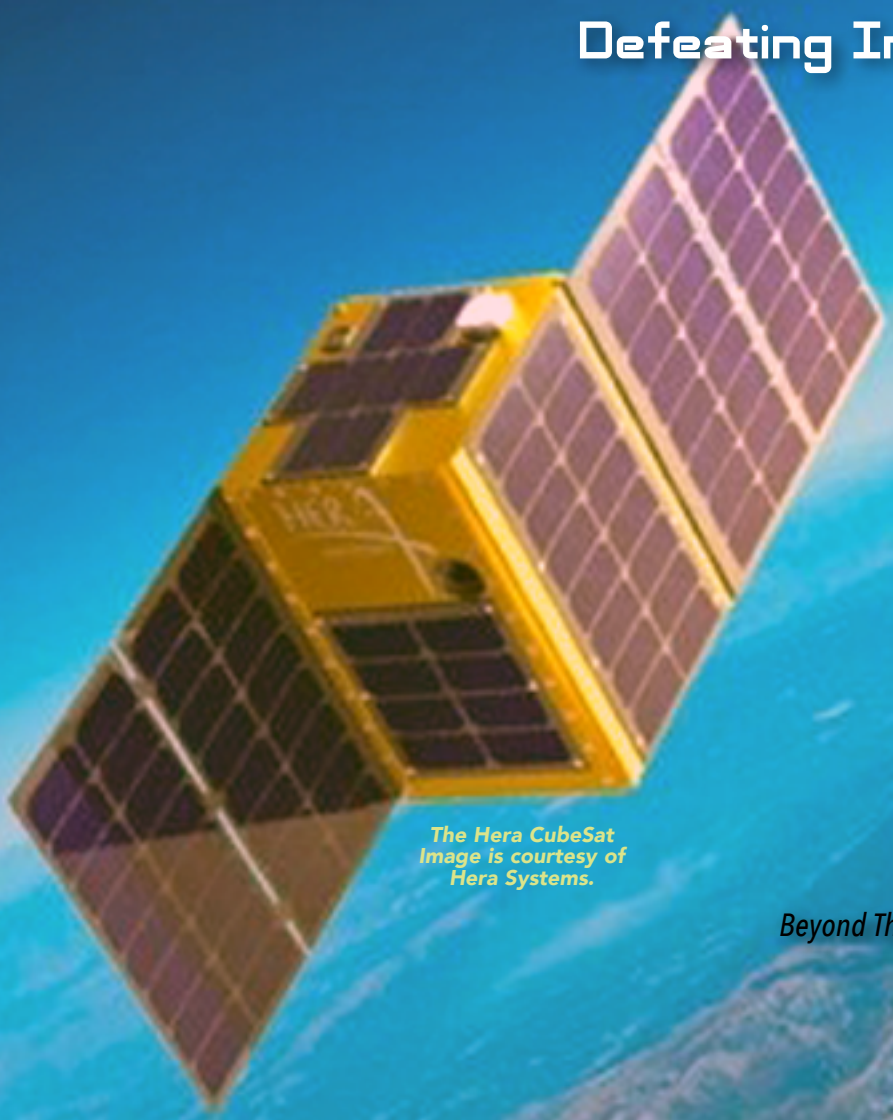
Worldwide Satellite Magazine – February 2016

SatMagazine

The Worlds of SmallSats and Defeating Interference Intrusions



The Hera CubeSat Image is courtesy of Hera Systems.

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SmallSat Symposium Supplies Substance

Don't bother with blather... empty verbosities won't be making any appearances at the upcoming ***SmallSat Symposium***. To be held on Tuesday, February 23, and Wednesday, February 24, 2016, this major event will occur at the Hogan Lovells Conference Center in San Mateo, California, and is organized and sponsored by *Satnews Publishers*. If you are reading this missive prior to those listed dates, here are the subject-matter experts who will be weighing in on the smallsat phenomenom that is changing our industry. For those reading this information after February 24, this is what you missed, much to our regret.

Symposium details at: ***smallsatshow.com/***

Jason Andrews, CEO, Spaceflight Industries
Jenny Barna, Launch Mgr, Spire Global, Inc.
David Barnhart, Director/Co-Founder, USC Space Engineering Research Center
Christopher Baugh, President — NSR
Peter Beck, CEO & CTO, Rocket Lab
Dr. Sami BenAmor, Director, Thales AS
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Dr. Josef Koller, Office of the Secretary of Defense for Space Policy
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Clayton Mowry, President, Arianespace
J. Armand Musey, Summit Ridge Group
Sunil Nagaraj, V.P., Bessemer
Janet Nickloy, V.P., Harris Corporation
Carlos Niederstrasser, Orbital ATK
Paul Oppenheim, V.P., Vanguard Space
Dr. John Paffett, CEO, SSTL-US
Dara A. Panahy, Partner, Milbank, Tweed, Hadley & McCloy
Doug Patterson, V.P., Aitech Defense
Barbara Plante, President, Boreal Space
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Mike Safyan, Director, Planet Labs
Dr. Alex Saltman, Sr. V.P., GeoOptics
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David Strobel, CEO, Space Micro
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Dr. Marco Villa, President, Tyvak Nano-Satellite Systems
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The Opening Launch Salvo For Arianepasce — Intelsat 29e Pushed To Slot

Arianespace kicked off its fast-paced 2016 operational schedule with the 70th consecutive launch success using Ariane 5 on January 27, which orbited a pioneering new-generation satellite for this workhorse vehicle's leading commercial customer.

Lifting off exactly on time from the Spaceport's ELA-3 launch zone in French Guiana, Ariane 5 pushed the Intelsat 29e satellite to orbit.

This was international operator Intelsat's milestone first high-throughput Epic^{NG}-series spacecraft and headed into geostationary transfer orbit after a flight sequence that lasted approximately 30 minutes—the mission was designated Flight VA228 in Arianespace's numbering system.

30+ Years Of Cooperation

Intelsat 29e, which had a liftoff mass estimated at 6,552 kg, is the 56th Intelsat satellite to be launched by Arianespace to date, extending a long relationship between the two companies that was further underscored by Arianespace Chairman and CEO Stéphane Israël during his comments from the Spaceport.

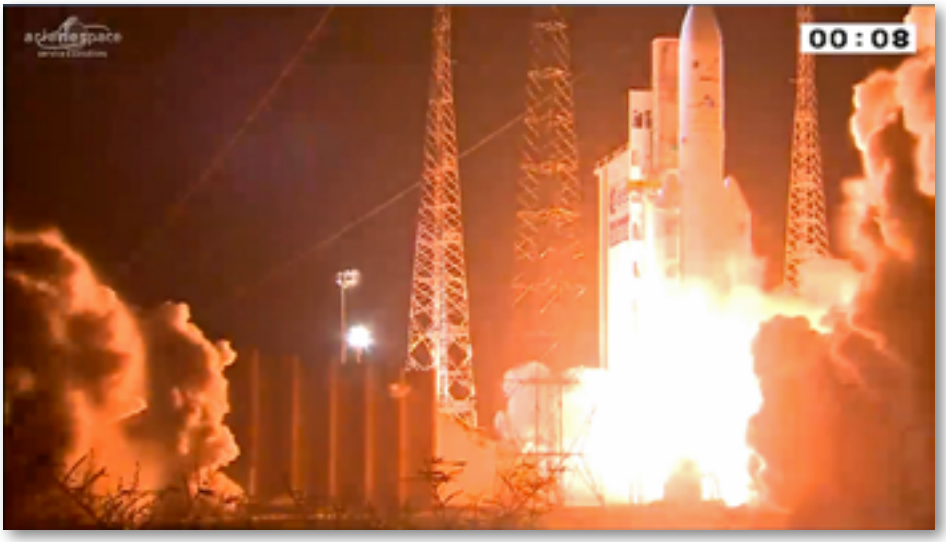
"Our companies started their cooperation more than 32 years ago with the launch of Intelsat 507 in 1983," he said, speaking from the Jupiter control room. "We are particularly proud to contribute to Intelsat's goal of delivering global high-throughput satellite services with the launch of the first of its new Epic^{NG} series."

Intelsat 29e has one of the most advanced digital payloads commercially available, operating in the C-, Ku- and Ka-bands.

The spacecraft will offer enterprise-grade broadband services to fixed- and mobile-network operators, aero and maritime mobility service providers, along with government customers; and its coverage area is the Americas and over the North Atlantic (for sea and aviation routes).

Positioned at 50 degrees West over Brazil in geostationary orbit, the satellite has a design life of 15 years and is the first of a new generation of telecom satellites that will provide the fastest commercially available connectivity to mobile network operators, aero and maritime mobility service providers and government customers. Coverage is the Americas and over the North Atlantic for shipping and aviation routes.

Israël added that Arianespace's support for Intelsat is far from over, saying, "Our roadmap is now clear: Arianespace is ready to deliver



Intelsat 33 and Intelsat 36 this year, and next year, it will be Intelsat 37."

During his own post-launch comments, Intelsat CEO Stephen Spengler paid tribute to Arianespace for another successful launch with one of the company's spacecraft. He added, "It is known for delivering, and tonight, Arianespace delivered."

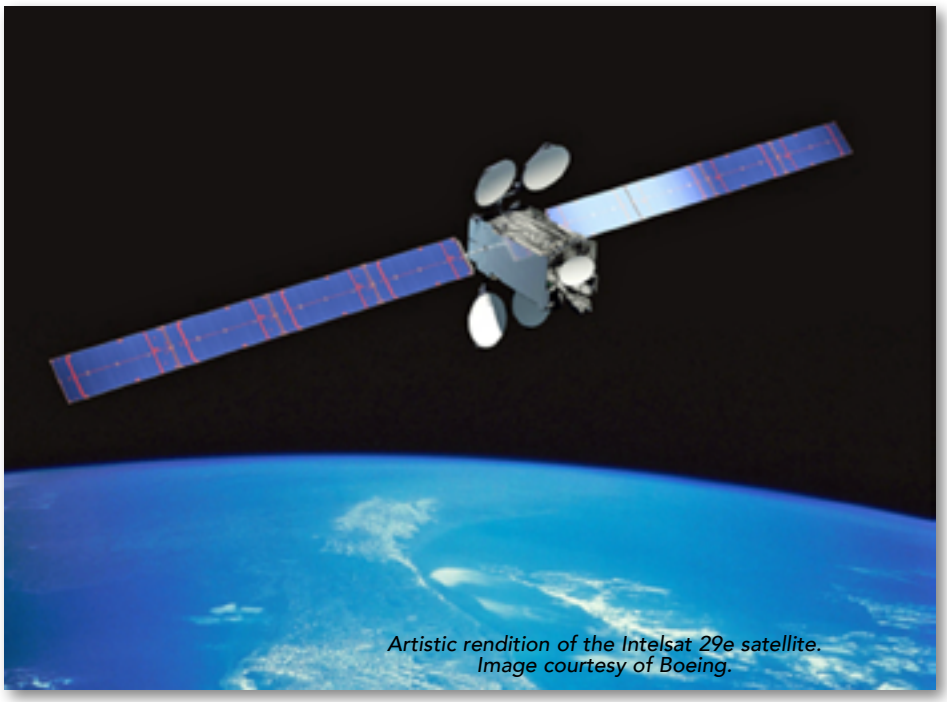
A Warm Welcome

Payload prime contractor Boeing also was acknowledged following Intelsat 29e's successful launch.

This launch marked the first time in more than eight years that one of their company-built satellites was orbited on an Arianespace mission. With this flight, the company has launched 51 Boeing-built spacecraft in total.

Speaking to the Boeing team members in attendance, Israël added, "We are on track for another series of successful launches with no less than four of your future satellites in our order book."

These four spacecraft consist of the two additional Intelsat satellites for launch in 2016 and 2017; along with SES-15, which will be orbited for operator SES, and one for an undisclosed customer.



Artistic rendition of the Intelsat 29e satellite. Image courtesy of Boeing.

Boeing Satellite Systems President Mark Spiwak was in attendance at the Spaceport and offered his own special take on Arianespace's role in the Flight VA228 success.

"It was cloudy all day today, and Stéphane—I don't know how you did it—but as the rocket was ready to go, the clouds parted and it was a beautiful evening." He added jokingly, "I commend Arianespace for having a higher ability to control the weather."

A Launch, And A Year, To Remember

Tonight's mission was unique for more than its pioneering Epic^{NG} payload. First, Intelsat 29e has the distinction of being a single telecommunications satellite on a dedicated Ariane 5 flight, which is in contrast to the typical two-passenger configuration for this launcher on missions to geostationary transfer orbit.

Flight VA228 also was the first Arianespace mission since 2002 to be performed in the month of January—giving the company an excellent start as it targets a record operational year for Ariane 5, with as many as eight launches to be performed in 2016 using the heavy-lift vehicle.

"Be it for telecommunications or other applications such as ATV (Automated Transfer Vehicle resupply spacecraft) toward the International Space Station, nobody should dispute that Ariane 5 has already made history in the launch industry," said Arianespace's Israël as he looked to the future successor. "We do not intend to rest on our laurels. 2016 will be the year of the full confirmation of Ariane 6, which will be our success story for the next decade."

Altogether, Arianespace has the objective of performing up to 11 missions in 2016 with its full launcher family of today - consisting of the heavy-lift Ariane 5, medium-lift Soyuz and lightweight Vega.

arianespace.com/

intelsat.com/

boeing.com

EUTELSAT 9B Rises Up + Payload Traveling Down The Space Data Highway

The International Launch Services (ILS) pushes EUTELSAT 9B from pad via a Proton rocket.. Photo is courtesy of ILS.

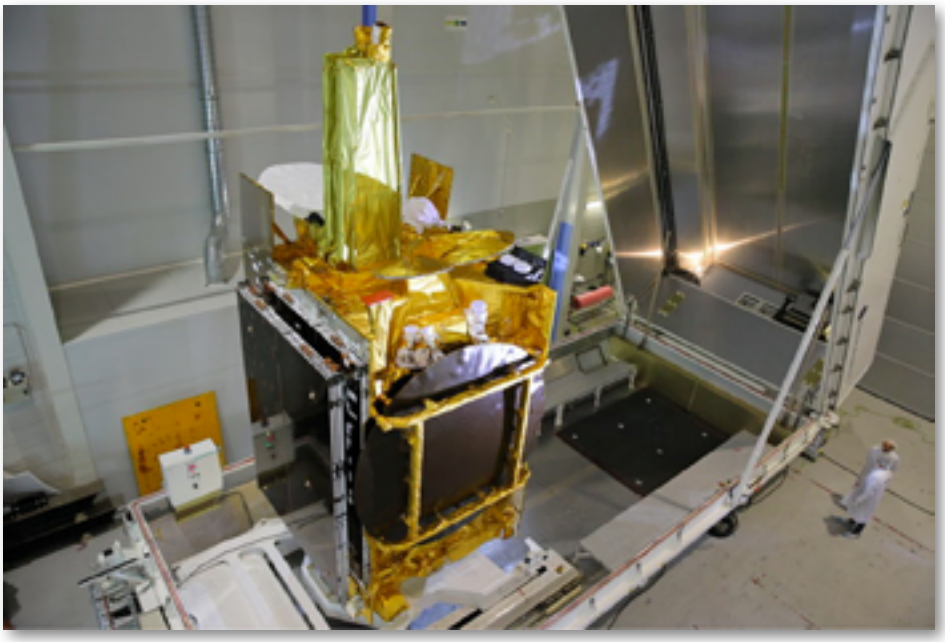
EDRS-A, the first relay satellite of the SpaceDataHighway, was successfully launched into geostationary orbit on January 30, 2016, hosted by the EUTELSAT 9B satellite via an International Launch Services Proton launch vehicle.

After a test period, this satellite will become operational for its first end-user customer by mid-2016.

The SpaceDataHighway system will provide high-speed laser communication in space at up to 1.8 gigabits per second.

This major program, which cost nearly 500 million euros to develop, is the result of a public-private partnership (PPP) between the European Space Agency (ESA) and Airbus Defence and Space.

Using communication relay satellites such as EDRS-A, the SpaceDataHighway will be able to transfer high-volume information from Earth observation satellites, UAVs and surveillance aircraft, or even from a space station such as the ISS.



The European Data Relay System's first node, EDRS-A, is packed into its flightcase atop its host satellite Eutelsat-9B in Airbus Defence and Space's facilities in Toulouse, France. It will be flown in an Antonov plane to Baikonur, Kazakhstan, for launch. Photo is courtesy of Airbus Defence and Space.

Thanks to the very high communication rates possible with lasers of up to 1.8 Gbit/s and the geostationary orbit positioning of the relay satellites, up to 50 terabytes per day can be transmitted securely in near-real-time to Earth, as opposed to the delay of several hours currently experienced.

The laser technology developed by Tesat Spacecom, a subsidiary of Airbus Defence and Space, offers a highly precise pointing capability that enables two laser terminals located 75,000 km apart to be connected. In parallel, Airbus Defence and Space will validate the broadband (1.8 Gbps) laser link concept between EDRS-A and an Airbus A310 MRTT mid-2016.

Airbus Defence and Space is also solidly committed to partner General Atomics for the airborne laser terminal product development efforts that should become available for communication with EDRS-A.

As lead contractor of the EDRS-SpaceDataHighway PPP, Airbus Defence and Space not only co-finances, owns, manufactures and operates the system but as well commercializes it.

The German Aerospace Center (DLR) is also significantly participating in financing the system and also in the development and operation of the ground segment. Overall, eleven European countries are involved in the consortium.
The first communication node of the SpaceDataHighway system, EDRS-A, is a hosted payload carried on Eutelsat 9B, a Eurostar E3000-type satellite built by Airbus Defence and Space and to be operated by Eutelsat.

EDRS-A will be positioned at 9 degrees East and will be able to establish laser links with orbiting observation satellites and UAVs positioned over Europe, Africa, Latin America, the Middle East and the eastern coast of North America.

EDRS, the future data highway in space
Airbus Defence and Space will enable real-time image delivery from space.
Artistic rendition courtesy of Airbus Defence and Space.

