, and I could then buy capacity directly from other providers.

Deregulation opened up a great deal of flexibility. So much so that the face of industry transformed from larger monopolies and government players to smaller operators that could pop up seemingly anywhere and sell point-to-point business solutions.

This has presented hurdles. Today, many of the original teleport operators are having difficulty keeping their antennas and equipment running effectively, or updated, due to the high cost of equipment replacements and the lower margins demanded by clients and colocation resellers. Building a new teleport generally isn't feasible — not with the high cost of the equipment, and the intense level of competition here in the United States.

However, there appears to be a more positive picture in Europe. While nations there are struggling with the economy as well, their governments are eager for foreign investment, hoping to boost jobs and otherwise pump up the local state of business. As a result, teleport operators have new opportunities to invest in freshly created hybrid facilities that use both satellite and broadband fiber, creating international gateways to support the seamless flow of business data across the oceans. (*See the sidebar for a closer look at MTN's new teleport in Santander, Spain.*)

Is the current state of industry challenging? Of course it is. Given the downturn, the level of competition and the rapid pace

View of the Santander Teleport

of technology advancements and market changes today, this is to be expected. But we constantly seek to stay on top of these business realities and, so far, we've managed to do so.

We've faced harsher climates before. Remember when fiber optics were coming and they were going to put us out of business? That didn't happen. It initially threatened our presence in delivering capacity from one continent to another. But there was still a great need for point-to-multi-point satellite communications.

Today, satellite teleport companies must apply technologies to invigorate foreign investment in policy-making and regulatory liberalization to help evolve both old and new teleport businesses. This will allow us to take full advantage of rapidly shifting market demands and opportunities so that companies can continue to grow and prosper.

For example, today when we combine with broadband fiber optic networks to create hybrid fiber/satellite centers, we can offer so much more in data information and digital entertainment. That's the kind of service level/innovation that we expect to keep our industry strong for another 30 years — and counting.

About the author

Richard Hadsall has brought years of experience and accomplishments to his position as CTO at MTN Satellite Communications, and and CTO of MTN Government Services, a subsidiary of MTN. From his entrepreneurial beginnings in 1976 as founder and CEO of Crescomm, to his role as co-founder of MTN, Hadsall has played a pioneering role in the development of the maritime telecommunications industry. In 1984, Hadsall founded MTN's teleport facility in Holmdel, New Jersey. He also played an instrumental role in creating and overseeing the development of the company's Santander International Teleport located in northern Spain, which routes MTN's core business for C-and Ku-Band in the Middle East and IOR regions.

MTN Satellite Communications recently completed a project that serves as an outstanding example of the favorable business climate in Europe: The opening of a new teleport in Santander, Spain.

Partnering with ERZIA, a leading provider of VSAT maritime communications in Spain, the teleport serves as a centralized gateway for VSAT communications with coverage over the Americas, Europe and Asia. It is one of the first in the world to deliver C- and Ku-band commercial service as well as secure X-band for government customers at a single location. With the ability to see all of the satellites in the GEO orbit from 60W to 64E, the Santander teleport is now covering a region that stretches throughout Western Australia, North America, the Mediterranean Sea and the Indian and Atlantic oceans.

Much of the challenge in Europe stems from the fact that existing teleports are formerly government owned. It's up to companies such as ours to partner with local communications companies like ERZIA to introduce improvements in key areas such as network efficiency, reliability and customer service. Our Santander teleport, for example, boasts a fully manned 24/7 network operations center, with European time zone coverage and local language operators to ensure a positive user experience for our global customers.

The existing business structure in Europe is that of a highly supportive nature. Government officials there are eager for these kinds of opportunities to give a shot in the arm to the sagging economy and boost local employment. The Santander project demonstrates how the industry can work with government to achieve these goals, while opening up communications with a high degree of innovation.

A Case In Point

Water Management With Satellite Technology

by Geoffrey Bruce-Payne, Manager, Field Application Engineering Group, SkyWave Mobile

According to the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, in the United States, the annual damage due to floods cost the nation USD 5 billion annually, while losses due to droughts average USD 10 billion per year. In addition, the country's freshwater supply is critically stressed by a growing population, especially in environmentally sensitive areas along the coasts. The inconsistent availability of water along with the increasing demand is driving many government jurisdictions to regulate and monitor this critical resource.

One way to meet these requirements is to gather and analyze water quality and quantity data as it travels from source to consumer and back. Water monitoring data is not only used for operational decision making and historical recordkeeping, but also to evaluate the effect of measures implemented to improve water resource management. This article looks at six stages of the water process and the opportunities for monitoring to improve delivery, regulation and emergency response.

Water flow is measured in cubic feet/second or gallons/min and is calculated using depth and velocity data of a stream. The satellite-based communication terminals allow flow monitoring data from devices like stream gages or agricultural water meters, to be collected in a central location in near real-time. They also notify government agencies of water events or monitoring equipment breakdowns and consequently allow them to respond quickly to emergency situations.

Flow forecasts are used for optimizing the operation of water resource systems, such as reservoir operation, flood control, shipping commerce on rivers or potable and industrial water supply. Flow monitoring is also used for habitat protection, including maintaining minimum instream flow requirements in natural rivers.

The **United States Geological Survey** (**USGS**) uses a system of stream gages to monitor flow rates in major rivers and streams. Stream gages use float, pressure, optic, or acoustic sensors to determine the height of water in a stream and calculate discharge (flow). Information from these sensors is used to determine water availability and predict likelihood of droughts or floods in specific regions of the country. USGS publishes near real-time data that shows the stages of all the stream gages that they measure.

In addition to monitoring and sending data from sensors, satellite-based communication terminals can be used to remotely control equipment such as pumps, valves, or gates. For example, in canal management, the integrity of a canal can be compromised in heavy rain storms when the canal is overfilled and spills over. Spill gates, which lead water back into natural drainage systems to protect the canal in case of flooding, are impractical to manually operate due to difficult driving conditions in heavy rain storms. These gates can be remotely operated at low cost using two-way satellite communications equipment. If the canal is used for delivery of water to customers, head gates that direct water into each lateral (sub-canal) can also be controlled remotely to decrease costs and improve customer service.

STAGE 1 — WATER SOURCE

Water sources can be divided into two broad categories: Surface water and ground water. Surface water includes all water that stays on the surface of the Earth like lakes, reservoirs, rivers and streams, whereas ground water is water contained in aquifers that are below ground. Both source types can be monitored with sensors.

With water source monitoring, government agencies can collect information about the quantity and quality of water available. Monitoring systems that have integrated satellite-based communication capabilities help to cut down the costs associated with gathering and analyzing data while making government agencies more responsive to emergencies or changes in water sources.

Case Study: Observation Wells with Satellite-Based Communication Systems

Government-owned observation wells in the state of Kansas dot the banks of Lower Republican River, which is a major source of water for the state's farmers and is highly connected with the local water table. The observation wells are used for gathering data about the water level in the alluvial aquifer throughout the water year, and correlating this data with rainfall and streamflow figures for predictive modeling purposes. The state is also interested in the impact of farming and other activities on the water quantity.