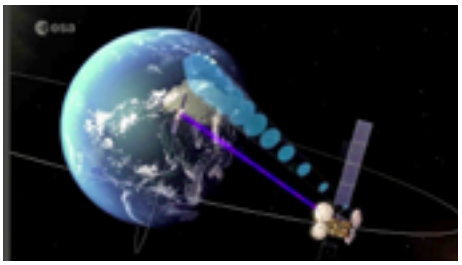
A second satellite will be launched in 2017, which will extend the coverage, capacity and redundancy of the system.

Airbus Defence and Space and ESA are looking for partnerships to further expand the SpaceDataHighway by 2020, with a third node to be positioned over the Asia-Pacific region. The Pacific Rim region, for instance, has witnessed a dramatic rise in the communication needs for airborne missions.

As part of the Copernicus initiative, the European Commission is the anchor customer for the SpaceDataHighway. Its use will allow the Sentinel-1 and Sentinel-2 satellites, all equipped with laser communication terminals, to significantly accelerate the delivery of time-critical and large volumes of data to Earth monitoring centers.

In case of crisis or natural disaster management, up-to-date, near real time information is crucial for the authorities to prepare the most appropriate emergency response.

"SpaceDataHighway is no longer science fiction. It will revolutionize satellite and drone communications, and help to keep the European space industry at the forefront of technology and innovative services," said Evert Dudok, Head of the Communications, Intelligence & Security (CIS) business line at Airbus Defence and Space.



International Launch Services (ILS) successfully placed the EUTELSAT 9B satellite into geosynchronous transfer orbit, for Eutelsat Communications of Paris, France.

With this mission, ILS completed its 92nd Proton launch overall and 1st Proton launch of 2016. Since its maiden flight in 1965, this was the 410th aggregate launch for the Proton vehicle, including both Federal and commercial missions.

The launch of EUTELSAT 9B, built by Airbus Defence and Space, was conducted for Eutelsat using the Proton Breeze M launch vehicle, manufactured by Khrunichev State Research and Production Space Center (Khrunichev), the majority owner of ILS and one of the cornerstones of the global space industry.

The Proton Breeze M vehicle carrying EUTELSAT 9B launched from Pad 39 at the Baikonur Cosmodrome, on January 30, at 04:20: local time (22:20 GMT and 17:20 ET on January 29).

The first three stages of the Proton used a standard ascent profile to place the orbital unit (Breeze M upper stage and the EUTELSAT 9B satellite) into a sub-orbital trajectory.

The Breeze M performed planned mission maneuvers to advance the orbital unit first to a circular parking orbit, then to an intermediate orbit, followed by a transfer orbit, and finally to a geosynchronous transfer orbit. Separation of the EUTELSAT 9B satellite occurred 9 hours, 12 minutes after liftoff.

EUTELSAT 9B is a high-capacity 56-transponder Ku-band satellite for Eutelsat's 9 degrees East position. Capacity will be spread across five footprints, with frequency reuse optimizing overall bandwidth.

EUTELSAT 9B will address high-growth digital TV markets through one pan-European footprint delivering wide coverage and four regional footprints. EUTELSAT 9B also hosts the first data relay payload for the European Data Relay System (EDRS) being implemented through a Public Private Partnership (PPP) between ESA and Airbus Defence and Space.

ILS President Kirk Pysher said, "The EUTELSAT 9B launch truly represents an example of an international partnership: a European-made satellite for Eutelsat with an ESA / Airbus Defence and Space payload launched on a Russian rocket by an American company. The entire EUTELSAT 9B team of Eutelsat, ILS, Khrunichev and Airbus Defence and Space worked very hard to ensure mission success. We want to express our sincere thanks to Eutelsat for their confidence and trust and look forward to launching future satellites in the Multi-Launch Agreement, designed to provide Eutelsat additional schedule flexibility, and assured access to space at cost effective prices."

"Our congratulations to ILS and Krunichev for today's flawless launch that sees a new Eutelsat satellite propelled on its way to geostationary orbit. This sophisticated satellite program reflects outstanding collaboration between Eutelsat, ESA, Airbus Defence and Space, ILS and Khrunichev. We look forward to putting EUTELSAT 9B to work for the benefit of our broadcaster clients and to the inauguration of the ground-breaking European Data Relay System that illustrates the complementary programs of geostationary and Low Earth Orbit (LEO) satellites for fast transmission of data flows back to Earth," said Michel de Rosen, Eutelsat Chairman and CEO.

eutelsat.com/

ilslaunch.com/

www.esa.int/

airbusdefenseandspace.com/

HughesNet Going To The Dogs

The judges, staff, volunteers and veterinarians who run the 1,000-mile Yukon Quest International Sled Dog race will stay in touch with each other and the outside world over HughesNet high-speed satellite service from Hughes Network Systems, LLC (Hughes.

HughesNet, which services more than one million active users, is the Official Communications Sponsor for the U.S. portion of the race.

High-speed Internet access and voice (VoIP) service are essential to quickly and efficiently communicate weather updates, course warnings and other information to make the race safer. It also enables officials to update results on the website and steadily feed information to fans and media around the world.

With nationwide coverage, HughesNet brings the many benefits of high-speed Internet to people and businesses no matter where they live or work—even in ex-urban and rural areas with limited terrestrial broadband, such as Alaska.

Hughes partner Will Johnson, owner of Alaska Satellite Internet, installs the satellite terminals on the U.S. half of the Yukon Quest trail. Johnson flies the systems to the six U.S. checkpoints—landing on roads when no landing strip is available—sets them up, and manages network operations throughout the race.

The Yukon Quest officials responsible for major operations during the race—Marshal Doug Grilliot, Manager Alex Olesen, and Head Veterinarian Dr. Nina Hansen—rely on the satellite VoIP (Voice over Internet Protocol) service to coordinate operations up and down the course.

Telephone access between checkpoints enables them to speak directly to each other and their team members to keep the dogs, mushers, support crews and Yukon Quest staff safe as they cross the Arctic terrain.

The 33rd Yukon Quest 1,000 Mile International Sled Dog Race started on February 6, 2016, in Fairbanks, Alaska and ended in Whitehorse, Yukon, Canada.

"So much of executing the Yukon Quest hinges on being able to talk to each other up and down the trail," said Marti Steury, Yukon Quest Executive Director—Alaska. "Months of preparation go into the race, but with so many people moving around at once, it's impossible to anticipate everything that can happen. The high quality of HughesNet service enables our race staff to talk instantly and resolve situations quickly and accurately."

"The Yukon Quest is the ultimate challenge for our technology—a challenge we've met twice before and are looking forward to succeeding against again," said Peter Gulla, senior vice president, marketing, Hughes North America.

"Our satellite units have worked in extreme cold over vast distances in all kinds of weather to provide the Yukon Quest with voice and data service for managing the race and keeping the world up to date on each development in real time. We're glad that we can help the race run as safely and smoothly as possible. We don't have time for committee meetings. We have to decide and go. The Hughes HX system helps us knock hours off the decision-making process. That increases safety levels and our team's productivity."

hughes.com/

Digging Into ORBCOMM

ORBCOMM Inc. has announced that Terex Materials Processing, a business segment of Terex Corporation (Terex), has selected ORBCOMM to deliver a customized end-to-end telematics solution to track and monitor Powerscreen® and Terex® Finlay machines.

ORBCOMM's comprehensive dual-mode solution will provide global satellite data service combined with cellular connectivity through ORBCOMM's wireless partner, AT&T, along with state-of-the-art hardware and a robust web-based platform for asset management.

Terex is a diversified global equipment manufacturer for a variety of industries, including construction, infrastructure, quarrying, recycling, surface mining, shipping, transportation, refining, utilities and maintenance.

ORBCOMM's heavy equipment telematics solution will provide Terex Materials Processing and their customers with critical asset data such as the location, engine hours, utilization, fuel levels, and urea levels as well as monitor engine fault codes or other alerts that are generated during the machine's usage.

ORBCOMM will also provide a powerful web portal for data analytics and reporting that has been tailored for Terex by ORBCOMM's team of engineers.

Terex Materials Processing has officially begun offering the factory installed deployment of ORBCOMM's telematics system on its machinery and expects to standardize the solution across several different models that ship from its primary factory in Ireland.

orbcomm.com/en/solutions/fleetedge

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Autonomous Spacecraft Maneuvering Demo'd By Deep Space Industries + UTIA Space Flight Laboratory

The world's first demonstration of autonomous spacecraft maneuvering was recently completed by Silicon Valley-based Deep Space Industries (DSI) and the Space Flight Laboratory (SFL) of Toronto, Canada.

Using their highly-successful CanX-4 and CanX-5 pair of nanosatellites, SFL operators executed a DSI-defined experiment on-orbit, in which the world's first spacecraft-to-spacecraft orbit maneuver was commanded by one satellite and executed by the other.

In this experiment, one of the two spacecraft (CanX-4) autonomously programmed the other (CanX-5) to perform an orbit change using its on-board propulsion system, over a shared S-band Inter-Satellite Link (ISL) radio.

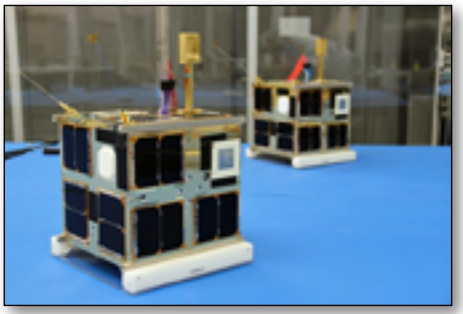
CanX-5 subsequently executed the maneuver, raising its orbit, as confirmed by operators at SFL's Mission Control Center (MCC) in Toronto and data from the Joint Space Operations Center (JSpOC) at Vandenberg Air Force Base.

To the best of each organization's knowledge, this is the first time in history that one satellite has autonomously commanded another to execute propulsive maneuvers, with no operator in the loop.

"This experiment was a key demonstration of a critical capability for multi-spacecraft asteroid missions, as well as constellations of spacecraft in Earth orbit," said Grant Bonin, DSI's Chief Engineer.

"It was also a first step in demonstrating ship-to-shore command relay in-space, which could potentially reduce the difficulty of communicating with very small spacecraft at long range."

"The experiment was an important risk reduction exercise for DSI, which intends to use small spacecraft for initial asteroid prospecting missions in the next five years," Bonin continued.



UTIAS Space Flight Laboratory. CanX-4 and CanX-5 are a pair of identical nanosatellites built by the Space Flight Laboratory, and launched in June 2014. The pair accomplished their dual satellite formation flying mission in October of that year. The satellites were recently re-tasked by SFL operators to perform a command and control relay experiment for Deep Space Industries, in advance of DSI's upcoming asteroid mining missions.

"The ability to relay commands from spacecraft to spacecraft, and perform in-space maneuvers autonomously, without operator intervention, is a critical capability that has major implications for mission-level redundancy—not just for asteroid missions, but also for low-cost Earth orbit constellations. This also shows that, if necessary, we can take the operator entirely out of the loop during a mission, which can translate into significant savings."

Deep Space Industries' partner, the Space Flight Laboratory at the University of Toronto Institute for Aerospace Studies (UTIAS), challenges the current state-of-the-art in space technology performance while achieving remarkably low cost without sacrificing quality or introducing risk.

In an age where significant advances have been made in data processing and information technology, SFL strives to leverage the latest advances in commercial technologies to provide performance advantage in space for tomorrow's space-based data users.

The organizations' high rate of success and distinguished legacy of being on the forefront of space technology make the team a great fit for partnering with Deep Space Industries.

"Teaming with a satellite provider like SFL is a big win for us," said DSI CEO Daniel Faber. "DSI's philosophy is to partner with other organizations whenever it makes sense, in a way that maximizes complementary capabilities. Having a partner like SFL allows us to tap into almost 20 years of heritage, experience, and capabilities, while giving DSI the capacity to focus on key elements of its own roadmap, by leveraging already well-honed skill sets that exist elsewhere."

"We are very pleased to have contributed to DSI's objectives through the tasking of CanX-4 and CanX-5. SFL welcomes the opportunity to partner with DSI, and we see great potential in such collaboration," said Dr. Robert Zee, Director of SFL.

"For SFL, it is an opportunity to apply our heritage and experience in an emerging application area, one that can potentially revolutionize humanity's use of deep space. SFL recognizes the pioneering work of DSI and their talented team, and looks forward to future projects with DSI."

Bonin concluded, "Technologies such as launch-safe high-performance propulsion systems, long-range, high-data-rate communications, and autonomous spacecraft relative navigation are at the core of DSI's current technology development efforts. By combining our enabling technologies with the excellent satellite platforms being offered by SFL, DSI can provide innovative, reliable and robust systems for a wide range of customers and mission types, both in Low Earth Orbit and beyond."

This work is the first project in what both organizations expect to be a long-term strategic relationship to bring cutting-edge, low-cost space technologies and missions to market, while also enabling low-cost asteroid missions.

deepspaceindustries.com/

SDA To Assist Members With Interference Struggles

As part of a continued drive to improve the integrity of satellite services, the Space Data Association (SDA) announces the launch of a new geolocation support service for its members.

Geolocation is an important process used to identify the geographical origin of transmissions to a satellite and requires specialized measurement equipment located around the globe managed and operated by skilled engineers.

The new service proposed by the SDA offers a support matrix between satellite operators whereby they will share resources and expertise to locate sources of interference.

Members who are subject to interference on any of their satellites can now count on a system and a process to engage support from other SDA members and request help in performing a geolocation.

Interference continues to cause problems for satellite operators and can be disruptive to customer services.

When it occurs, and in the absence of Carrier-ID for the interfering carrier, geolocation is an important tool that enables quick and efficient resolution.

Once located, satellite operators can then take the necessary steps to resolve the interference. The new service is currently available free of charge to all SDA members."

"The SDA is actively pursuing its policy of information exchange and cooperation in order to ensure quality of service for the satellite communications community," said Mark Rawlins, Chairman of the Space Data Association.

"In offering this service, we will be able to help our members resolve interference issues quickly and efficiently. Interference is an industry issue. A problem affecting one member today may affect another tomorrow."

space-data.org/sda/

More Than $5 Billion Expected For Passenger Connectivity Services By 2025

According to Euroconsult's newly released report, ***Prospects for In-Flight Entertainment & Connectivity***, total revenues from passenger connectivity services are expected to grow from $700 million in 2015 to nearly $5.4 billion by 2025, a 23 percent CAGR over the 10-year period.

"At the end of 2015, 72 airlines had already installed or announced plans to install passenger connectivity systems on board, and the number of connected commercial aircraft had increased by 21 percent compared to the end of 2014," said Geoffroy Stern, Senior Consultant at Euroconsult and editor of the report.

"The launch of High Throughput Satellites (HTS) in both Ku-band and Ka-band is expected to be a game-changer for the in-flight connectivity market," Mr. Stern continued. "Total Ka-band HTS supply will increase threefold to reach 1,500 Gbps by 2018, while Ku-band HTS supply will increase fivefold to reach 285 Gbps in 2018. Beyond 2018, an even larger volume of capacity, targeting the in-flight connectivity market, is expected. HTS systems will not only tremendously increase data speeds to the plane compared to regular satellite systems, but will also significantly lower costs, thereby further driving the adoption of IFC services. With more airlines opting for cabin connectivity, companies that have not yet made a decision will be increasingly pressured to offer such services to match their competitors."

The number of connected commercial aircraft is expected to grow from 5,300 to 23,100 over the 2015-2025 period, accounting for 62 percent of the global fleet.

The significant upward revision compared to our previous forecasts is mostly driven by the expected faster adoption of VSAT-based solutions (for both Ku and Ka-bands).

In the business aviation market, the share of VSAT solutions is also seen increasing dramatically, as the largest service providers on the commercial aviation market, such as Panasonic and GEE, announced plans at the end of 2015 to address this market. Overall, Euroconsult estimates that VSAT bandwidth will grow from 2.0 Gbps in 2015 to 120 Gbps in 2025.

Beyond cabin connectivity, the smart plane concept is taking shape. Thanks to the growing implementation of connectivity on board aircraft and to technological innovations in various aspects of avionics, airlines today have a major opportunity not only to offer new services to passengers but also to optimize flight operations.

Connected aircraft or smart planes are a new generation of aircraft that are considered to be nodes in a very wide network of interconnected systems. While currently in its infancy, the smart plane concept is expected to develop further in the near future, and this should create untapped new opportunities for a wide range of players.

Tremendous changes are expected in the service provider landscape. Six players currently offer cabin connectivity services for commercial airlines, namely Gogo, Panasonic, GEE, Thales, SITA OnAir, and ViaSat.

However, competition is set to intensify with some equipment manufacturers and satellite operators moving down the value chain and new entrants set to penetrate the market by 2017. Service providers are currently facing high operational costs and are struggling to be profitable.

Connectivity services require significant upfront commitment and investment in satellite capacity and ground infrastructure. Given this operating leverage, an increase in the installed base and a better utilization of satellite capacity commitment are crucial for service providers hoping to increase their gross margins.

In 2015, the average annual revenue per commercial aircraft (ARPA) ranged from $125,000 to $135,000 for both Gogo and GEE. Key industry players have already indicated that the ARPA could reach $250,000 to $300,000 in the next three to five years, mainly driven by higher take rates and increased bandwidth delivered to planes, enabling passengers to significantly increase their data consumption. When adding the potential stemming from operational services, the ARPA could even surpass $300,000.

The IFC hardware market for the commercial aviation segment is primarily driven by the success of individual service providers who generally act as equipment solution integrators and the primary link between end-users such as airlines.

While the space segment (capacity) is unquestionably an important facet of IFC services, service providers are increasingly relying upon equipment, notably antenna technology, to differentiate their offerings.

From only four players active in 2015 (Panasonic, ViaSat, Aerosat, and Tecom), the antenna manufacturer market is poised for fragmentation as no fewer than a dozen players are seeking to position themselves in the commercial aero segment.

InfoBeam

Harris CapRock Takes Five

For the fifth consecutive year, Harris CapRock Communications has been ranked number one one in the listing by the World Teleport Association (WTA).