In the past, water level data was gathered manually or semi-manually by a hydrological technician who was scheduled to drive to each well and either measure the distance to the water or download data from an electronic data logger installed on the site. To eliminate the need for regular site visits, AMCi, an environmental and water monitoring solution provider, developed a monitoring system that sends data over satellite from the electronic data loggers to the state's water management offices.

As a result of installing the system, the State of Kansas government was able to reduce man hours, fuel costs, risk and insurance required for this monitoring activity. The monitoring system also helped to minimize data loss and reduce maintenance costs by sending alarms if the installation had broken down or was vandalized, or in case of flooding, where the electronic equipment was at risk of being damaged by water.

STAGE 2 — WATER FLOW

"To address growing water resource challenges, the National Weather Service is putting more emphasis on forecasting the full spectrum of flows ranging from droughts to floods." — *Gary Carter*, "Working Together to Live With a Limited Water Supply", National Weather Service, 2005.

STAGE 3 - WATER CONSUMPTION

During the water consumption process, there are many opportunities to monitor the water and wastewater flow rate, level, and quality. About half of water consumed in the United States is used for thermoelectric power generation, with irrigation being a close second.

In thermoelectric-power generation, flow rate monitoring and control ensure that correct amount of water enters the plant. Reservoir or tank levels can also be monitored to ensure that enough water is available for the electricity generation process. In farming activities, to avoid water waste and to conform to conservation mandates, water monitoring systems can ensure that neither too much nor too little water is used. Both weather and soil moisture sensors can be monitored and data sent to a central location for analysis. Information can then be fed to irrigation systems which can be controlled remotely according to soil requirements. Consequently, farmers can optimize yield of crops while decreasing water usage and costs at the same time. In all applications, water that is returning to the water table can be monitored for quantity and chemistry.

Water Monitoring In Agriculture

The agricultural industry is a major user of water management technology because both costs and revenue depend highly on water. The following are some examples of remote monitoring applications that help decrease costs and increase productivity of farms.

- Sprinkler control
- Low-flow irrigation system (micro-irrigation) control

- Water meter data collection
- Soil moisture sensors to start/stop irrigation when needed
- Tank and reservoir level sensors and alarms
- Valve and pump monitoring and control of on/off state or rate of flow

When water monitoring installations are in place, there is also an opportunity to tie other assets into the existing system. For example;

- Greenhouse temperature and humidity monitoring and control
- Livestock waste lagoons level to avoid overflow
- Pig and poultry farm temperature monitoring and control
- Chemical and other storage tanks

STAGE 4 — WATER CONSERVATION

Water conservation activities are closely linked with water consumption activities. The more closely water consumption is monitored, the easier it is to implement water conservation initiatives.

Case Study: Agricultural Water Meters and Water Accounting

In Western states of the US, water rights are separate of land and can be bought and sold as an independent resource. When water becomes scarce, senior right holders are the first to receive water, while junior right holders may be cut off from supply. Water flow and other consumption data is used in water accounting to support administration of water rights.

State government-mandated water meters for regulatory purposes are installed on all farms for the purpose of water accounting. While in the past, water meter readings were either self-reported by farmers or collected manually by agency technicians who periodically drove to the various meter locations, today's conditions ask for more accurate and timely information.

Using satellite-based reporting systems allows state governments to collect near real-time information on the amount of water delivered to each farmer. State governments can make sure each farmer does not exceed the authorized yearly amount of water or authorized rate of use. In addition, soil moisture sensors installed deep in the ground are used to measure the amount of water percolating into the water table. By returning water into the aquifer, the farmer gets credit for unused water and can ask for this water out of priority when the resource is scarce.

STAGE 5 — WATER QUALITY

Water quality monitoring and wastewater monitoring involve analyzing the physical, chemical and biological character of water and looking for factors that may pose a risk to human and livestock health as well as the environment. Examples of parameters that can be monitored include:

Water quality sensors can be installed in reservoirs or downstream from potential contamination source as part of a larger water monitoring system. If ground water contamination occurs, chemistry sensors in observation wells enable plume detection and tracking. Once a certain threshold of chemical is reached, satellite communication terminals connected to the sensors are used to transmit this information allowing quicker response to changes. The timeliness and accuracy of water quality data leads to many benefits including reduced costs associated with cleanups and increased public safety.

STAGE 6 —WEATHER MONITORING

Weather events have significant impact on water quality and quantity. Satellite-based monitoring systems can be used to reliably transmit weather station data, monitor for events like floods or overloading of sewer systems and feed data into irrigation and other water management systems. Weather conditions and events that are monitored include:

- Rainfall intensity and duration
- Temperature
- Solar radiation
- Wind direction and speed
- Relative humidity
- Soil moisture
- Leaf wetness
- Snow pack (SNOTEL systems)

Case Study: Flood Water Management

Riverside County, California manages over 20 flood water basins with dams or other mechanisms to capture water and prevent it from moving downstream. Used mainly during the wet season, these reservoirs play an important role in preventing flood damage in the county.

The county recently replaced its outdated and unreliable radio-based observation with a satellite-based remote monitoring system designed by AMCi. The solution includes sensors that monitor the water level in the reservoirs and sends status messages every 24 hours. During a possible flood event, the satellite terminals are re-configured remotely to send level information every hour or even every 10 minutes, depending on the need of the county.

The terminals are also configured to notify country officials of sudden "up" or "down" events in the reservoir levels. Sudden "up" events warn that a reservoir is about to overflow while sudden "down" events may signify dam failure — either of which require immediate action. Rain gages high in the drainage system help predict the amount of water that will need to be managed.

In this application, it was important to use equipment that was not dependent on terrestrial systems because, in the county's experience, terrestrial-based communication terminals are more likely to fail in a rain event, when they are most needed. A satellite-based application was the ideal solution.

Monitoring Benefits

Gathering and analyzing water quality and quantity data as it travels from source to consumer and back is a vital component of managing this critical resource. Water monitoring systems, which include sensors and satellite-based communication terminals, offer agencies responsible for water resources the ability to receive information in near real-time without the costs associated with having personnel travel great distances to collect historical information. Water monitoring systems with satellite-based communications provide the capability to receive notifications and alarms in near real-time to enable faster emergency response and reduce costs. Finally, information collected with these systems also provides agencies the tools and knowledge to implement everything from water source monitoring systems to water conservation initiatives.

For more information, access http://www.skywave.com or http://www.amc-wireless.com.

About the author

Geoffrey Bruce-Payne joined SkyWave Mobile Communications in 2005 in Product Management and Marketing, and has more than 15 years of experience in the telecommunications industry. As Manager of the Field Application Engineering group, Geoff is responsible for global training, consulting and engineering services for SkyWave. Prior to joining SkyWave, Geoff held progressively senior positions leading product management and product marketing teams with Nortel Networks, Innovance Networks and Ciena. He has worked with customers in various industry segments involving remote monitoring and control. Geoff holds a Bachelor of Engineering (Electrical) degree from Carleton University in Ottawa.