The company also ranked sixth on The Global Top Twenty in 2015 based on total revenue.

Harris CapRock's teleports consistently meet the highest requirements for National Institute of Standards and Technology compliance for confidentiality, integrity and availability.

All of its teleports are designed with fully automatic 1:1 redundancy to achieve maximum availability and are managed 24 hours a day, seven days a week.

"Harris CapRock offers the most advanced tools and technologies and our global infrastructure enables us to deliver reliable, quality communications services to our customer anytime, anywhere," said Tracey Haslam, president, Harris CapRock Communications.

"Our position on the WTA's Top Teleport Operator Rankings reflects our commitment to our customers that no matter how remote or variable their environments may be, their communications will be second to none."

A comprehensive listing of The Independent Top Twenty, The Global Top Twenty and The Fast Twenty of 2015, as well as all of the years since the rankings debuted in 2004, are available ***at this direct link***.

It's Gold For CPI ASC Signal Division

The ASC Signal Division of Communications & Power Industries LLC (CPI) has won a contract for eight multi-band antennas to be installed by Brazilian integrator Seal Broadcast & Content to provide coverage of the 2016 Rio Olympic Games and other regional sporting broadcasts for a major Latin American broadcast network.

The contract includes one 7.6-meter dual C- and Ku-band transmit/receive antenna and seven 4.5-meter antennas configured with a mix of C-and K-band receive-only and Ku-band transmit/receive capabilities.

All of the antennas are equipped with the Next-Generation Controller (NGC) from CPI ASC Signal Division.

The NGC gives the operator a single, simplified, central device to control and operate multiple antenna systems.

The NGC's advanced features include remote access and tracking capabilities built into the system, an internal spectrum analyzer, redundancy control systems, and many other high-performance controller features.

The 31st Summer Olympic Games kick off in Rio on August 5, 2016 and will vault Latin America into Olympic annals for the first time in history.

The city has invested more than 100 billion dollars in infrastructure and transportation to support the Games as well as the World Cup played in Rio in 2015.

"The Olympic Games are the ultimate test for broadcasters in terms of performance, reliability and flexibility," said Keith Buckley, president of CPI ASC Signal Division.

"In selecting our antennas, Seal and its customers were mindful of our reputation for delivering the highest possible performance, a dedication to engineering quality and our low total cost of ownership."

ascsignal.com/

The IRG's Newest Member

The Satellite Interference Reduction Group (IRG) has announced that NovelSat has become the latest member to be welcomed to the group.

NovelSat is a technology company dedicated to providing the next-generation standard for satellite communications. â€¯NovelSat develops and delivers bandwidth efficient satellite transmission solutions comprising advanced modems, modulators and demodulators. Its products are DVB Carrier ID compatible.

"We are delighted to have NovelSat join our growing list of members," Commented Martin Coleman, Executive Director, IRG. "It's the support from companies such as NovelSat, which has already embraced our initiatives, such as Carrier ID, that helps us in our quest to reduce satellite interference."

Dan Peleg, CTO, NovelSat said, "An important part of the NovelSat strategy is to improve spectral efficiency while introducing advance satellite interference mitigation algorithms. Joining IRG was a logical step for us, and we look forward to being more involved in the group's global activities."

satirg.org/membership/
novelsat.com/

InfoBeam

Better Beaming With NSSLGlobal

NSSLGlobal announces a significant upgrade to its fully-owned and operated VSAT network with the activation of two new beams.

Launched in response to specific market needs, these two beams significantly extend the reach of NSSLGlobal's global VSAT network, providing its maritime customers with wider and more robust connectivity at sea, while also boosting coverage on land.

The company's VSAT network already covers 95 percent of the Earth's surface, including all of the world's major commercial shipping routes, mining areas, offshore oil rigs and fishing domains.

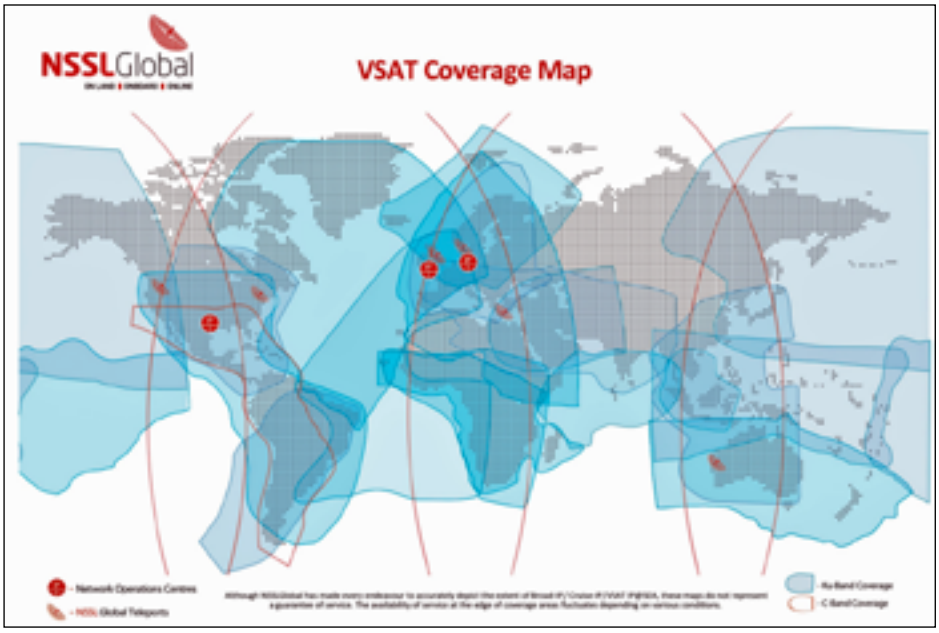
These additional beams will not only extend the network, but also provide greater availability through overlapping coverage in key areas of these markets.

The new Ku-band beam went live at the beginning of January 2016 and runs on the Yamal-402 satellite (55 degrees East) covering Sub-Saharan Africa and waters around Madagascar and the Indian Ocean.

This will further extend NSSLGlobal's coverage into the Indian Ocean, further improving user experience for vessels cruising in the Indian Ocean and using NSSLGlobal's VSAT service.

In addition, this beam will further strengthen the coverage over the African continent, which is also a strategically important area.

NSSLGlobal also added new, global C-band coverage in January 2016. Running on the Intelsat IS-23 (53 degrees West), the new beam is specifically targeted to give increased capacity and alternative look angles for vessels in the Gulf of Mexico.



The beam also covers most of the North and South American mainland, coastal waters to the West of Mexico, and significant coastline around the South Americas.

In September 2015, NSSLGlobal won the 'VSAT Service Provider of the Year' award at the prestigious VSAT Industry Awards. The award recognized the scope and quality of the services and coverage NSSLGlobal provides, as well as its customer-centric approach and leading support services for both sea and land-based satellite communications.

Sally-Anne Ray, Managing Director of NSSLGlobal, said, "The addition of these new beams highlights NSSLGlobal's ongoing commitment to investing in our fully owned and controlled VSAT infrastructure and giving our customers the industry's best service.

"Owning our infrastructure gives us the flexibility to cater for every potential client's need, whether that's with off-the-shelf or fully-bespoke products and packages. This differentiates NSSLGlobal from most other providers, allowing the company to deliver world-leading coverage, service and support, and create fully-bespoke VSAT packages for its customers.

"Our new Gulf of Mexico beam will offer vessels a better, more robust service in one of the most crowded shipping areas in the world. The new Ku- beam helps maritime companies to take advantage of faster shipping routes in the Indian Ocean, while maximizing satellite coverage uptime. Ultimately we want NSSLGlobal to be known for offering the best, widest and most robust coverage in these strategically important regions."

nsslglobal.com/

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GaAs + GaN BUCs Roll Out

A new generation of compact C- and Ku-band BUCs that were built using GaAs and GaN technologies have debuted from Alga / MitecVSAT.

The Alga / Mitec VSAT low cost compact C- and Ku-band BUC is built for VSAT stabilized platforms and mobile stations, while also offering benefits for fixed site and offshore applications.

Weighing less than 7 lbs, these products make them ideal for feed mounting. BUC features include...

- *From 10w to 40w of available power*
- *From 5w to 20w of linear power*
- *Single form factor design*
- *Ku-band: 5 power levels. C-band: 4 power level*
- *Dual LO (Switchable). Covers both regular and ext. Ku*
- *Built-in Telemetry for critical parameters such as: RF power detection, mute control, over temperature shutdown, summary alarm*
- *WEB interface, SNMP monitoring, RS 485, RS232, Ethernet and dry-contacts M&C Interface*
- *1:1 switching logic built into the BUC eliminating expensive external controller (Optional)*
- *IP65 rated housing and Fan (weather proof construction)*

alga.ca/
mitecvsat.com/

Range Safety System Contract

Thales Alenia Space Belgium has signed a contract with Airbus Safran Launchers (ASL), prime contractor for the Ariane 6 launcher on behalf of the European Space Agency (ESA), to participate in development of the range safety system for Ariane 6, including a qualification launch.

The new Ariane 6 launcher was approved by ESA's ministerial-level council meeting in December 2014 to ensure that Europe retains its leadership in the fast-growing commercial launch services market, while continuing to address European requirements for government missions.

Two versions of this launch vehicle are planned: Ariane 6.2, with two strap-on solid boosters, mainly intended for government satellites; and Ariane 6.4, with four strap-on boosters, capable of dual launches and mainly intended for commercial payloads.

The first launch of Ariane 6 is planned for 2020.

The main function of the range safety system is to neutralize the launcher if its trajectory endangers people or property.

The system's core comprises electronic units that are fully designed and built by Thales Alenia Space Belgium.

These core units will be used in conjunction with other components, shared by the Ariane 5, Vega and Soyuz launchers, to form the entire range safety system.

thalesgroup.com/en/homepage/belgium

A Swede Launch

A TEXUS 53 rocket was successfully launched from Esrange Space Center in northern Sweden above the Arctic Circle on January 23, 2016, at 08.30 UTC.

The payload reached an altitude of 252.6 km and the flight was near perfect with very low disturbances during the whole flight with approximately six minutes of microgravity.

The TEXUS program started in 1977 and is carried out at Esrange Space Center joint OHB-System (former EADS Astrium and Kayser Threde) and SSC. SSC is responsible for the launch operations. The TEXUS campaigns are sometimes financed by ESA or jointly financed by DLR and ESA.

The Project

The TEXUS project is a sounding rocket program with the primary aim to investigate the properties and behaviour of materials, chemicals and biological substances in a microgravity environment.

More than 500 sounding rockets and 550 stratospheric balloons have been launched from Esrange Space Center. This gives the Center a leading position on the world map of launching facilities. In addition we provide the largest civil ground station for satellites in the world.

InfoBeam

SES Elevagtes Senegalise Students

SES and their local partner, Ecole Supérieure Multinationale des Télécommunications (ESMT), have announced the 4th ELEVATE program in Senegal to support satellite and digital television migration in the country.

ELEVATE, launched in 2012, is the SES Quality Assurance and Accreditation training program for installers across the African continent which aims to create an engaged installer network essential to support DTH growth.

An ELEVATE certificate provides the opportunity to generate more income, as well as further develop skills, learn cutting edge techniques, and improve the overall quality of installations.

The 4th ELEVATE program will provide training from February 2 through 4, 2016, to 116 local satellite installer's students and ten trainers in partnership with ESMT, an international institution of higher learning based in Senegal.

ESMT offers professional certifications and graduate programs in telecommunications.

In addition to the training sessions, installers are provided with specialized tools, free training material and downloadable manuals.

Also, as part of the growing partnership, SES will use ESMT trainers to support the ELEVATE programme in Nigeria to train more installers.

The SES ELEVATE team has so far trained over 5,000 installers in the Democratic Republic of Congo (DRC), Cameroon, Nigeria, Senegal, Côte d'Ivoire, Uganda, Kenya, Zambia, Malawi, Tanzania and Niger, and the number continues to grow across the continent.

Learn more at ***africa.ses.com/17738814/elevate***

"The ELEVATE training program has a 'Train the Trainer' aspect. Together with our local partner ESMT, SES colleagues identified talented installers and provided them with training and guidance on how to become instructors, thus enabling them to train other local installers. This allows SES to train more installers across French-speaking West Africa," said Ibrahima Guimba-Saidou, Senior Vice President, SES Commercial in Africa.

Mr. Mouhamadou Arabani Saibou, Director General of ESMT, added, "SES has the capacity and expertise to connect companies and communities across the country, and with the rest of the world. SES is partnering with ESMT to increase skills development and job creation across Africa."

Smallsats AggieSat4 + Bevo-2 Kibo'd From ISS

Expedition 46 flight engineer Tim Peake of ESA captured the photo above on January 29, 2016, from the International Space Station, as the robotic arm in Japan's Kibo laboratory successfully deployed two combined satellites from Texas universities.

The pair of satellites—AggieSat4 built by Texas A&M University students and Bevo-2 built by University of Texas students—together form the Low Earth Orbiting Navigation Experiment for Spacecraft Testing Autonomous Rendezvous and Docking (LONESTAR) investigation.

The satellites will demonstrate communication protocols between them and with ground stations, as well as systems that allow the satellites to navigate through space and relative to each other and to orient themselves in three dimensions.

Flight demonstration of these abilities, necessary for unmanned craft to be able to rendezvous and dock in space without direct human intervention, will contribute to future satellite missions as well.

Students from Texas A&M University and The University of Texas came together for the LONESTAR investigation.

This collaborative effort sent a pair of satellites, AggieSat4 and Bevo-2, to the International Space Station earlier this month.

The satellites were released from the space station, where AggieSat4 ejected Bevo-2 as part of a demonstration of technology with applications for future space exploration.

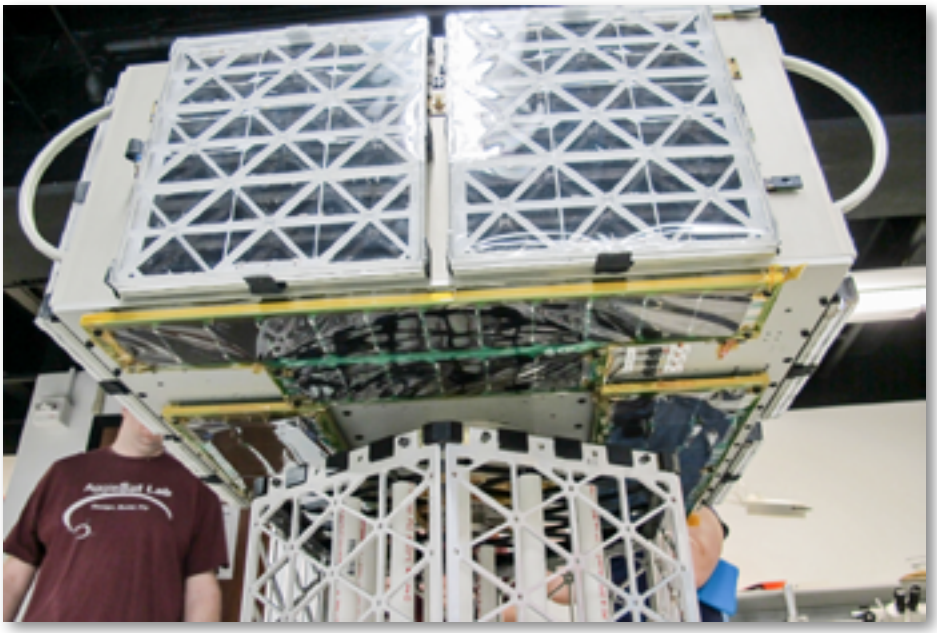
"The overall objective is to find ways for small spacecraft to join together autonomously in space," said Dr. Helen Reed, professor of aerospace engineering and director of the AggieSat Lab at Texas A&M.

"We need simple systems that will allow rendezvous and docking with little to no help from a human, which will become especially important as we venture farther out into space. Applications could include in-space assembly or reconfiguration of larger structures or systems as well as servicing and repair."

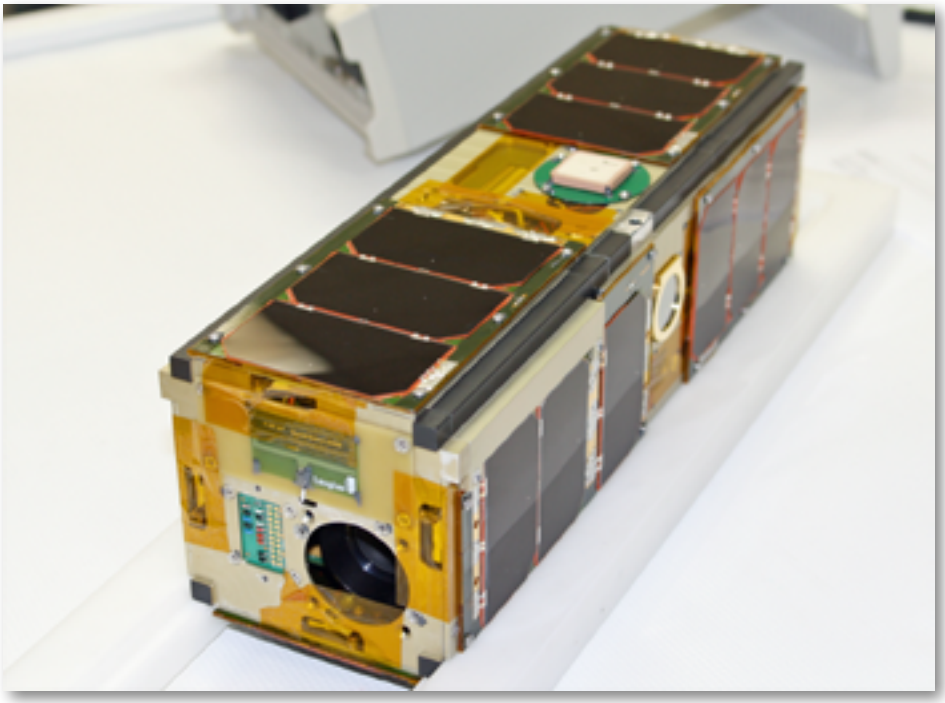
Smallsats are less expensive to build and investigators can more easily find space on rocket launches to send them into orbit, but it does take creative thinking to design a functioning satellite with smaller volume and less power.

Bevo-2 is 13.3 inches long, 5.3 inches high and 5.3 inches wide, about the size of a loaf of bread.

AggieSat4 measures 24 by 24 by 12 inches, slightly larger than a piece of carry-on luggage. Together the satellites weigh 114 pounds.



AggieSat4, developed at Texas A&M University for the LONESTAR investigation. Photo is courtesy of NASA



The completed Bevo-2 satellite ready for launch for the LONESTAR investigation. Photo is courtesy of Texas A&M University/ Dexter Becklund

The satellites were independently developed by student teams at the two universities. Both teams were responsible for development plans for their satellite and had to meet established mission objectives.

This required the teams to perform all stages of a project life cycle, including project management, development of design requirements and interface control documents between the two satellites, fabrication and testing, integration of hardware and software and systems verification.

"It is all part of enhancing the student experience by having them in a real–world development project," said Darryl May, LONESTAR project manager and senior technical advisor in the Aeroscience and Flight Mechanics Division, Johnson Space Center.

This hands-on experience for students in designing, building and flying spacecraft is an important aspect of the investigation. It is also good, Reed pointed out, for students to learn to work closely with other organizations.

"That is the way it works in industry, with multiple entities involved," Reed said. "It's been a good collaboration, we've really enjoyed it and are thankful that NASA came up with the idea.

"The students have realized they have to work together and both craft have to work for the system to be successful."

Dr. Glenn Lightsey, professor of aerospace engineering and head of the Texas Spacecraft Laboratory at The University of Texas, explained that it takes a lot of coordination for two spacecraft to share information and base their actions on the information they receive from each other.

"I have heard our two satellites described as 'space tourists' who will be taking pictures of each other and sending those pictures back to Earth," he added.

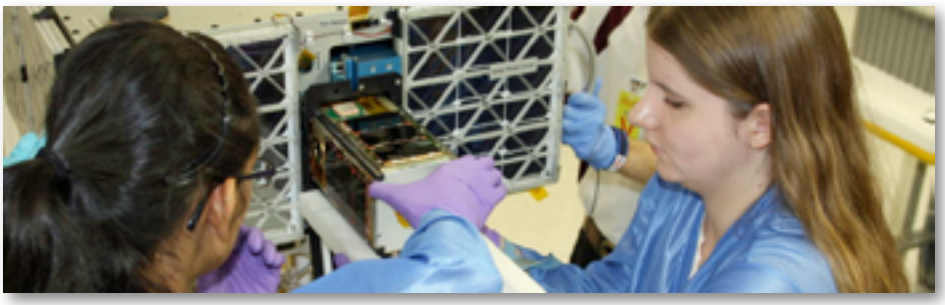
Flight performance data from the investigation will indicate the readiness of technology development for autonomous rendezvous and docking objectives on future missions.

May explains that the work has four different objectives: controlling the attitude or orientation of the craft in three dimensions, navigation performance, communications and thruster performance.

"The next step will be to actually perform an autonomous rendezvous and docking," said May.

That step, of course, will also require a lot of collaboration.

Story by Melissa Gaskill,
International Space Station Program Office,
NASA Johnson Space Center
Editor: Jennifer Harbaugh



Students from the University of Texas Satellite Lab work in collaboration with the Texas A&M University Satellite Lab to remove the Bevo-2 from AggieSat4 in order to upload and test their final code.

Photo is courtesy of Texas A&M University/ Dexter Becklund

The Continued Rise Of CubeSats – Part II

By Jos Heyman, Senior Contributor

Only six months have passed since my article *The Continued Rise of CubeSats* was published in the July/August 2015 issue of *SatMagazine*.

That feature discussed CubeSats and already many things have changed in the exciting world of CubeSats, also nowadays called smallsats.

The number of these satellites launched or deployed since that previous article has also risen dramatically, in particular as the result of an Atlas V launch on October 8, 2015. Unfortunately, the number of failures have also increased due to the failure of the first Super Strypi launch on November 4, 2015. ***Table 1*** below does not include 18 CubeSats that remain on the International Space Station pending deployment, as of this writing.

Year	Launched	ISS deployed	Failed
2003	6		
2004	0		
2005	2		1
2006	4		15
2007	7		
2008	6		2
2009	9		
2010	16		
2011	7		3
2012	18	5	
2013	80	4	
2014	36	46	30
2015	56	49	29
Total	247	104	80

Table 1. The number of CubeSats launch / deployed.

Larger CubeSats

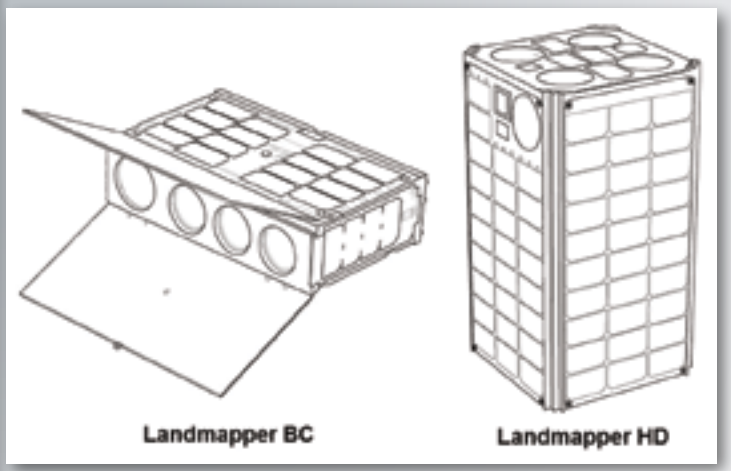
Aquila Space + Astro Digital

The 1U CubeSat is now forming the basis for larger platforms as demonstrated by two recent proposals for Earth Observation (EO) constellations that are expected to take off this year.

Aquila Space and ***Astro Digital***, two San Francisco based companies, will establish the **Landmapper** constellation of 30 EO satellites. The constellation, to be launched starting in 2016 over a four year timeframe, will be comprised of ten Broad Coverage (BC) satellites and 20 High Definition (HD) satellites. The project aims to increase the supply of imagery available to customers that are currently users of Landsat data by providing higher resolution imagery on a more frequent basis than provided by Landsat.

The **Landmapper BC** satellites are based on Aquila's ***Corvus-BC*** platform, a 6U CubeSat which will carry a payload that will provide imagery in the red, green and NIR spectral bands at a resolution of 22 meters.

The **Landmapper-HD** is based on Aquila's ***Corvus-HD*** platform, a 16U CubeSat unit that will carry a payload with a resolution of 2.5 meters, operating in the blue, red, green, near-infrared and red-edge spectral bands.



Operating from an altitude of 600 km, the constellation will provide updates every three to four days.

Hera

California based **Hera Systems** hopes to establish a 48 CubeSat EO constellation to provide daily imaging services with a resolution of 1 meter. The launch of the first nine satellites is expected to occur in late 2016. While Hera was originally considering satellites in the range of 50 to 60 kg, ultimately selected was a 12U CubeSat platform.

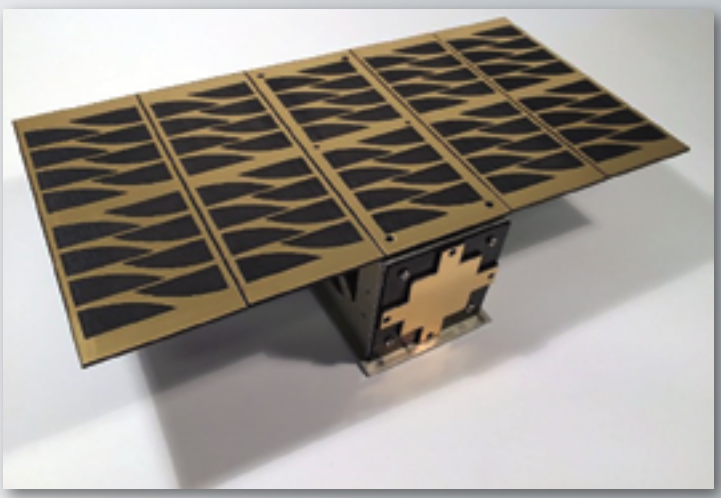
The Hera CubeSat. image courtesy of Hera Systems.

Even Smaller...

The acceptance of even smaller satellites, the 5x5x5 centimeter *PocketQubes*, is also spreading quite rapidly.

PocketQube Unicorn

The **European Space Agency** (ESA) is funding a double PocketQube for a trial that will relay data from a geostationary satellite to a satellite in Low Earth Orbit (LEO) of 620 kilometers in cooperation with **Avantin UK**.



The PocketQube Unicorn. Image is courtesy of European Space Agency.

Identified as *Unicorn-1*, the 400 gram satellite will be fitted with an S-band ISL radio. Launch will take place in late 2016, with Unicorn-1 as one of the payloads on the Dnepr launch vehicle that will place the *Unisat-7* in orbit.

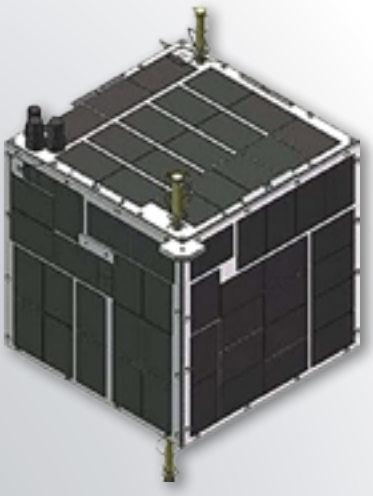
There are also a number of other projects using PocketQubes that include several amateur satellite builders, such as the *OzQube* project which was described in the June 2015 issue of *SatMagazine*.

Chinese Developments

CZ6

In one of the more interesting developments of the latter half of 2015, the first launch of China's *CZ 6* launch vehicle occurred on September 19, 2015. This launch carried a number of small satellites, demonstrating first of all that China has the capability to build these small satellites, and, secondly, that these small satellites would not necessarily follow the 10x10x10 centimeter CubeSat pattern to the letter.

Two of these were built by the **Zhejiang University** as *Zheda Pixing* (ZDPS)-*2A* and *-2B*. Each of these satellites measured 25x25x25 centimeters and possessed a mass of mass of 12 kg and demonstrated advanced guidance, navigation and control algorithms for formation flying, evaluation of the performance of an ammonia, micro-propulsion system as well as to test a dual-frequency GPS receiver.

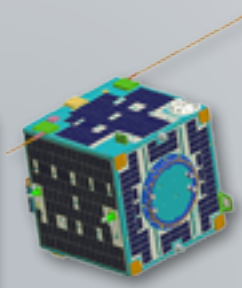


China's ZDPS-2.

ZDPS-2

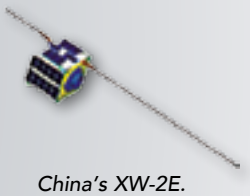
On board CZ 6 were also a series of *XiWang* (XW) *-2* series of small satellites, which have also been referred to as *Chinese Amateur Radio Satellite* (CAS)*-3*

XW-2A



China's XW-2A.

XW-2A was a 40x40x40 centimeter satellite with a mass of 25 kg that carried out atmospheric physics experiments and amateur radio missions. The satellite also carried two smaller satellites, *XW-2E* and *XW-2F*, which were released separately. These two satellites measured 12x12x12 centimeters and had a mass of 1.6 kg. They also carried amateur radio payloads.



China's XW-2E.

XW-2E

XW-2B, *-2C* and *-2D* were identical 25x25x25 centimeter satellites with a mass of 10 kg each—they conducted atmospheric physics experiments and amateur radio missions.

Also known as *DCBB*, *XW-2G* was a 2U CubeSat built for educational purposes by **Shenzhen Aerospace Dongfanghong HIT Satellite Ltd.** together with *CAMSAT*.

Also known as *Zidingxiang-2* and *LilacSat 2*, *XW-2H* was a 20x20x20 centimeter satellite with a mass of 11 kg designed for education, amateur radio communication and technology demonstrations. This satellite was built by a team of students from the **Harbin Institute of Technology** (HIT) and carried a radio amateur transponder as well as a thermal infrared camera. Akso tested aboard this satellite was new software.

Tiantuo-3 was a 20 kg technology satellite built by the **National University of Defense Technology**. This craft was also known as *Luliang-1* and the satellite tested an AIS payload for ship tracking as well as an ADS-B (Airplane Data Relays) system. In addition, Luliang-1 ejected the *XiWang* (XW)*-2I* satellite, which was also known as the *Chinese radio Amateur Satellite* (CAS)*-3I*, *Zhineng hao shouji weixing*, *NUDT PhoneSat* and *Kaituo-1B*. XW-2I was a satellite with a mass of 1 kg and was based on smartphone technology, and was also developed by the National University of Defense Technology.

The satellite carried and deployed four *Xingchen* (XC) satellites which had a mass of 0.1 kg and measured only 98 x 98 x 7 mm. They were used in an experiment to control a cluster of satellites using intersatellite communications, although the formation flying was not possible as the Xingchen satellites did not have propulsion systems. Two were controlled by Tiantuo-3 and two by XW-2I.

Naxing-2, also known as *Nano Satellite* (NS)-*2*, was developed at the **Tsinghua University** and evaluated various, new, satellite components such as micro star trackers, micro sun sensors, MEMS gyroscopes and magnetometers, quartz tuning fork sensors and GPS/BDS navigation receivers. This satellite also carried two nanosatellites, *ZJ-1* and *KJSY-1*, which were deployed into orbit.

Zijing (ZJ)-*1* was a 234 gram picosatellite developed at **Tsinghua University** to evaluate micro CMOS cameras and MEMS magnetometers, as well as formation flying on tethers with KJSY-1 and intersatellite communications.

Kongjian Shiyan (KJSY)-*1*, was a 173 gram picosatellite jointly developed by Tsinghua University and **Xidian University** to test formation flying on tethers with ZJ-1 as well as intersatellite communications and GaN electronic boards.

Of significant note is that the four XC satellites, as well as the ZJ-1 and the KJSY-1, did not receive an International designation. Such indicates that either these satellites were not deployed or, and this is more likely, they were too small to be effectively tracked as individual spatial objects.

As if to prove a point, the first *CZ 11* launch on September 24, 2015, places three CubeSats in orbit. *Tianwang* (TW)-*1A*, *-1B* and *-1C* were 2U CubeSats developed by the **Shanghai Engineering Center for Microsatellites** (SECM) in collaboration with **Nanjing University of Science and Technology** (NJUST), Denmark's **GomSpace**, Portugal's **Tekever Space** and Sweden's *NanoSpace.* These were to undertake a range of networking experiments that involved a small constellation of low-cost satellites. On this flight, they tested the *GAMALINK* intersatellite communications technology.

Launch Vehicles

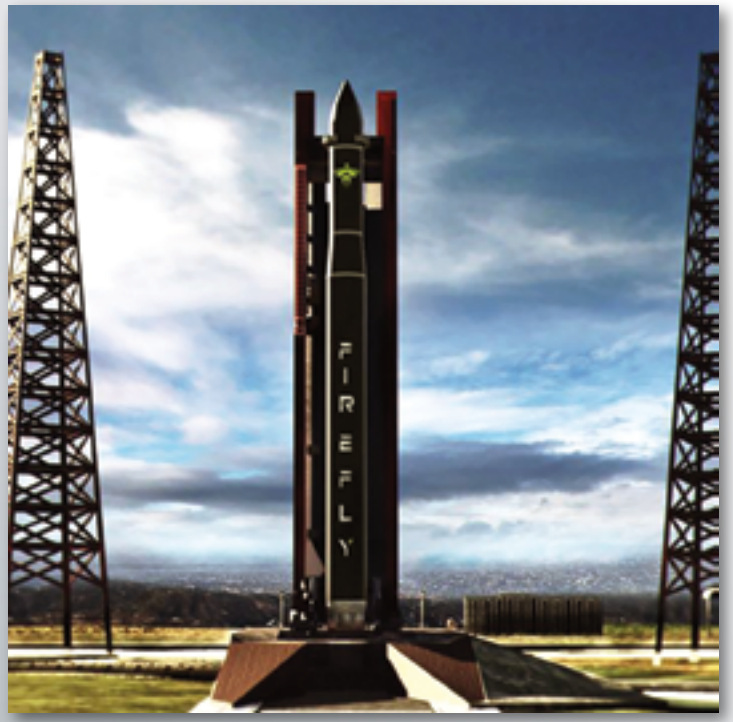
In the field of launch facilities, and recognizing the need for easier access to space to facilitate the launch of the many anticipated CubeSats, NASA recently awarded launch contracts to three firms for the deployment of small satellites such as CubeSats.

Ventura Class Launch Services

Identified as the **Venture Class Launch Services** program, the contracts have been awarded to **Firefly Space Systems** with the *Firefly Alpha*, **Rocket Lab USA** with the *Electron*, and **Virgin Galactic** with **LauncherOne**. None of these launch vehicles have flown as of this writing, and the program envisages the first test flights to occur before April of 2018, with each flight carrying payloads ranging from 45 to 90 kg.

Firefly Alpha

Separately, and recognizing that a few extra kilograms on a launch vehicle really does not have any impact on the cost of a launch, **United Launch Alliance** (ULA) has now decided to offer six, free, CubeSat rides on two *Atlas V* launches in 2017.