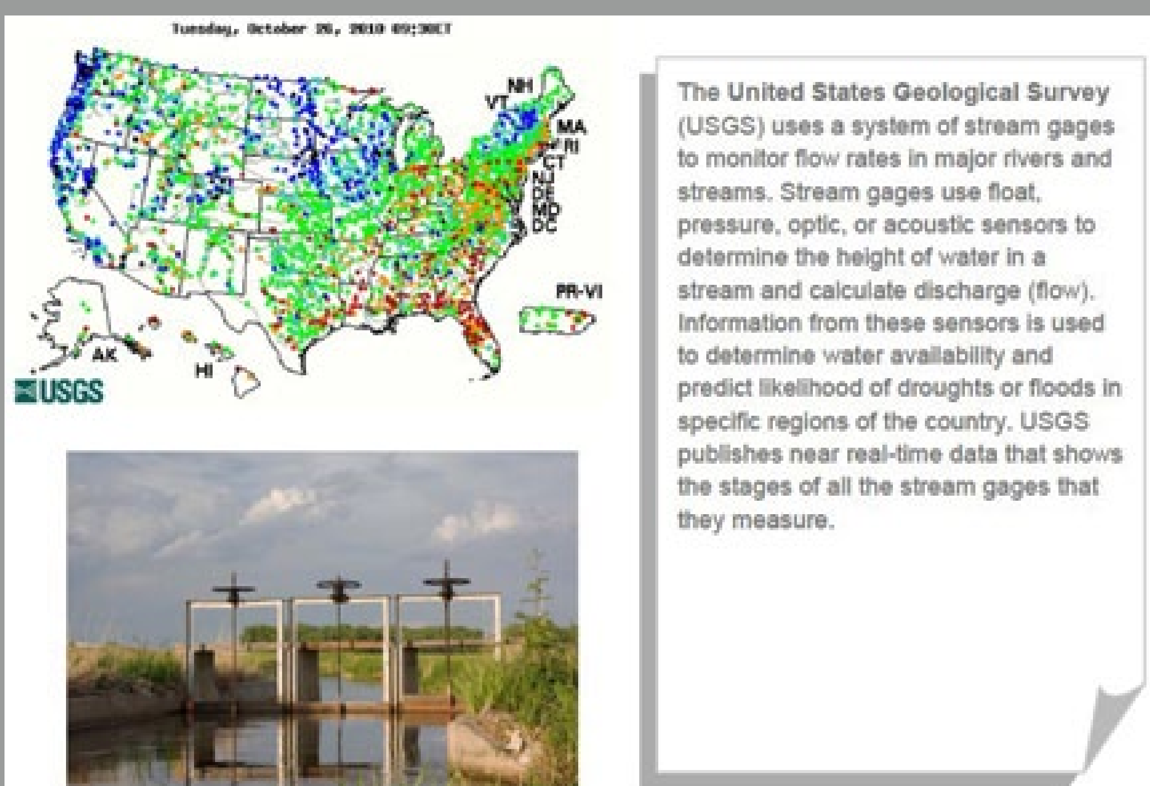
Water management with satellite technology

Emergency notifications through satellite:

- *Receive immediate alerts when safety thresholds are reached to control flooding or react to changes in water quality*
- *Reduce costs by knowing when expensive equipment may be flooded*

Data communications through satellite:

- *Download complete data from data loggers and remote meters*
- *Improve data integrity by receiving data often and from a single source*
- *Reduce costs by eliminating the need to send technicians to remote locations*



Designing Highly Reliable, Compact, VSAT Systems For Mission Critical Applications

by Gabriel Racah, Director of Marketing, ORBIT Communications Systems

Today's world is truly connected with a wide range of technologies that allow communication in homes and workplaces in cafes and airports and while we're on the road. But demand for always-on connectivity goes way beyond the reach of terrestrial and cellular coverage — from special forces with a mandate to report mission-critical field imaging to passengers of ocean-going cruise ships who want to log onto their favorite social networks. The expectation to be "online" at all times is truly global.

Satellite communications has earned its rightful place in the arsenal of communications solutions for a connected world and is often the only viable solution for remote areas. There's a wide range of satellite communications (SatCom) technologies that support one- or two-way communications. However, this article will focus on (Very Small Aperture Terminals) VSATs.

Orbits, Interference + The Need for Regulation

VSAT is a generic name for an entire class of two-way fixed or mobile solutions with a remote terminal that typically features a dish size between 30cm/12" and 3m/118". VSAT terminals communicate with geostationary satellites that orbit the Earth at an altitude of 35,786 km (22,000 mi) over the equator. Communicating from Earth to a single satellite at that distance is not in itself a major challenge, but doing it in a crowded sky is a another matter. (*See Figure 1, below*.)

The proliferation of geostationary satellites has reached the point where less than two degrees can separate adjacent satellites. Transmission from Earth must be focused precisely on the right spot or it could interfere with another satellite. Stricter regulations mandate that earth stations limit their transmission towards adjacent satellites by pointing exactly towards the target satellite and by testing the antenna emission patterns to ensure they do not contain any "side-lobes" emitting energy off center. This is an easy enough task from a large, fixed system but it can be difficult when transmitting from a compact, mobile platform. (*See Figure 2 on the next page*.)

Intensive development, simulation and testing efforts are required in order to design and produce antennas that comply with today's regulations. While this task in by no means easy, it becomes even more challenging when the antennas become smaller. This has led the industry to set de-facto standards for minimal antenna size. For example the norm for C-Band systems is to feature a dish of at least 2.4m/94-inches.

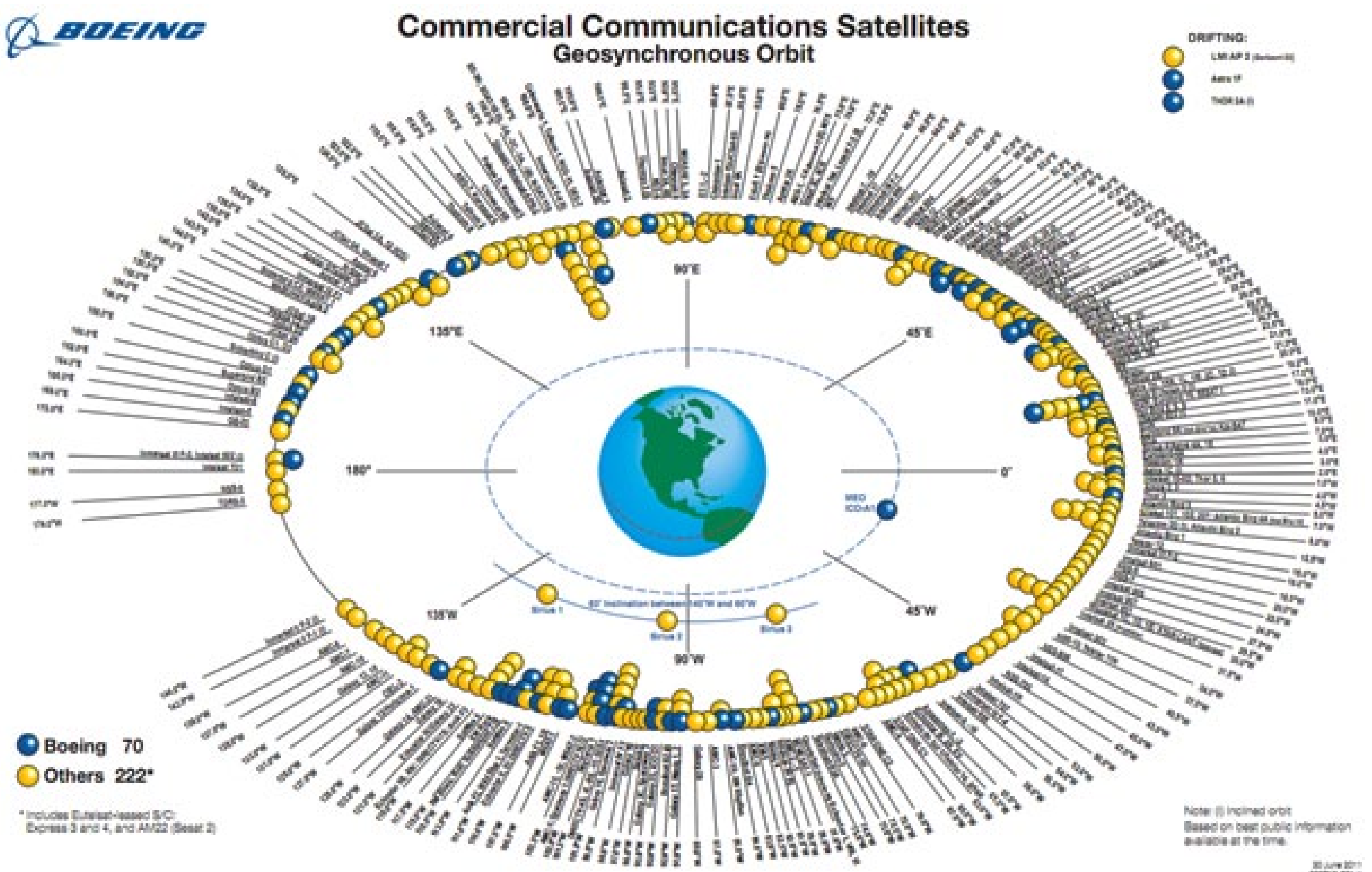


Figure 1: A Crowded Sky – Commercial Geosynchronous Satellites in Orbit (Courtesy: Boeing)

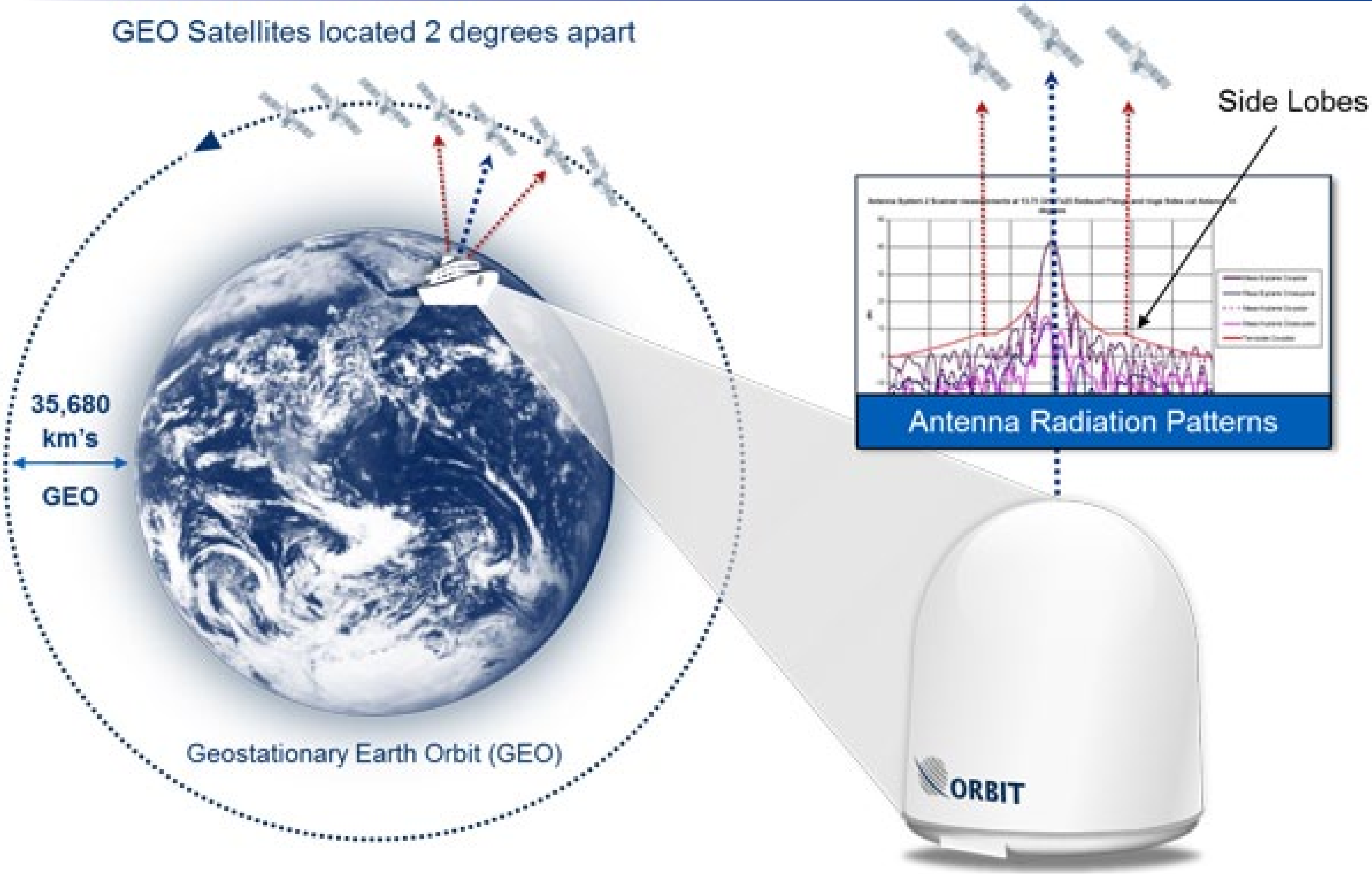


Figure 2: Radiation Patterns + Risk of Interference

Bandwidth, Power, Costs and Efficiency

With the growing demand for bandwidth, the industry is in a continuous race to improve the efficiency of the limited satellite capacity to transmit more data over a given satellite radio capacity. This is the domain of companies like iDirect, Hughes, Gilat, Comtech, Viasat and others, who keep developing more efficient ways to translate bits in to radio signals and vice versa.

Transmitting higher bandwidth radio signals come hand-in-hand with higher transmission power which, as discussed above, is allowed if the beam is focused on the target satellite and the antenna emission patterns do not contain any "side lobes." Reducing the size of the antenna will have an impact on the RF performance and as a result, in order to meet regulations, the system will be required to limit the power of transmission, and therefore their maximum usable bandwidth.