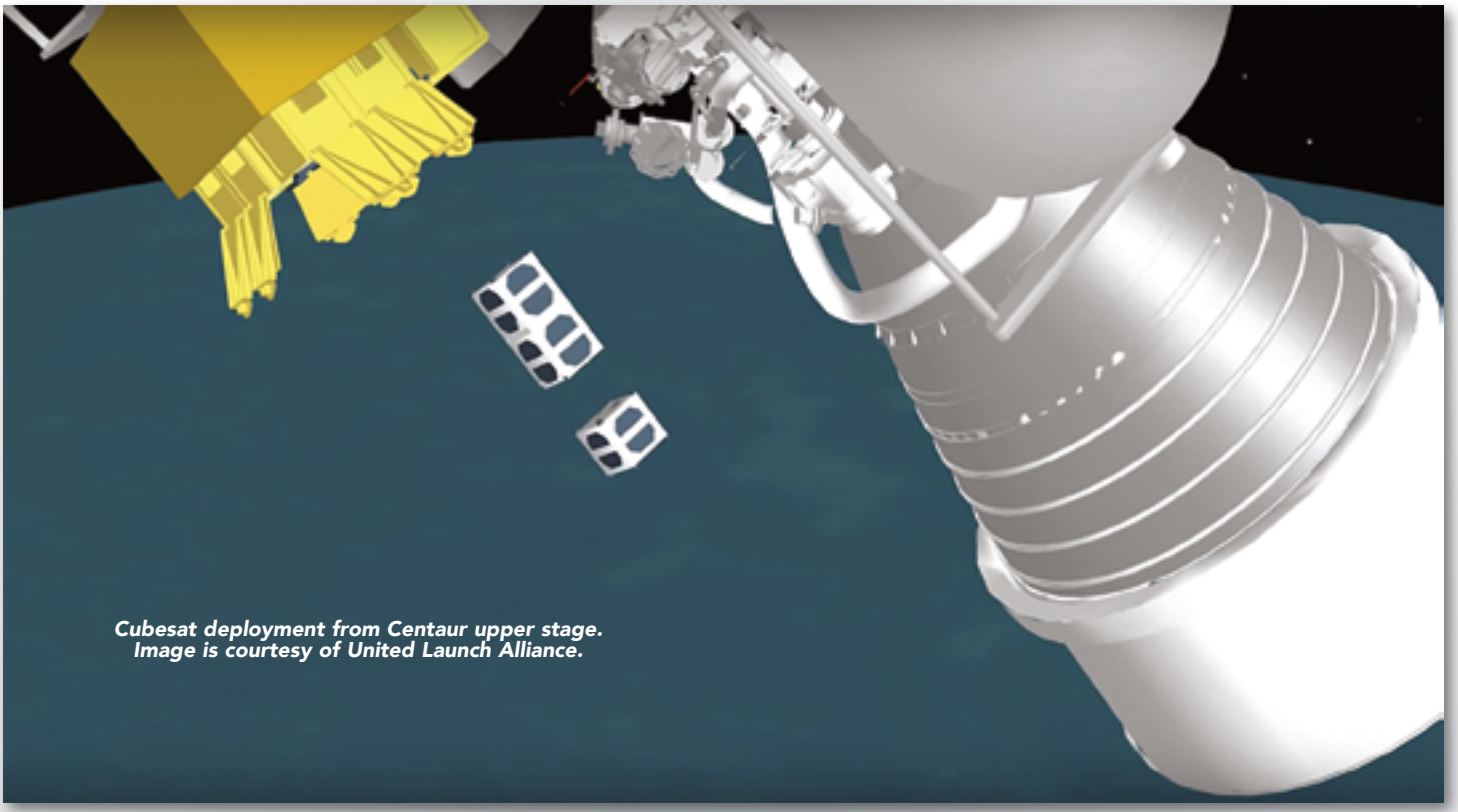
Firefly Space Systems' Firefly Alpha.

The company committed to this program in their bid to tap into the growing market of smallsats, as the company plans to place a standard CubeSat carrier with as many as 24 berths on the aft bulkhead carrier, bolted to the rear end of the *Centaur* upper stage. This location will prevent interference with the launch's main payload and the CubeSats will be spring ejected. ULA's intention is to also place a similar device on the future *Vulcan* launch vehicle.

CPOD

Tyval Nano-Satellite Systems has proposed the *CubeSat Proximity Operations Demonstration* (CPOD) mission to demonstrate the rendezvous, proximity operations and docking of two 3U CubeSats. Sponsored by **NASA's Small Spacecraft Technology Program** and **Space Technology Mission Directorate**, the techniques to operate two satellites in close proximity to one another other is seen as enabling on orbit inspection and servicing of satellites and to allow multiple satellites to operate together in space.

CPOD.



Cubesat deployment from Centaur upper stage. Image is courtesy of United Launch Alliance.

To be launched in 2016, the two CPOD CubeSats will be placed in a common orbit. They will maintain an intersatellite link to share data. Many of the operations will be performed autonomously using on-board processors and flight software for guidance, navigation and control. Using on-board navigation systems, one of the satellite will perform a series of circumnavigation maneuvers relative to the other satellite.

The long term application of this technology is targeted toward the field of debris inspection/removal, resupply, spacecraft inspection, along with formation flying activities as an extension of the host satellites.

CubeSat Operational Concerns

With the number of small satellites released in what are often considered random orbits that are determined by the principal payloads, NASA has reported that one out of every five CubeSats launched between 2003 and 2014 is in violation of international guidelines that call for satellites to deorbit—by force of nature or their on-board systems—within 25 years of retirement. CubeSats operating in orbit below 600 km are expected to meet this 25 year deadline; however, those in higher orbits may exceed that deadline.

Related to all this is the concern being expressed by operators of communications satellites in geostationary orbits, that large constellation of satellites in lower orbits may interfere with the proper functioning of the geostationary satellites. In particular, reference has been made to the *OneWeb* proposal to place 720 satellites in lower orbits to provide Ku-band broadband Internet services.

While the proposed OneWeb satellites, with a mass of 150 kg, are not considered nanosatellites or smallsats, it is easy to see that similar problems could occur with CubeSat networks.

The emergence of commercial CubeSat constellations has caught big operators 'with their pants down.' For instance, the U.S. National Geospatial-Intelligence Agency (NGA) hopes to request funding to begin experimenting with the various imagery products that are becoming available from a new generation of commercial satellite operators and data analytics firms.

Considering that Planet Labs, with its *Flock* constellation, has been operating now for close to two years, it becomes clear that the large agencies, such as NGA, are in a disadvantaged position and have been too slow to react to the rapid advance of the CubeSat and smallsats, in general. Now is the time all must catch up with v technologies.

Jos Heyman, a retired accountant, is the Managing Director of Tiros Space Information (TSI), an 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 organizations.

Jos has more than 40 years of experience in the historical aspects of astronautics and is the editor of the ***TSI News Bulletin****.*

Redefining The Business Of Space

We call them Nanos, Picos and CubeSats—vessels of voyage that 500 years ago might have been the Niña, the Pinta and the Santa Maria.

From the shores of Spain to the frontiers of space, humanity's quest for knowledge now includes a small satellite (smallsat) revolution to advance Earth Observations (EO), remote sensing and boundless scientific research and discovery.

Ball Aerospace is currently building an instrument for the company's first official CubeSat mission. However, the company's foray into the smallsat sphere began well before this segment became an emerging market. In the 1980s, Ball Aerospace developed two human-rated Smallsats designed for launch from the Space Shuttle.

"Ball's project included the two small spacecraft plus a release canister to launch the CubeSat-sized experiments from the shuttle's bay called the modified Get-Away-Special, or GAS can, launch system," said Mark LaPole, director of Ball's Advanced Imaging efforts. "Our smallsat design included multiple miniaturized and light-weighted innovative components designed for experimental missions as part of a low cost solution to support research payloads on the shuttle."

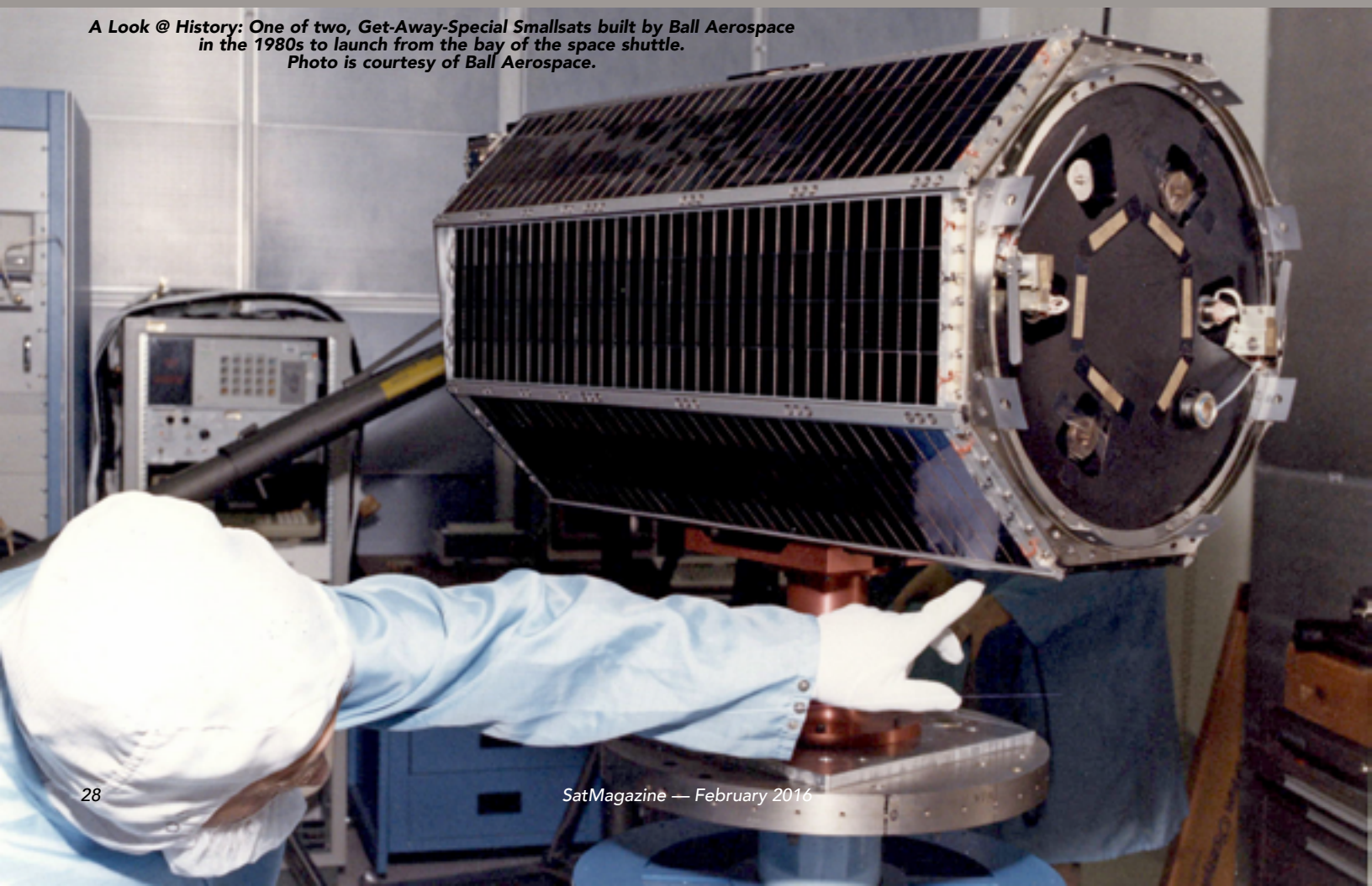
The short-lived Get-Away Special (*see photo below*), officially known by NASA as the Small, Self-Contained Payloads program, came to an end following the 2003 Columbia Shuttle disaster when NASA redefined their funding priorities. That didn't stop Ball Aerospace, however, from thinking large and small about the future of critical technologies and capabilities.

Pivot Point

Fast-forward to 2015, when NASA's Science Mission Directorate announced the agency would fund Ball's Compact Infrared Radiometer in Space (CIRiS) as part of a program that tests new technologies in space before they become part of a full-fledged mission. The program is called In-Space Validation of Earth Science Technologies (InVEST) in support of NASA's Earth Science Division (ESD).

With solar panels folded inward for launch, Ball's CIRiS could fit entirely within a small shoebox (4x8x12 inches). This volume will encompass an earth-observing instrument and all components for communication, stabilization and other spacecraft operations in low-earth orbit. The CIRiS instrument is an uncooled radiometric imager whose high performance benefits from an on-board absolute calibration system based on new technology developed at Ball.

The CIRiS radiometer joins a portfolio of advanced sensors Ball Aerospace has developed over six decades. 2016 marks the company's 60th anniversary in the aerospace industry.



A Look @ History: One of two, Get-Away-Special Smallsats built by Ball Aerospace in the 1980s to launch from the bay of the space shuttle. Photo is courtesy of Ball Aerospace.

Ball's eyeglasses for the Hubble Space Telescope—an instrument called the Corrective Optics Space Telescope Axial Replacement instrument—is arguably the most celebrated of these instruments.

COSTAR is one of seven optical instruments Ball has built over the life of the 25 year old landmark telescope, plus two star trackers, five major leave-behind equipment subsystems and more than eight custom tools to support astronauts during servicing missions.

Hello Pluto

COSTAR may have put Ball on the map for the firm's technical ability to solve hard problems in space, but in July 2015, another Ball camera was taking center stage. It turns out that no matter how far from Earth you travel a picture is still worth a thousand words.

Journalists around the globe proved the adage in trying to find words to describe the first astounding images of Pluto taken by Ball's light-weight Ralph camera (*see photo below*). Traveling aboard the New Horizons spacecraft for nearly 10 years, Ralph revealed for the first time maps that show what Pluto, its moons, and soon what other Kuiper Belt objects look like. Ralph's suite of detectors is fed by a three-mirror telescope with a resolution 10 times higher than the human eye. Small but powerful, the camera weighs only 23 pounds and uses approximately seven watts, the power of a standard night light.

Ball engineers who worked on the Ralph camera say the short time they had to build Ralph was challenging, which made the wait to see the mission's outcome even more challenging.

"We had 20 months to build Ralph, but a decade to wait before we knew whether or not the instrument would last and successfully do what it was built to do," said Ball's Ralph Program Manager, Lisa Hardaway. "That's a long time in our industry to wait for anything."

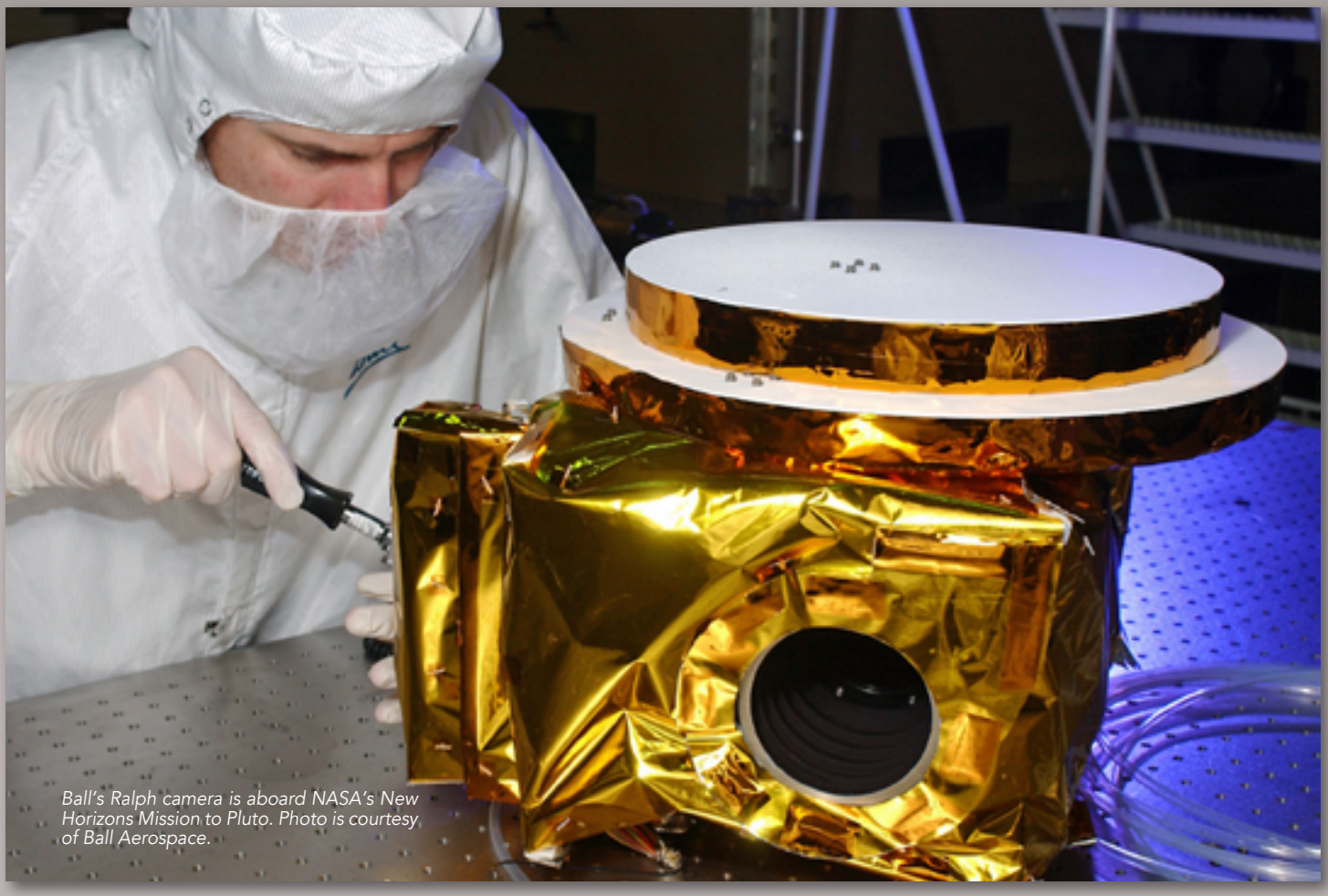
The wait proved to be worth it, as Ralph and the companion cameras worked perfectly to capture historic high resolutions images of Pluto as New Horizons passed by the dwarf planet.