The easiest and most common way to use small antennas while preventing interference is to use "spread spectrum." In other words, the transmission is spread over a much wider range of frequencies than that required by the data rate (typically 10 times the actual data bandwidth). This may be acceptable in military and homeland security applications, in which very small terminals can allow the transmission of critical information from the battlefield. However, in a world in which satellite bandwidth is as scarce as it is today, such inherently inefficient solutions bear exorbitant service costs and are often unacceptable in commercial applications.

VSAT Systems Get Smaller

Maintaining high RF performance and fully meeting regulation while reducing the size of the VSAT terminal to a minimum can be challenging as the design has to find the optimal trade-off between size, weight, service cost, RF performance and maximal allowed bandwidth. For example, in developing a new generation of stabilized maritime C-band VSAT systems, one must maintain the advantages of the relatively large C-band (global coverage, all-weather performance) while addressing the challenges that traditionally come with such systems.

A typical maritime C-band terminal features a 2.4m/94-inch dish and is hosted in a 3.8m/150-inch dome — due to its size, the system must be installed on site over several days and only fits large vessels. The challenge is to maintain RF performance while drastically reducing the deck space, and also to shorten the installation time.

Finding the right formula is a delicate balancing act between several interdependent factors: for example, going from the traditional prime focus antenna to a dual-offset design increases the RF efficiency and improves the radiation pattern. But, such an antenna demands a very special type of stabilized pedestal in order to provide seamless hemispherical coverage, which in turn demands that the stabilization and motion control algorithms allow for complex axis mapping. Given the complexity of such projects, computer simulation software for antenna and mechanical design has been instrumental in making the development of high-performance compact VSAT solutions possible.

In conclusion, designing high-performance compact VSAT solutions is complex, but it has become even more complex with the growing importance of satellite utilization, efficiency, and compliance to regulation. Ultra-compact VSAT solutions with lower RF performance are important for special applications in which portability and footprint are necessary, but for the vast majority of defense and commercial applications in which cost and efficiency are required, smaller VSAT systems are expected to achieve the same standards as their larger siblings.

Figure 3: OrBand™ maintains industry-standard RF performance in a compact footprint

ORBIT VSAT Solutions

By using breakthrough RF design and original pedestal concepts ORBIT has created the OrBand™ — a revolutionarily compact C-band system which offers industry-standard RF performance (G/T and maximum EIRP/bandwidth) while taking 40 percent less deck space. The system features a 2.2m/87" dual-offset Gregorian antenna which, together with a high efficiency dome, complies with the strictest of industry regulations by satellite operators including Intelsat, Eutelsat and Anatel. With a compact 2.7m/106" footprint the system can now be installed in vessels with limited available deck space (from container ships to frigates) which until now could only host smaller systems incapable to provide true global coverage.

An additional example of system optimization is a VSAT solution designed for high-speed trains. Delivering broadband to trains moving at over 300km/h (186mph) required a VSAT system that could fit within the maximum allowed 50cm/20" clearance — sticking to a conventional approach would have resulted in a sub-par RF performance and high service costs. By taking an original approach, the low-profile the stabilized Ku-band OrTes AL-3602 system adds only 45cm/17" in height but hosts a large elliptical dish, increasing system gain and allowing it to meet Eutelsat regulation.

IBC's Big Screens Carry Fat Signals

by Chris Forrester, European Editor, SatMagazine

IBC is always full of surprises, and while visitors will always head for their favourite Halls to seek out the latest re-invention of this or that piece of kit, for me the two overwhelmingly fascinating exhibits concerned screens, and both represent good news for satellite broadcasters. On the one hand there was NHK's "milestone" screen in the shape of a Sharp 85-inch prototype LCD designed to handle 8K transmissions of its spectacular Super Hi-Vision/Ultra HDTV technology.

The other equally impressive 'screen' was NDS' magnificent video wall which stretched across a 3 x 2 mosaic of six **NEC X551UN** 55-inch edgeless flat-panels (each delivering 1920 x 1080, and with just a 5.7mm content gap) — more on this video wall in a moment

In many respects, NHK's spectacular demo wasn't simply the 85-inch LCD, or the even more impressive 275-inch projection screen, or even their never-less-than amazing test footage, which this year showed the final launch of the Space Shuttle Endeavour captured in May, which rumbled right into your body helped by the 22.2 channel surround sound system.

Their other key test footage was taken from the wildly colourful **Copa America** soccer finals in Argentina in July, which managed to totally capture the infectious enthusiasm of fans — and the on-pitch action. Live action came from the **BBC**'s **Television Centre** and the most mundane of images, that of Wood Lane and London's red buses and tube trains trundling to and from the Wood Lane station! The image quality was like that of an open window, such was the depth of realism achieved.

All this was truly extraordinary. However, for me the even more important message was the progress made by the Japanese over the past year. Dr. *Keiichi Kubota*, head of NHK's science, technology and research laboratories, said significant technical progress has been made in the last year, especially in image displays. "Up until now, almost everything that we have done has been projected onto screens and in darkened theatres. For broadcasting, we need direct-view displays, such as Plasma or LCD units. We now have an LCD working at 85-inches, developed jointly by NHK and Sharp. Our goal now is to move onto a second-generation set, probably at 70-inches but with finer, reduced-size pixels."

> "[NHK'] management is pushing very strongly to start the experiments in 2015. It is a possibility, but many elements have still to come together." — *Dr. Keiichi Kubota*, **NHK R&D**

Dr. *Kubota* said the Super-HD camera's lens had also been dramatically reduced in weight, and size, from 80kgs in its first-generation to today's third-generation lens at "just" 20kgs. Images from London came into the theatre at 250 Mb/s having been compressed using H.264 algorithms. Dr. *Kubota* added that while development work continued on all of the key elements in the video chain, the next major thrust is further compression with

The NEC X551UN 55-inch edgeless flat panel display

Ikegami Super Hi Vision Compact Camera

a target of around 100 Mb/s using the emerging *High Efficiency Video Coding*, (**HEVC**) which is expecting to be an MPEG standard within the next year or so.

HEVC is truly a vital component in the NHK system. Although the BBC's **Dirac Professional** system was used in early work by NHK, they are now waiting for the joint *ISO/IEC Motion Picture Experts Group* and the **ITU**'s *Video Coding Experts Group* to resolve and fix the standard, with a first draft scheduled for February 2012 and a Draft International Standard likely to emerge by about July 2012.

It is this work which, on the current timetable, should see a ratified standard in place by January 2013. In other words, the joint NHK and BBC efforts to capture images from next year's ***2012 London Olympic Games*** might be 'pre-standardisation' in terms of video compression. Dr. *Kubota* was enthusiastic about the opening and closing ceremonies being filmed, and that NHK's cameras (they have only two UHV cameras at the moment) would be working hard in and around the London Games, beaming their signals to crowds of viewers in some U.K. city centre locations via the BBC.

To date, NHK has been working to a very structured timetable which scheduled test transmissions to start in 2020. Dr. *Kubota* says the official target "has not been changed — yet. But our management is pushing very strongly to start the experiments in 2015. It is a possibility, but many elements have still to come together."

NDS ***Surfaces***

For broadcasters this is an incredibly short time-scale. There were plenty of senior broadcast engineers and studio equipment vendors at September's **IBC** who are already responding to RFP's that extend well beyond a four-year timescale. Even allowing for the 'experimental' aspect of NHK's commitment, and extending that by another four to six years this suggests that perhaps in 10 years we might see the first non-Japanese deployments of *Ultra High-Definition*, probably by the likes of **DIRECTV** or **BSkyB**. These broadcasters have always placed a very high value on image and programming quality, especially in sports, and natural history/documentary footage.

Of course, the satellite industry is going to love Super HDTV. All that fat 100 Mb/s content, soaking up fresh transponders, not to mention sports contribution feeds bouncing around the planet.

NDS: Surfaces

The other stunning display on show was the NDS 3.5m across 'video wall', officially called '***Surfaces***' (*See the opening graphic for this column*.) One commentator accurately said he was "blown away" by the demo, and others used "breathtaking' and ''amazing' in a similar vein. What truly was staggering was the amount of wholly contextual information that was drawn together by the NDS kit, and using existing metadata. In other words, everything they showed could be achieved today.

The NDS team, led by *Simon Parnell* (VP/Technology), has recognised the inevitable adoption of ever-larger screen sized, and as they grow they end up 'displaying' a huge acreage of black nothing when not in use. There's also the quite real prospect of almost wall-sized displays, as well as video-capable flexible screens and 'wallpaper' perhaps within the next five years or so. NDS, as always, have a solution standing by. First, in this particular version, they matched the room's wallpaper on the screens, making the display almost invisible! That was neat, but there was much more.

The real advantage of any giant screen is having real estate to play with. A Hollywood 4,000-line movie or HDTV drama might well fill all six screens, but for day-to-day use, the NDS team see different elements coming into play on the screen, with social media's speech 'bubbles' popping up, or news/weather reports and connected home applications each potentially playing their part.

Indeed, it is those existing Apps that make 'Surfaces' so intuitive and desirable. Using a lightweight wireless tablet as the control device, NDS has 'Mum' switching on the radio, but where the video wall then draws down the radio station's ID and playlist, a clock, and upcoming audio temptations as well as the latest news headlines. The on-screen data says that a celebrity is about to be interviewed on a breakfast TV show, and 'Mum' decides she wants to watch it. The 'radio' shrinks away to be replaced by the network's video feed. NDS have engineered what they describe as an Immersive Bar on the tablet, similar to a volume control, and this permits the viewer to decide how immersive they want the video experience to be. Slide it 'up' and the screen image gets bigger. Slide it 'down' and the screen can shrink back to any desired size. What's more, the whole concept takes about a nano-second to 'learn', it is completely intuitive.

With this demo, NDS have taken the TV experience well beyond video, exploiting the immense variety of Apps already out there, along with text and image-based news feeds and data, as well as supplementary media sources and programme-specific additional information. The assembled result depends on NDS' *Service Delivery Platform* for functionality, plus a bit of extra computing.

What is truly spectacular is that this treatment could be supplied today. *Nigel Smith*, NDS' VP/CMO, while admitting this might be a costly investment today, in a few years could easily cost less than today's higher-end displays. "Surfaces means there's no TV set filling up the lounge," he added.

My view is that whatever the cost of today's Surfaces concept, there are plenty of well-heeled buyers out there who would immediately buy into the technology. In my viewing group just about everyone said if they had the cash they'd write the check there and then! The fact is that there are plenty of home theatre owners or wealthy folk for whom writing the cheque is no hardship.

Five years from now Surfaces might be well past the early-adopter phase and be near mainstream — *yes, it's that good*.

About the author

Chris Forrester is a well-known broadcasting journalist and industry consultant and has been reporting on the "broadband explosion" for more than 25 years. Since 1988, Chris has been a freelance journalist who specializes in content, the business of television, and emerging applications, on all delivery platforms.

The NHK specification

85-inch LCD Ultra High-Res (7680x4320 pixels)
250Mb/s signal compressed using H.264
BBC-IBC Fibre links used NTT's Academic Network
8-channel video switcher/slow-motion unit

The NDS specification

Hardware

Quad core CPU PC
ATI Eyefinity 6 Graphics card
6 x NEC X551UN 55-inch panels
(1920 x 1080, 5.7mm content-content gap)
iPads

Software

Large Surface: HTML5 application running in ***Google Chrome Web Browser***
Companion: HTML5 application running in ***Apple Safari Web Browser***
Large Surface & Companion application synchronised using ***WebSockets***
Contextual metadata from ***NDS SDP Web Service API***

Streaming Video Meets Rocket Science at SpaceX

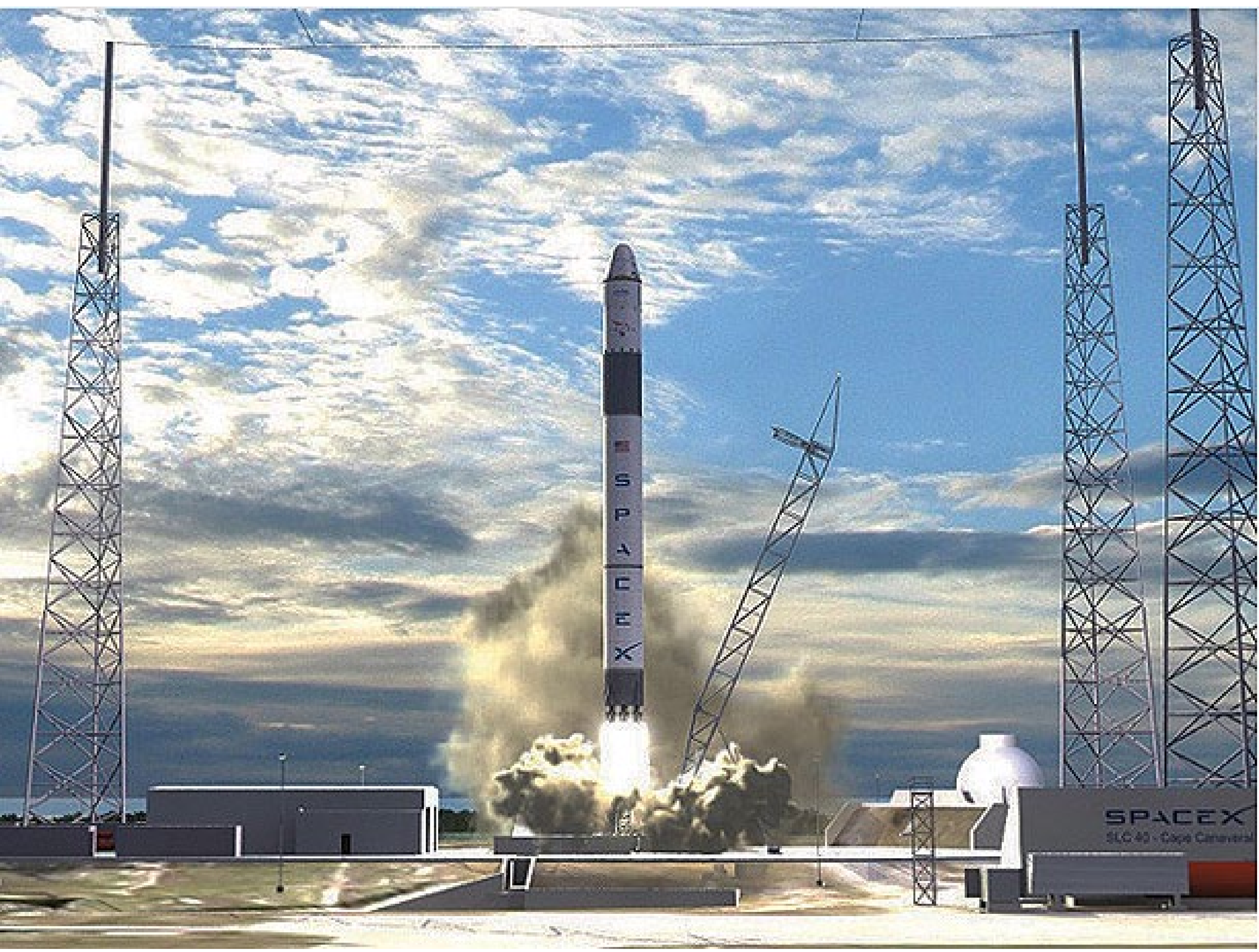
by Branden Spikes, Chief Information Officer, SpaceX