A Celebration Of Longevity

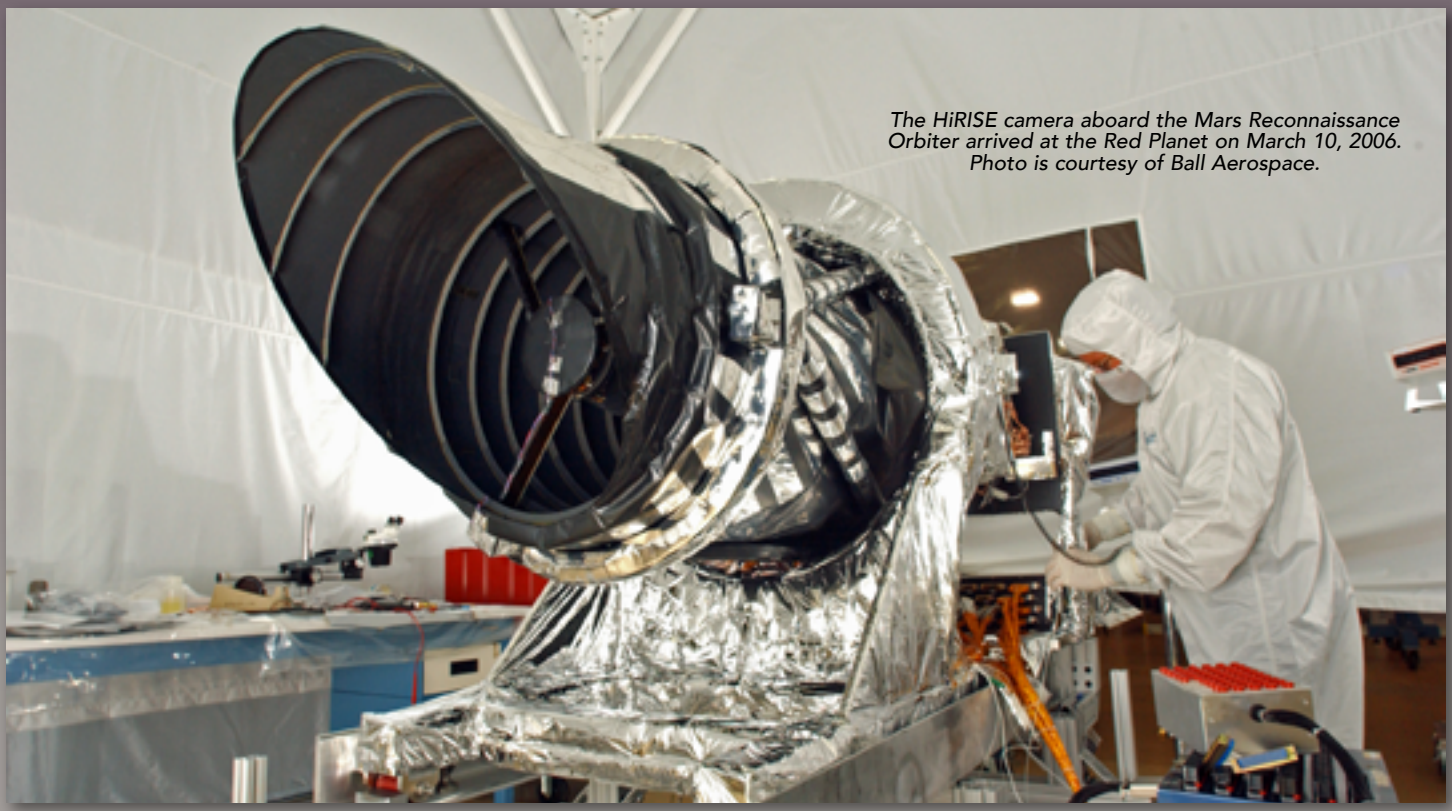
The ten year wait for a "mission accomplished" might feel long, but when an instrument lasts that long in the harsh environment of space, that's cause for celebration. Ball will celebrate two such milestones this year.

First up is the 10th anniversary of Ball's HiRISE camera (*see photo above*), aboard the Mars Reconnaissance Orbiter which arrived at the Red Planet on March 10, 2006. HiRISE has allowed the study of the age of Martian features, identified landing sites for future Mars landers, and in general, provided far greater detail of the Martin surface than has previously been captured from orbit. By doing so, it is allowing better studies of Martian channels and valleys, volcanic landforms, possible former lakes and oceans, and other surface landforms as they exist on the Martian surface.

As of early 2016, HiRISE had acquired more than 41,000 observations of Mars' surface in unprecedented detail. The camera operates in visible wavelengths, the same as human eyes, but with a telescopic lens that produces images at resolutions never before seen in planetary exploration missions.



Ball's Ralph camera is aboard NASA's New Horizons Mission to Pluto. Photo is courtesy of Ball Aerospace.



The HiRISE camera aboard the Mars Reconnaissance Orbiter arrived at the Red Planet on March 10, 2006. Photo is courtesy of Ball Aerospace.

These high-resolution images enable scientists to distinguish 1 meter size (about 3 foot size) objects on Mars and to study the morphology (surface structure) in a much more comprehensive manner than ever before. HiRISE also makes observations at near-infrared wavelengths to obtain information on mineral groups.

A month later, on April 28, 2016, a pair of NASA satellites—CloudSat and CALIPSO—will mark 10 years on orbit. CALIPSO, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, and CloudSat were launched into a 705 kilometer (438 mile) circular sun-synchronous polar orbit. They fly in orbital formation as part of the "A-Train" constellation of three other EO satellites that include Aqua, Aura and Centre National d'Etudes Spatiales' PARASOL. Together, the A-Train satellites have substantially increased understanding of the climate system and the potential for climate change.

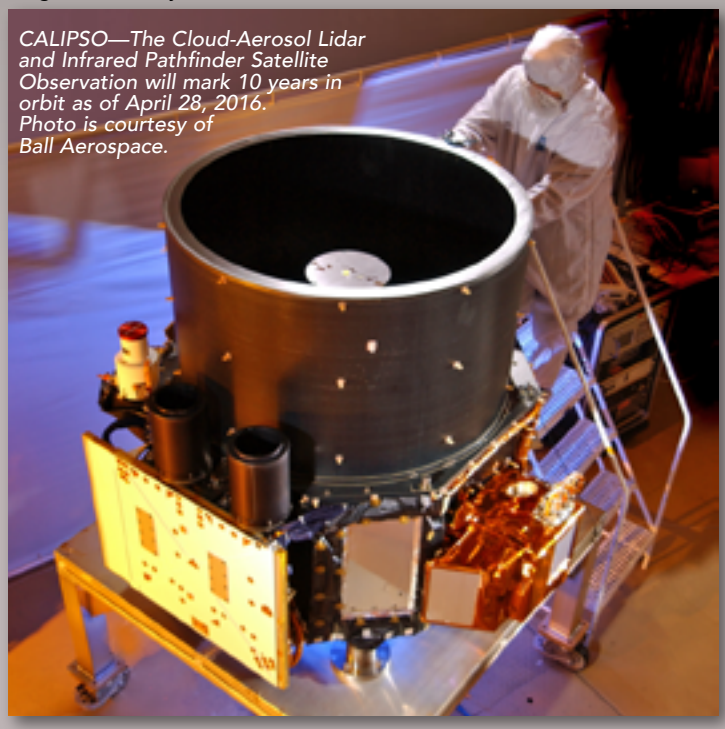
For CALIPSO, Ball Aerospace built the LIDAR (Lidar Detection and Ranging) and wide-field camera instruments, the communications equipment, and integrated the payload for the CALIPSO program. (Ball also built the CloudSat spacecraft for the NASA mission, and tested and integrated the Cloud Profiling Radar payload.)

Across The Spectrum

Like CALIPSO and CloudSat, NASA's Global Precipitation Measurement (GPM) mission has played a critical role in Earth's weather and environmental forecasting since its launch in February 2014. Ball's radiometer for the mission called the Global Precipitation Measurement-Microwave Imager is currently setting the gold standard for data accuracy for all other radiometers in the eight satellite GPM constellation.

Ball also has a long history in providing instruments to study the ozone layer dating back to the 1980s. The company is currently providing NOAA and NASA with the Ozone Mapping and Profiler Suite (OMPS) flying aboard the Suomi National Polar-orbiting Partnership satellite. The OMPS sensor will also launch aboard the 2017 Joint Polar Satellite System and future JPSS iterations.

Ball is known as an industry leader in remote sensing and is currently building its second EO Operational Land Imager (OLI) for the next Landsat mission. Ball Aerospace earlier teamed with NASA and the U.S. Geological Survey to provide the OLI for Landsat 8, returning continuous land surface observation unmatched in quality, detail, coverage and length since early 2013.



CALIPSO—The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation will mark 10 years in orbit as of April 28, 2016. Photo is courtesy of Ball Aerospace.

OLI—Ball's Operational Land Imager aboard the Landsat 8 mission. Photo is courtesy of Ball Aerospace.

"Our customers are increasingly interested in new architectures for their missions and are looking for innovative ways to complete their goals," said Makenzie Lystrup, director for new business at Ball.

"Never-before-imagined missions are the life-blood of Ball and we're looking forward to another sixty years of challenges as the industry and marketplace continue to evolve," she said.

Like the iconic ships that set sail for the New World, Nanos, Picos and CubeSats—the smallsats fleets—are poised to deliver boatloads of discoveries for decades to come.

ballaerospace.com/

When it comes to instruments and sensors, Ball has proven experience across the entire electromagnetic spectrum. Two spectrometers currently in house are being built in tandem in order to capture design efficiencies between the two instruments, which share the same technology.

The air quality and environmental monitoring spectrometers are called TEMPO and GEMS and are being built for NASA and Korea Aerospace Research Institute, South Korea, respectively. GEMS is a geostationary scanning ultraviolet-visible spectrometer designed to monitor trans-boundary pollution events for the Korean peninsula and Asia-Pacific region.

The GEMS instrument has a 2-axis scan mirror and a 1k x 2k focal plane array using a Charge Coupled Device to image the ultraviolet/visible spectrum.

TEMPO, NASA's Tropospheric Emissions: Monitoring of Pollution mission, will make unprecedented air pollution measurements over North America, from Mexico City to Canada and from coast to coast. The TEMPO instrument, being developed under a firm, fixed-price contract, is also a geostationary ultraviolet visible spectrometer that will provide daylight measurements of ozone, nitrogen dioxide, sulfur dioxide, formaldehyde and aerosols.

Smallsats + The Sensors of the Future

As the emerging market for smallsats continues to grow, powerful new uses will be found for imaging, space science, weather and climate, biology research, growing security threats and communications.

Sensor designers will be called on to minimize size, mass, and power requirements and leverage new or improved measurement capabilities with lowered costs. Those missions rely on a short lead and development timeframe which suits Ball's agile and flexible business development model.

Ball's GMI radiometer is aboard NASA's Global Precipitation Measurement Mission. Photo is courtesy of Ball Aerospace.

The Future Of Smallsat Optical Communications

By David Mitlyng, Senior Vice President, Business Development and Strategy, BridgeSat, Inc.

Space-based optical communication systems are poised to take a breakthrough role in commercial smallsat missions.

Backed by successful on-orbit demonstrations, and led by new technology developments, the migration to optical communications from traditional radio frequency (RF) designs will provide a significant leap in the data downlink capabilities of low Earth orbit (LEO) small satellites.

Even today, LEO Earth observation smallsats generate more data than can be downlinked due to power limitations, a general paucity of available (RF) spectrum, variable pass durations and limited access to ground stations. Currently, approximately 27 percent of these smallsats generate more data than they are able to downlink, according to a recent study by Northern Sky Research (NSR).

That percentage will only widen as the number of smallsats in LEO increases, and the payloads create greater amounts of data from more capable imagers, live video feeds, synthetic aperture radar, and hyperspectral imaging sensors. Over the next decade, the amount of data that will be cumulatively downlinked by small satellites is expected to reach 3.9 exabytes, also according to the NSR study. Traditional RF capabilities alone

Space-to-ground transmission through BridgeSat's optical communications network provides large amounts of data delivery for satellite operators. Image is courtesy of BridgeSat.

may struggle to handle this growth, so a new data transmission alternative is needed that provides greater bandwidth through a service that is fast, secure, and offers lower latency.

To meet this need, BridgeSat, Inc. is developing a commercial, optical communications downlink-as-a-service system. BridgeSat is a wholly owned subsidiary of Allied Minds, an innovative U.S. science and technology development and commercialization company based in Boston.

Providing An Optical Communications Turnkey Solution

BridgeSat's mission is to speed the adoption of optical communications systems by providing operators with a full turnkey solution that seamlessly connects satellites and high-altitude unmanned vehicles to the ground, and accommodates accelerating demand for accurate and frequent data collection from LEOs.

Designed to either augment existing RF systems or provide a primary downlink channel, BridgeSat's solution includes mission analysis, upfront design work, delivery and integration of space terminals, and access to a ground network that provides delivery of the operator's data directly from their satellite or UAV to their server.

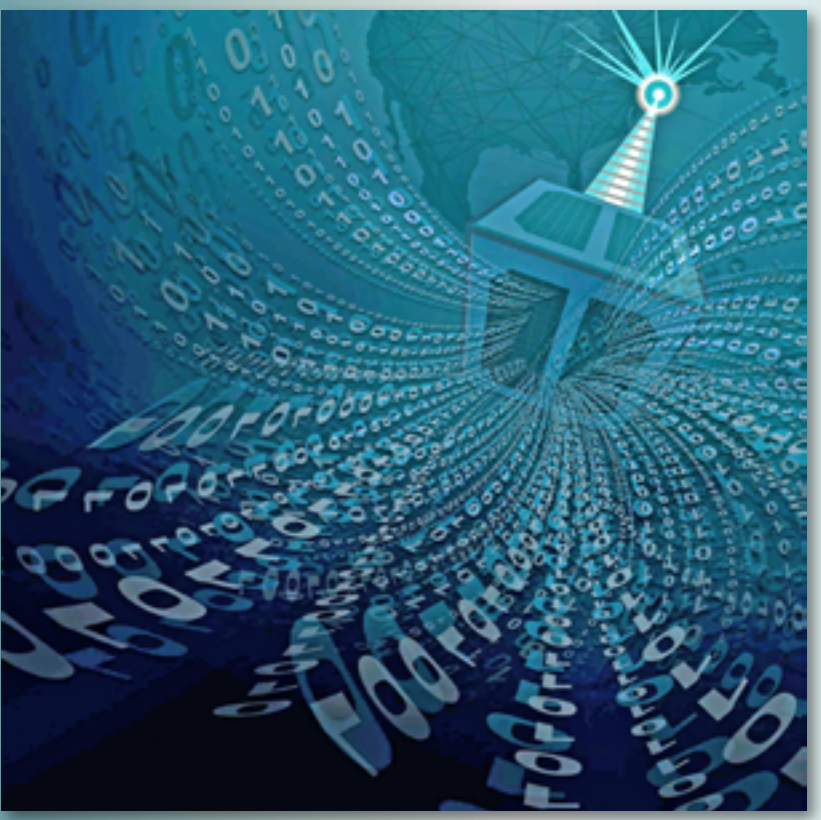
The system is designed to also overcome the two main impediments that had historically challenged satellite-to-ground optical communications: the requirement for precise beam steering and the attenuation caused by cloud cover. Ground station site diversity is essential for optical communications to be a viable operational system. BridgeSat plans to establish a worldwide network of stations for spacecraft operators to use, regardless of their choice for the space optical terminal.

The BridgeSat solution emerged from research at The Aerospace Corporation (Aerospace) that focused on developing a small optical communications terminal for the NASA OCSD mission. Aerospace approached optical communications as an enabler to provide high data rate transmission that would fit on a 1.5U cubesat for the OCSD mission.

This strategy echoed the approach taken by multiple research agencies, universities and photonics labs across the world in optical communications, and has helped to establish a foundation for the potential mass adoption by commercial smallsat operators.

Optical communications systems offer certain advantages over traditional RF communications, including:

- ***High communications data rates**: Traditional RF systems often offer much less than 1 Gbps data links. In comparison, today's optical communications systems offer several Gbps downlink, with clear technology paths for future expansion*
- ***Small size**: Newly developed optical communications satellite terminals are available at less than 1 kg, with a form factor that fits within a 1U CubeSat standard volume*
- ***Low power consumption**: Newly developed optical communications satellite terminals can consume less than 20W, which compares favorably with RF hardware*
- ***Secure data links**: Optical communications links are more robust in contested environments against interception, interference and jamming*



Bolstered by the additional collaborations of other leaders in communications, including Draper, the BridgeSat solution aims to mirror many of these benefits by offering:

- ***High data throughput with low latency**: The data downlink rate is currently designed for up to 2.5Gbps, with an increase to 10Gbps planned for the future*
- ***Small form factor**: Seamlessly fits satellites of all sizes, making it easy to implement*
- ***Cost effective**: Lower $/bit than equivalent radio-frequency (RF) systems*
- ***Customized service**: Upfront design of an optical communications system that is matched to each customer's specific requirements and satellite platform*
- ***Greater security**: Optical communications is inherently more secure*

Long Heritage

The Aerospace Corporation is one of several organizations that have a long history of developing space-based optical communications. Until now, these systems had been largely limited to on-orbit technology demonstrations by the likes of NASA, the National Institute of Information and Communications Technology (NICT), the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), the German Aerospace Centre DLR and NASA Jet Propulsion Laboratory (JPL).

Some programs of significance include:

Launched August 1994, the NICT Engineering Test Satellite VI (ETS-VI) Experiments demonstrated 1 Mbps bi-directional optical links to the NICT optical ground station

Launched May 21, 2001, the Geosynchronous Lightweight Technology Experiment (GeoLITE) demonstrated high rate optical communication links at both LEO and GEO altitudes

Launched July 12, 2001, ESA's Advanced Relay and TEchnology MISsion (Artemis) demonstrated an optical inter-satellite link with the French space agency CNES's Earth observation satellite, SPOT 4, and an aircraft

Launched August 2005, the JAXA Optical Inter-Orbit Communications Engineering Test Satellite (OICETS, also known as Kirari) demonstrated both inter-satellite link and satellite-to-ground downlink

Launched in 2007, the Near Field Infrared Experiment (NFIRE) satellite carried a laser communication terminal developed by Tesat-Spacecom. This terminal was used for LEO-to-ground optical communication tests at up to 5.6Gb/s, and for optical crosslink tests with the TerraSAR-X satellite

Launched September 6, 2013, the Lunar Laser Communication Demonstration (LLCD) demonstrated successful 622 Mbps downlinks from the Lunar Atmosphere Dust and Environment Explorer (LADEE) spacecraft in a lunar orbit, to NASA's Lunar Lasercom Ground Terminal (LLGT), JPL's Optical Communications Telescope Laboratory (OCTL), and ESA's Optical Ground Station (OGS)

Launched April 18, 2014, the Optical Payload for Lasercomm Science (OPALS) demonstrated 50 Mbps downlink from the International Space Station (ISS).

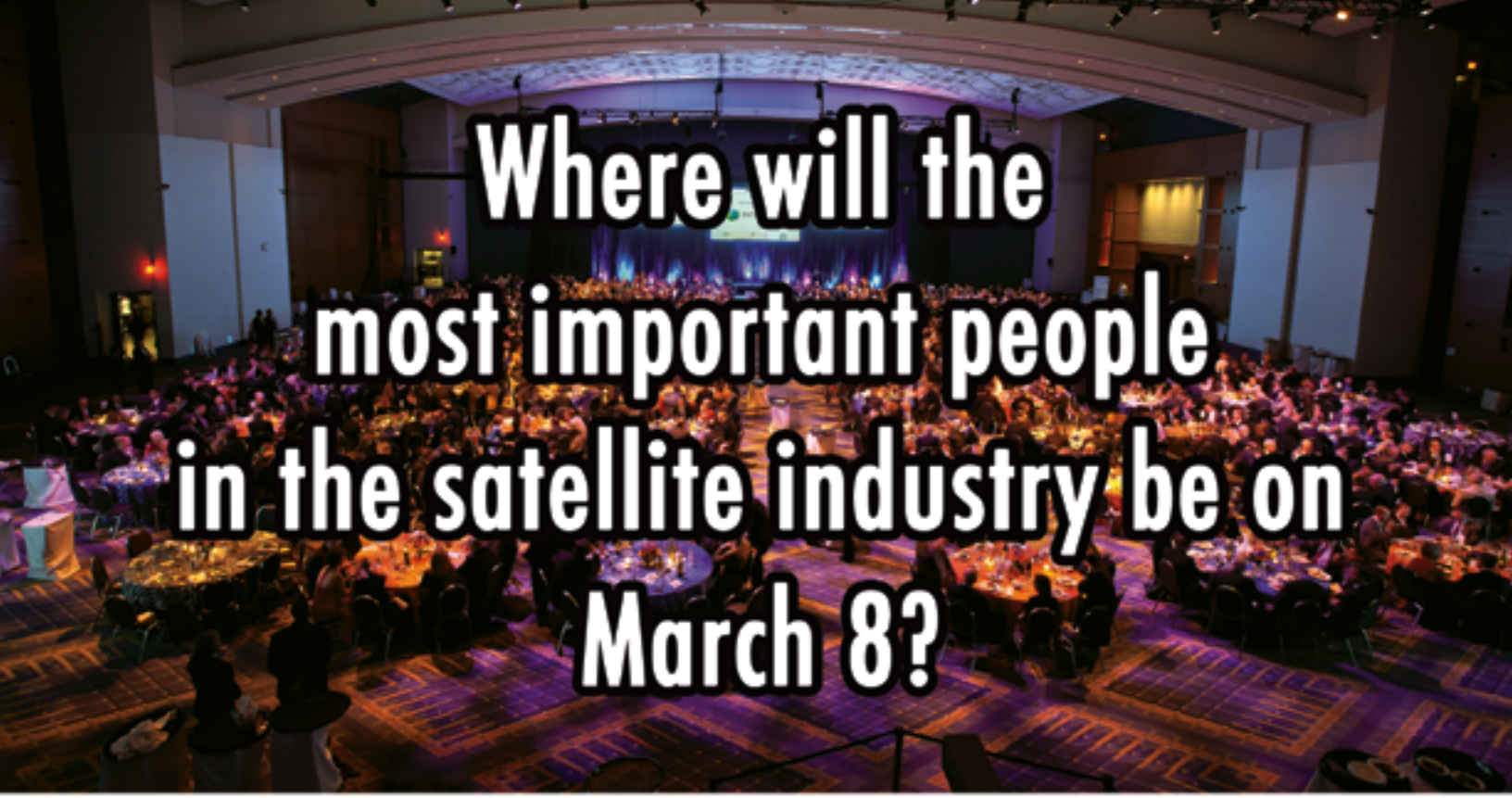
Even more ambitious optical communications systems are under development, including the ESA European Data Relay System (EDRS) and NASA Laser Communications Relay Demonstration (LCRD). While these agency systems will grow the state-of-the-art in optical communications in the long term, the formation of BridgeSat illustrates the nearer-term commercialization opportunity of optical communications technology.

Space-based optical communications systems are poised to make a breakthrough in commercial smallsat missions, and the timing is ideal for mass adoption by operators. Not only is the technology being thoroughly demonstrated in space, but it is based on well-established, commercial terrestrial optical communications technology.

Much like fiber optic cables provide the large point-to-point data pipes in terrestrial applications, optical communications has the potential to provide similar value to customers in the smallsat arena.

For smallsat operators looking to download large amounts of data from their satellites, optical communications offers the best solution, and BridgeSat stands ready to help enable this new market.

David Mitlyng is the Senior Vice President of Business Development and Strategy at BridgeSat Inc., an Allied Minds company dedicated to commercializing space-based optical communications. David more than 20 years of commercial satellite experience from SSL, Orbital Sciences, and Hughes Space and Communications. He has a MBA from the MIT Sloan School of Management (15-15), MS in Aeronautics and Astronautics from Stanford University, and BS in Aeronautical Engineering from California Polytechnic State University, San Luis Obispo, California.



SOCIETY OF SATELLITE PROFESSIONALS INTERNATIONAL
HALL OF FAME
BENEFIT DINNER

The SSPI Hall of Fame Benefit Dinner offers a unique opportunity to network and visit with clients, customers, suppliers, colleagues and industry friends. From the champagne reception to a gourmet meal to the induction of the honorees into the Satellite Hall of Fame, SSPI's annual Hall of Fame Benefit Dinner is always the talk of the industry.

On that night, SSPI will hold its annual Chairman's Reception. This invitation-only reception welcomes the C-Suite of the most important companies in our industry, including established players, their customers and innovative new entrants. It offers a relaxed and intimate atmosphere for conversation and networking at the end of a long day in meeting rooms, and before the excitement of the Hall of Fame Benefit Dinner.

March 8, 2016
Gaylord National
Convention Center
National Harbour, MD

Tickets are now available for the Hall of Fame Benefit Dinner. For more information or to purchase an individual ticket or a full table, visit www.SSPI.org.

Hurdling The Challenges Of Interference With CID

By Martin Coleman, Executive Director, the Satellite Interference Reduction Group (IRG)

Over the past couple of years, IRG has led the push for Carrier ID (CID) to make it far easier to resolve interference when such occurs.

A great deal has happened, with a new CID technology, specifications, a standard, requirements and processes to get CID up and running. However, despite these efforts, and the push from satellite operators to rollout CID, the users are not yet properly on board.

The Stats

The amount of capacity affected by interference at any one moment is quite small, approximately 1 to 2 percent of the total global capacity. There is a certain amount of complacency among users who may not have been affected by interference. However, the impact of interference to any customer can be extremely harmful and everyone needs to be on board to stop such from occurring. For most of the causes of interference, the technology and tools are already in place to drastically reduce the impact. CID is just one more tool in the interference toolbox. However, in the case of CID, IRG asked satellite operator members about the current percentage of CID uptake among their customers—this remains at less than 5 percent. Obviously, the uptake of CID remains low, but we are still at the start of CID rollout.

Knowledge + Understanding

Some of that reticence among users comes down to a simple lack of knowledge and understanding, as well as too many myths that surround the CID technology. Therefore, in order to combat such erroneous beliefs, users must be educated on a number of significant elements.

First, users must be armed with the knowledge that this challenge exists and what the causes of such are, as well as the service impact of satellite interference. Second, users must have an understanding of the various tools available to resolve interference, of which CID is but one. Operators need to be trained, products must be certified, and additional technologies and tools that are aimed at reducing interference must be made known. Users should understand what methods are the most appropriate for their operations and how such should be applied.

There are a number of resources available for users that address this subject, but often users may not be aware of where to look—this must be improved. The basics of CID may be found at IRG's main website: ***satirg.org/working-groups/carrier-id/***/ At IRG, a data library is being built that will gather a great deal of that information and other available resources in one location. IRG hopes this database can serve as a resource for operators, manufacturers, and users alike. This library can be a great place to start—simply look up the CID data category or use the built-in search facility.

Equipment

Another barrier remains to interference mitigation, and that is in the realm of equipment. While most manufacturers have now included CID in their products, this process can be costly for users who must replace all of their legacy equipment. The lifecycles on most satellite products are generally lengthy and the challenge is going to be persuading users to replace those products before the natural end of life of that product. One trend that has been most helpful is that the move to S2X—for the most part, all DVB-S2X products have CID. Additionally, the resolutions issued by the World Broadcasting Unions International Media Connectivity Group (WBU-IMCG) mean that all new equipment being purchased for SCPC and MCPC video transmissions must have CID.

This move has been most helpful... unfortunately this doesn't solve all of the issues. First, just because equipment is CID equipped does not necessarily mean that the user is going to turn CID on. More often that not, satellite products are shipped with CID switched off and must be enabled by the user once that particular piece of equipment has been installed. Second, companies buying equipment for other uses may still be purchasing products that lack CID. Once again, the same difficulty occurs in getting those to change to CID in the months or years to come, especially for those who have recently replaced equipment with non-compliant products. Third, simply having CID integrated doesn't necessarily ensure the quality of that product. Users need to be encouraged to only purchase certified products, whether that is through the Global VSAT Forum's (GVF) extensive program or other providers.

Technical Hurdles

Even with the correct equipment installed, users still face technical hurdles when ensuring the proper use of CID. They need to integrate the new equipment into their systems, learn how to use the technology and how to make certain CID is enabled. Even when CID is enabled, ensuring correct transmission is an important concern. Of course, monitoring equipment can detect CID and ensure all is correct.

If you are unsure as whether CID is enabled or not, fitted or turned on, then ask your manufacturer. Once enabled, the equipment will automatically assign your unique identifier—and that's it. Certainly tell your satellite operator that you have started using or intend to use CID. All major operators have begun integrating CID processes into their networks and many have detection systems in place and are ready to check that the ID is present. That is their part of the bargain. Together with the need to educate users about interference and CID in general, we need to offer the technical knowledge to make it easy for them to get on board with CID.

Overcoming The Hurdles

There remain a number of hurdles that must be overcome to ensure widespread implementation of Carrier ID as well as any subsequent anti-interference technologies. Technology, standards and requirements are an important step and are certainly making a difference to that uptake.

However, if the users don't have the appropriate knowledge and understanding regarding the problem, how interference can affect them, and the methods to resolve it, only so much can be achieved. Throughout 2016, IRG aims to increase that awareness through education, workshops and events and offer to satellite operators the information they need to ensure their customers are up and running with CID.

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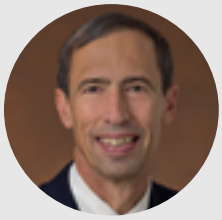

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Finding Elasticity In The Space Industry

By Carolyn Belle, Senior Analyst, NSR

A basic tenet of economics is that selling at a lower unit price very often means selling more units.

The *Financial Times* defines this as price elasticity, or "the degree to which the quantity of demand for an item is sensitive to change in the price of the item." Elasticity is important because it expands the addressable market, enabling a vendor to sell more, altering market share, and facilitating economies of scale that further decrease unit price. In the satellite manufacturing and launch industry, however, the level at which price elasticity manifests itself has been out of reach.

SpaceX's efforts at developing a low cost rocket were largely targeted toward this goal, as have been other efforts over the years to decrease manufacturing and launch price, but technical hurdles and high operator barriers to entry beyond CAPEX have largely prevented elasticity from emerging. Nonetheless, a sub-section of the space industry has already approached this point of elasticity.

NSR's *Nano and Microsatellite Markets, 2nd Edition* report (***nsr.com/research-reports/commercial-space/nano-and-microsatellite-markets-2nd-edition-/***) found that smallsats have begun to exhibit the hallmarks of an elastic market. Prices to design, build, and launch a smallsat have significantly fallen over the past decade, while launch rates have more than doubled. New operators are entering the field and the lower costs have facilitated the expansion of markets and services.

A Recent Growth Story

NSR has counted 14 smallsats (1-100 kg) launched in 2001, 22 in 2011, and 143 in 2015. This 15-year CAGR of 16.8 percent, compared to the 5 year CAGR of 45.4 percent, reveals that smallsat launch rate growth has been a steadily building trend which has risen rapidly in recent years. In the same 5 year period, the 'over 100 kg' GEO satellites saw a launch rate of 3.4 percent CAGR, while non-GEO satellite launch rates were flat.

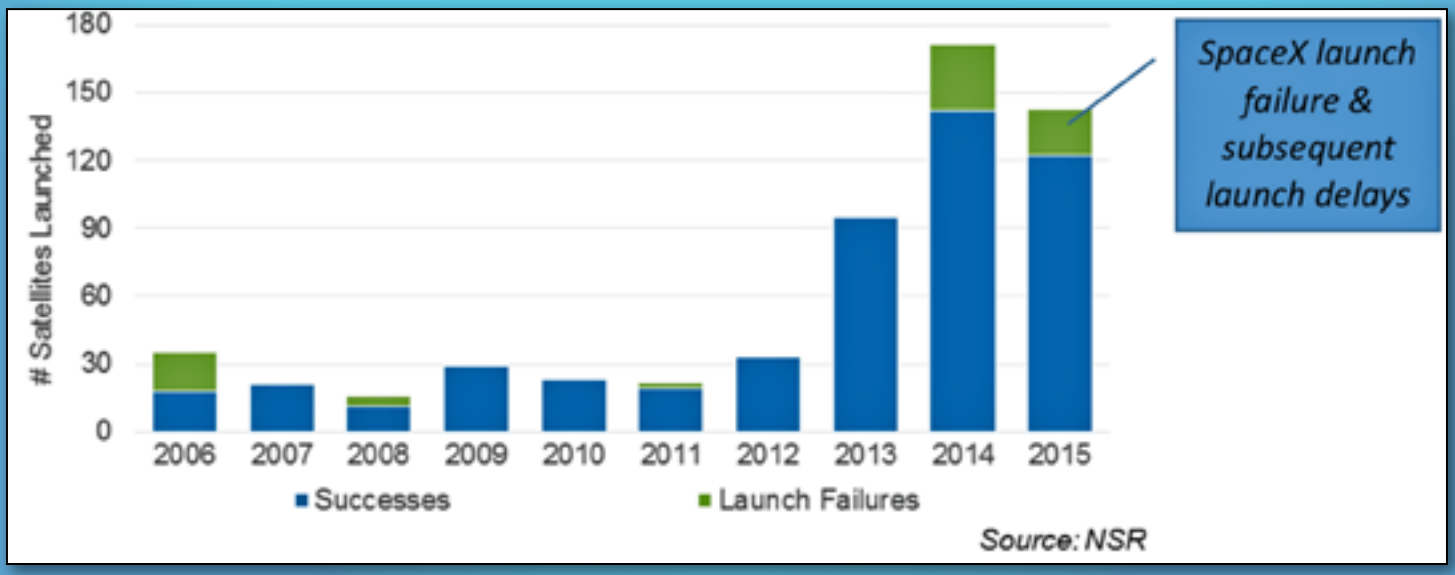
While the launch rate itself demonstrates market growth, the number of unique operators and target applications reveal market expansion and diversification. Indeed, 51 different operators launched smallsats in 2015, while only 41 launched large, over 100 kg satellites. Yet it is in analyzing the emergence of new operators that the true variations of the smallsat market become apparent: 28 operators (55 percent) launched a smallsat in 2015 but had not launched during the previous 5 years, while only 9 such operators (22 percent) were present in the over 100 kg market.

Market	Satellites launched, 2011	Satellites launched, 2015	5-year CAGR
<100 kg	22	143	45.4%
Non-GEO, >100 kg	76	76	0%
GEO, >100 kg	33	39	3.4%

Satellite Launch Rate Comparison by Mass, 2011 & 2015

This high growth has mainly been enabled by reductions in smallsat price and complexity. Smallsats, after all, are not new. The U.S.S.R.'s Sputnik 1 classifies as a smallsat, as do the first satellites launched by the US, UK, France, Germany, Japan, Australia, Argentina…

1 to 100 kg satellite launch record



The smallsat form factor itself is, therefore, not what makes this market elastic, but rather the development of new technologies and practices that enable a low CAPEX without sacrificing capabilities, and the concurrent emergence of downstream markets based on these lower price points.

The Building Blocks Of Smallsat Market Elasticity

Given the technology-heavy nature of the space industry, cost, capabilities, and complexity to design and operate the satellite must be considered in the decision to become a new operator or increase the number of satellites in one's fleet. NSR considers the three variables as contributing factors to the emerging elasticity of the smallsat market.

Advances in consumer-grade electronics and commercial software have altered the dynamics of satellite components, which were previously unique and specialized designs manufactured only for the space industry. For instance, something as accessible and low cost as a mobile phone has sufficient computing power to control a smallsat, and consumer cameras can act as Earth imaging payloads.

Furthermore, smallsats are designed for shorter lifecycles and do not require the same vigorous and expensive test equipment that are traditionally used before satellites are launched. This use of Commercial-Off-The-Shelf (COTS) components and reduced testing requirements in turn enables manufacturing to be completed by an in-house operator (or, in-garage, in some cases) rather than contracted through a specialist manufacturer, thereby decreasing overall cost.

Likewise, the decline in global launch costs has made launch opportunities via rideshares more accessible and affordable. This cost reduction has not yet been sufficient to transition traditional satellite markets into elastic markets, but has been a piece of the puzzle for smallsat market elasticity.

Launch brokerage services formed since 2010 facilitate the launch process for unfamiliar operators, eliminating the complexity of matching them with the correct launcher and finalizing contracts.