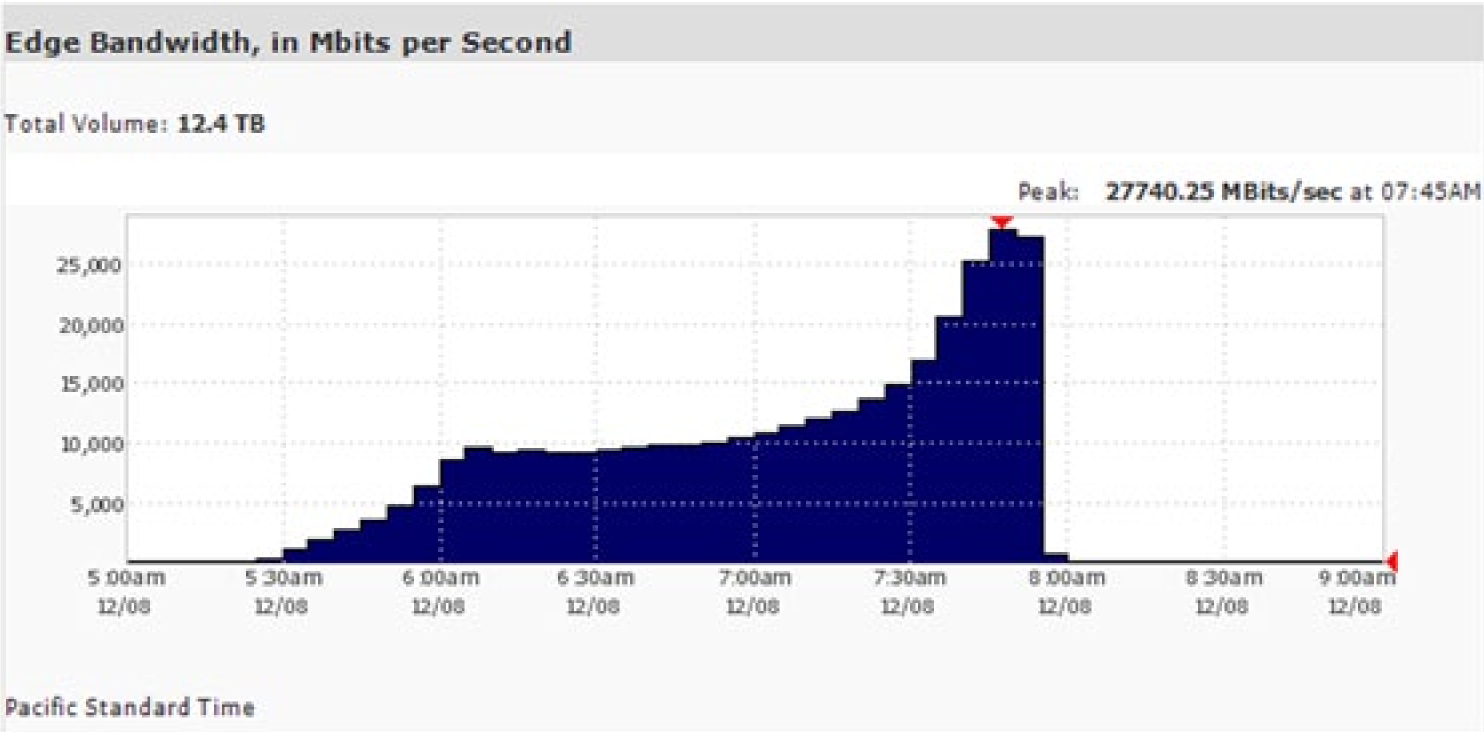
It takes more than rocket science to launch a rocket — and I should know. I work for SpaceX, a company that is revolutionizing rocket and space technology in order to take space exploration to the next level. SpaceX designs, manufactures, and launches rockets and spacecraft. Last year we became the first private company in history ever to launch and recover a spacecraft from orbit. That successful mission took place in December when we launched our Dragon spacecraft from Cape Canaveral and recovered it from the Pacific Ocean after a few hours in orbit.

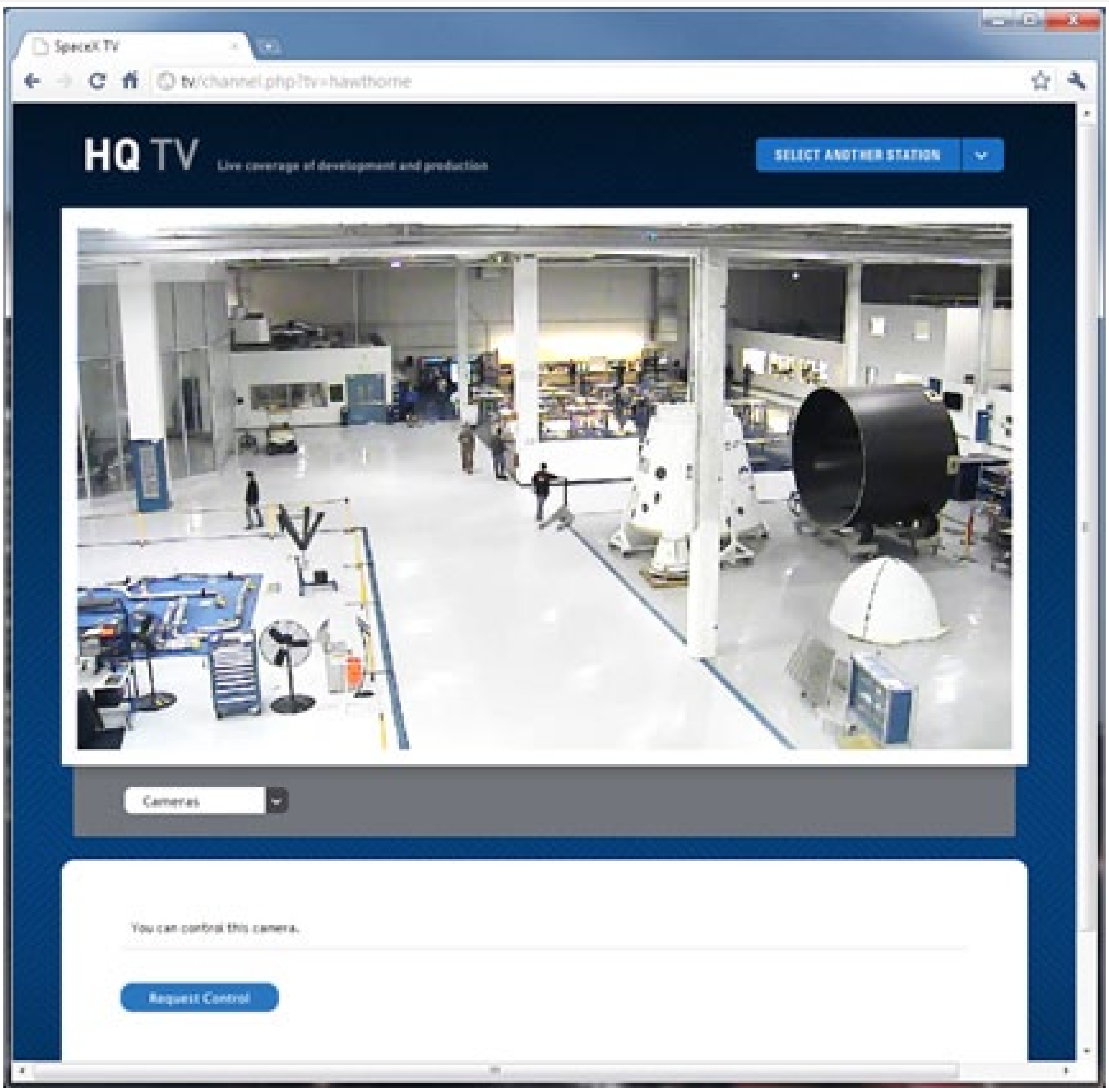
As our company's 1,300-plus employees work at different locations around the world, an important component of that success was continuous remote monitoring of preparation for the mission and the mission itself. And because we were making history on that day in December, there was enormous interest from the press and the public, with thousands tuning in to our webcast to see the launch. Both parties' needs were met through a sophisticated deployment of streaming video using dozens of video feeds and the ***Wowza Media Server*® *2*** multiplatform streaming solution.

The Wowza Media Server 2 high-performance video engine delivers our live H.264 video to multiple clients and devices. With their software, our video feeds can be viewed on most popular media platforms, including **Adobe**® ***Flash***®, **Microsoft**® ***Silverlight***®, **Apple**® ***iOS***, ***Android***™, and **Blackberry**®, as well as IPTV and even game consoles. This allows our employees to watch wherever they are on the device of their choice.

At **SpaceX**, our video system design reduces time delays and maximizes video quality with measures including using lossless HD-SDI source signals and encoding them into H.264 only once. Using Wowza's low-latency servers, we are able to build on the work we have done to deliver optimal image quality with minimal latency — even to engineers at the edge of our network. Our webcast is then provided to the public using the ***Wowza Media Server*** and the **Akamai** content delivery network.







For the December launch, we had live video delivery using more than 20Gbps of bandwidth to the Internet — streaming video that was viewed by approximately 100,000 people worldwide. Focusing on quality, we worked with Wowza to build a direct connection from our Wowza systems to Akamai's entry point without the unnecessary complexity of re-encoding.

The webcast enabled the public, our customers, and partners to experience the excitement of lift-off live in high definition, reminding people just how thrilling space exploration really is.

We brought in Wowza because we needed a system we could count on. We had encountered difficulties with the video feeds on our June 2010 space flight. At that time, we were using separate discrete software platforms for display, encoding, transcoding, and transmission to specific player technologies. Each of the systems had dynamic buffering, but synchronization and reliability were poor. SpaceX video streams are now delivered over a common IP network infrastructure. Every device on the network is set to deliver voice and video data with top priority so that the complex H.264 decoders receive 100 percent of the data on time. To accomplish this, my team and I used our expertise and dedicated enormous amounts of time to develop a simple, elegant network architecture to ensure packet prioritization at the remote cameras, the video viewers, and every network hop in between.

In spite of our best efforts, three days before the December launch, we discovered that buffering problems encountered by our edge delivery provider were interfering with our video stream. With the tightest of deadlines, we contacted Akamai because they have such a great track record. You can imagine the all-out effort it took for Akamai, Wowza developers, and our team to develop the code required to connect our Wowza system to the Akamai network. With the hard work, knowledge, and expertise from everybody involved, we were able to complete and test the system only a few hours before the webcast began. It was a tremendous success. And with Wowza, we now have a unified system that keeps the video feeds in sync throughout the network without crashing.

SpaceX designs and manufactures our vehicles in Hawthorne, California, tests them in McGregor, Texas, and launches them from Cape Canaveral, Florida. Our internal video feeds stream 24/7 to allow employees to monitor select operations. In the run-up to the December launch, SpaceX team members across the country were tuned into the camera feeds from Florida. Wowza gave employees at each of these locations reliable streaming media pushed to virtually any screen. Wowza cost-effectively enabled key personnel to tune in on their personal devices from work or home to be sure they didn't miss anything, improving the overall efficiency of our team. The new low-latency streaming video system also enables SpaceX employees to remotely pan-tilt-zoom the cameras, to inspect areas of interest more closely.

As we look to future streaming video improvements, we plan to make our software more bandwidth-aware, which will enable the cost-effective addition of new cameras. We also hope to create a user interface for archive retrieval, enabling the individual viewer not only to view the stream live but to view clips on demand. To develop these new features, our software engineers will be taking advantage of Wowza Media Server's open APIs as well as the company's comprehensive tech support.

At SpaceX, we are working every day to bring about significant breakthroughs that will improve the reliability and cost of space transportation. It's an ambitious task, and we need support we can count on. By making our closed-circuit monitoring system more robust, flexible, and functional, Wowza Media Server 2 improved a critical component of our successful mission. In addition, it allowed us to more effectively share Dragon's first flight with hundreds of thousands of viewers around the world.

About the author

Branden Spikes joined SpaceX in 2003 as CIO to develop, maintain and bolster its computing infrastructure. Spikes's expertise is demonstrated by his previous successes as an early employee at startups Zip2, a leading provider of enterprise software and services to the media industry, and PayPal, the world's leading electronic payment system.