Plans for launchers currently in development include reusability and high volume to drive prices down even more. In addition to SpaceX, Firefly, Virgin Galactic, and XCOR plan to reuse part of their launch system after each flight. Rocket Lab, in contrast, anticipates that high volumes and new manufacturing techniques will bring about lower launch costs.

While questions remain as to how to lower launch costs and make them more accessible, heightened competition and market trends leave little doubt that prices will fall in the coming decade and catalyze smallsat market elasticity. Customer crossover with traditional satellites exists, but the principal value proposition of commercial smallsats is in meeting emerging demand.

Earth observation and maritime tracking via AIS signals are initial markets ripe for low cost, consistent smallsat services, and smallsat players have attracted new customers and found opportunities by providing data sets previously unavailable or overly expensive.

This will drive EO market growth from the 43 percent of today's smallsat launches to 51 percent by 2024, even as the entire pie expands and Situational Awareness, Communications, and Science increase market share as well.

Today's Big Data hungry economy provides the necessary customer base for ongoing growth in these markets, compounded by each incremental decline in the cost of satellite services. Moreover, smallsats are now much more capable compared to those launched even a decade ago.

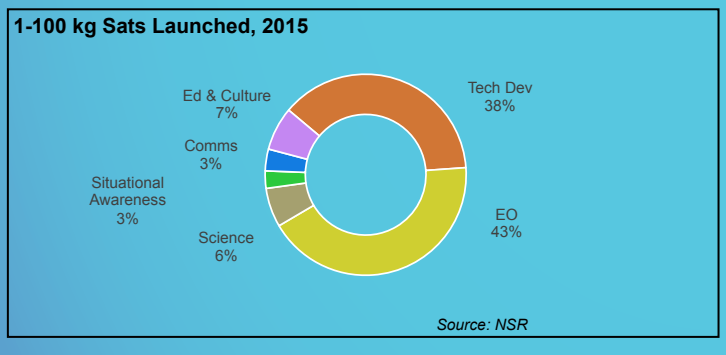
Implications For The Space Industry

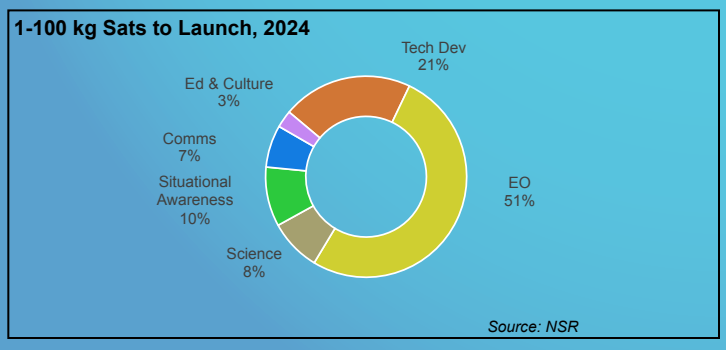
The elasticity that smallsats begin to bring to the space sector has the potential to make the market more mainstream, with positive impacts across the value chain. An expanded and growing population of operators creates more market opportunity for ancillary services: launch service providers, launch brokerage services, end-to-end communications services, and component manufacturers.

The R&D involved in creating new capabilities for smallsats and further improving manufacturing efficiencies could be applied to larger LEO satellites or even GEO satellites moving forward.

Additional new applications are expected to emerge as the price per satellite decreases; some might offer a unique commercial service and generate revenue, while others could provide cultural or educational value. Proposals for smallsat use range from Bitcoin blockchain management to on-demand shooting stars to broadcasts of original musical compositions.

University and high school level projects to design and build satellites are becoming a popular means of hands-on study, as are not-for-profit services such as Ardusat that provide cubesats as a leased platform to schools. Moreover, hands-on smallsat projects at the student level increases the skills and number of trained graduates entering the space industry job market.





Ultimately, despite the industry and mainstream press focus on the unprecedented launch rates, the truly significant aspect of smallsats is not what the launch rates were in 2015 or will be in 2020, but that they are changing the way people relate to space.

The flexibility for smallsats to be used in different ways, by different players, at different levels and for different purposes, expands the industry's scope and will open more opportunities.

The Bottom Line

Today's smallsat industry is markedly different from what has been seen before. Smallsats are more capable than those designed for constellations in the 1990s and as one-off satellites before that, and will only continue to advance.

At the same time, their requirements are becoming less exquisite and expensive, extending the population of builders and operators. While not all smallsat ventures will succeed, and stumbling blocks such as launch capacity and regulations remain, the simultaneous increase in capabilities and decrease in design, construction, and operation costs have opened new applications and pulled together the first threads of an elastic space market.

If allowed to grow, this budding smallsat market could revolutionize how people and non-space industries engage with space. While smallsats have not yet delivered elasticity to the space industry, ongoing development and rising interest make the potential for an elastic space sector more attainable than ever before.

nsr.com

Ms. Belle joined NSR as an analyst with several years of experience in the space industry, ranging from atmospheric chemistry to education outreach and market research. Her main focus is satellite manufacturing and launch markets, and in particular the trends surrounding creation of diversified space architectures. She also contributes to research in government and military communications markets in addition to participating in the diverse tailored consulting projects undertaken at NSR.

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No Oxymoron Here... Affordable, Rad Hard + Long Life For Smallsat Subsystems

By David J. Strobel, Chief Executive Officer, and Michael Dowd, Vice President, Space Micro

The emergence of commercial space programs that include larger constellations, plus constrained DoD and NASA budgets, are today's drivers of the need for lower cost subsystems—and often from non-traditional, and smaller size, suppliers.

The Premise

Space Micro's premise is that new space constellation companies can partner with intelligent space box or subsystem suppliers to achieve their financial models by leveraging new technologies that are coupled with innovation for space environment business success.

There is also benefit and major economy of scale gain by "bundling" the electronics subsystems/boxes, as depicted below, while also ensuring the control of key interfaces. Space Micro has demonstrated that a new, non-traditional, smaller company that is focused on space can provide such benefits by providing an entire suite of space-qualified electronics boxes.

The Need

Today's and tomorrow's smallsats, including the many commercial constellations, require dramatically lower costs to achieve their goals, all the while offering customers a high confidence of successful, operational lifetimes on orbit. This lifetime includes the MTBF for all factors that include surviving space radiation environments. To close the typical business model, even with substantially reduced launcher costs, on orbit lifetimes of two to eight years are needed.

Over the past two years, many of the commercial space satellite "constellation" programs, such as those listed below, have been announced. This list is far from inclusive. Others are not yet publicly announced and are "flying under the radar" for business reasons. Some are already funded while others remain in the conceptual and unfunded stages:

- *Clyde Space*
- *Dauria Aerospace*
- *DigiGlobe*
- *GeoOptics*
- *Hera Space*
- *NanoSatifi*
- *Northstar*
- *OmniEarth*
- *Skybox*
- *SpaceX*

- *Spire*
- *Tyvac*
- *WorldVu/OneWeb*

Lessons Derived From CubeSats

Direct application of typical 1-U or 3-U CubeSat technology is not the answer. Recent data presented by Tyvac at the Space Tech Expo in Long Beach, California, in 2015 cited more than 65 percent of CubeSats failed to adequately operate or failed their mission within six months on orbit.

Another study by NASA Goddard in 2015 revealed that the median life of a 1 kg 1U CubeSat is estimated to be 85 days. In contrast, the median life of a 4 kg 3U CubeSat is only 22 days. (*Reference: CubeSat data analysis, NASA Goddard Code 371, November 2015.*)

Impact Of Systematic Failures

Often heard is "My program can sustain a few spacecraft failures, and still be operational, due to redundancy in the constellation." This is true, but only if systemic failure modes are ignored. For example, if the wrong power MOSFET device is designed in and used in each spacecraft's PMAD, every satellite will fail.

This was proven in a European designed and manufactured Quick Launch spacecraft for ORBCOMM, in which those smallsats all failed within one year. ORBCOMM did receive a $44.2 million insurance settlement related to their Quick Launch satellite program, which failed due to power subsystem failures.

What Drives Unit Cost?

Smallsat unit production costs and, therefore, price are driven by many factors, most of which can be mitigated and/or addressed. Among these factors are:

1. *Volume of units—a very steep learning curve is observed after the first unit*
2. *Lack of traditional government oversight and reviews*
3. *Minimized CDRLs (contractual data items to be submitted)*
4. *Traditional government space parts programs can be tailored to the mission*
5. *"Speed" of the program—i.e., longer programs spend more money*

This last factor ("speed" of business) can be highlighted; one of Space Micro's recent commercial space customers required only four days to place a contract and that arrangement was less than 5 percent in page size of a small value DoD contract for just a study.

Technical Approach To Meet This Challenge

Assuming adequate power from solar cells, spacecraft lifetime is driven by the reliability of the electronics subsystems. That subsystem reliability is, in turn, driven by an intelligent design approach using appropriate parts selection, deratings, reliability prediction, testing and qualification, as well as thermal management.

Rather than using the antiquated DoD standard for reliability prediction (MIL-HDBK-217), which severely penalizes commercial versus Military spec parts, let's use selected Commercial-Of-The-Shelf (COTS) microelectronics with high volume production from world-class IC suppliers. Their failure rates are based on extensive life testing results and specific in terms of FITS. This is often in the range of less than 10 failures per billion hours.

These parts, although offering superb performance, may not survive in the environment of hostile space (electrons, protons, cosmic rays, solar protons, and so on.). Therefore, this design must understand how these COTS parts operate in those environments. This necessity requires extensive space radiation testing in ground-based proton beams, heavy ion beams and total ionizing dose sources.

Based on this test data, Space Micro's guarantee is that these parts will not suffer from destructive latch up in space—a catastrophic failure mode. The other radiation effects, such as Single Event Upset, Single Event Burnout, Single Event Gate Rupture, Single Event Functional Interrupt, and Total ionizing dose, are addressed with a combination of Space Micro's patented radiation mitigation techniques, and industry standard approaches.

Finally, to achieve the spacecraft lifetimes needed for the financial business case (often three to eight years), subsystem or board level testing, including additional burn in and temp cycling, may be applied on a tailored basis. An internal parts and next PCBA screening capability, such as burn in and life testing, is applied to increase the overall reliability.

The Business Model + Financial Approach

To meet these customer needs, Space Micro was established as a lean product company, but possessing all of the attributes that are listed below, all of which are required for successful and reliable product delivery. Many startup space subsystems firms may not have developed this cost effective infrastructure.

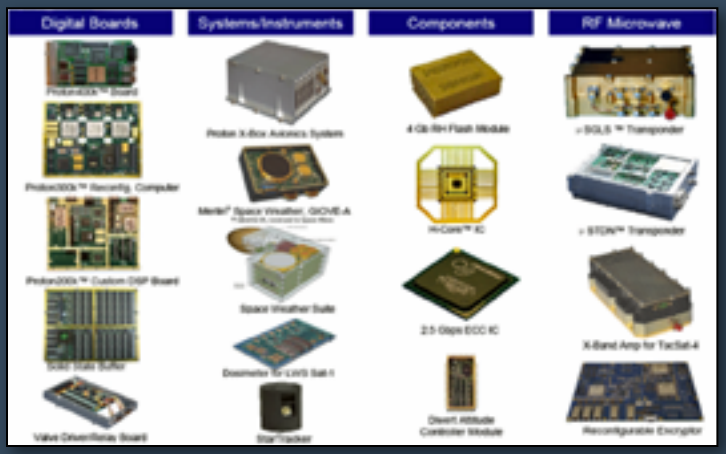
Financial Approach

Commercial space ventures will wish to partner with firms possessing a strong financial position and backing to ensure a source of supply. Space Micro's approach has been a balanced combination of leveraging DoD and NASA SBIR funding (over $30M, to date), employee-ownership, commercial bank financing for operating capital and capex, and customer program funding with milestone payments.

Space products There are many subsystems of electronics required for reliable space products, and they include:

1. *Communications (radios, transponders, data transmitters)*
2. *Avionics (C&DH)*
3. *Payload processing e.g. (image processing)*
4. *Guidance Navigation & Control (GNC) e.g., star tracker, sun sensors, ADCS*
5. *Power management and Distribution (PMAD)*

Photos of many of these COTS, rad hard space products developed at Space Micro are shown on the next page.



Confidence Factors

Previous space flight "heritage' is a major confidence and risk reduction factor in the industry. Following the company's business model, Space Micro was able to design, manufacture, deliver, and launch initial subsystems within four years of the company's inception in 2002. To date, Space Micro has accumulated more than 260,000 hours of successful space flight heritage on a combination of DoD and NASA missions/programs.

Another factor is the establishment of a Manufacturing Resource Planning (MRP) system that supports moderate volume production, not the traditional few units per year seen from most NASA and DoD spacecraft. The MRP is essential for managing both manufacturing flows and raw materials inventory.

Finally, the past history and customer base of the teammate/supplier. Space Micro has worked diligently to become an approved supplier of virtually all US space prime bus and payload contractors—please see the customer base graphic.

The production volumes, performance, reliability, and price points to enable these emerging commercial smallsat constellations can be achieved by a company applying an intelligent combination of technical approach and business model.

Bulletin

Space Micro has just finalized an exclusive licensing agreement with Texas A&M University. This agreement marks the start of a new joint initiative to embed A&M's novel algorithms and software into the Space Micro radiation hardened star tracker product line.

Space Micro's VP of Engineering, Michael Jacox, said, "We've built and demonstrated a diverse star tracker product line by implementing the unique Pyramid Star Identification and Calibration routines created by Drs Mortari and Junkins at TAMU. This license gives Space Micro the exclusive rights to use these techniques which have been shown to be superior for robust and rapid stellar attitude determination."

www.spacemicro.com

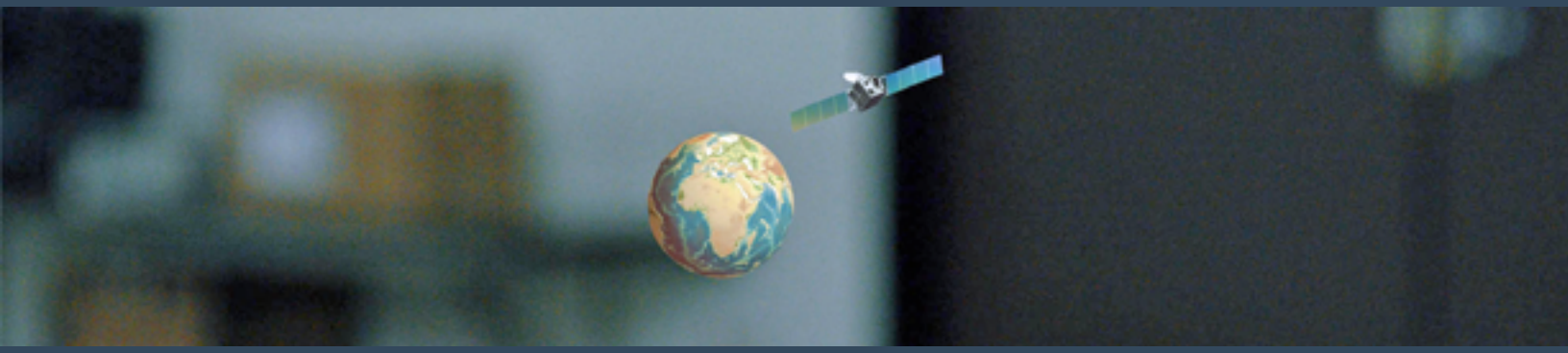
References
1. sat-failures at ***sat-nd.com***
2. CubeSat data analysis, NASA Goddard Code 371, November, 2015.

Mr. Strobel brings substantial expertise and experience in the management of complex space technologies and space market penetration gained during his seven years as the President of Space Electronics Inc (SEi), and his eighteen years at SAIC and Northrop Electronics. Prior to co-founding Space Micro, he built SEi from a small R&D startup company to a valuable 125 employee business with $13M in annual sales; his successful leadership lead to Maxwell Technologies' decision to acquire SEi in 1998.

Mr. Strobel was also a United States Air Force officer, and managed several R&D programs during his service. He holds two US patents for space radiation shielding, and has received an MBA from Claremont, an MS in Systems Management from the University of Southern California, an MS in Nuclear Engineering from Cornell University, and a BS in Astronautical Engineering from the US Air Force Academy.

Michael Dowd brings 18 years of experience selling advanced components and computers to the global space community. Prior to joining Space Micro, Michael worked for Maxwell Technologies managing the sales of their radiation hardened components and computers to the international customers.

During his time at Maxwell, he expanded their business in Europe, Russia and India by creating and leveraging strong relationships with customers and business partners. He received a B.S. in Mechanical Engineering from Cornell University.



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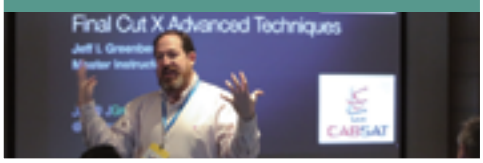

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Counting Down To The FCC Deadline

By Roger Franklin, Chief Executive Officer, Crystal

Over recent months, there has been much discussion about upcoming deadlines for Carrier ID (CID).

For broadcasters operating within the US, the most relevant deadline is growing closer. Now is the time to act for those not yet on board with CID.

The FCC Ruling

The FCC ruling (***http://satirg.org/wp-content/uploads/2013/09/FR-2014-02-12.pdf***) comes into force starting June 1, 2016. The ruling specifies that transmissions of fixed-frequency, digitally modulated video signals with a symbol rate of 128,000/s or more from *Satellite News Gathering* (SNG) vehicles or other temporary fixed Earth Stations must be identified through use of an *Automatic Transmitter Identification System* (ATIS).

The FCC ruling also stipulates a number of requirements relating to the type of CID used—it must be the **DVB-CID**, which also became an ETSI standard back in 2013. Crucially, this Carrier ID standard adds a low power, spread spectrum carrier underneath the host carrier it will identify.

This means that the correct transmission doesn't need to be interrupted to identify the interfering carrier. This enables the operator to drastically minimize the impact on the correct user. The message must continuously repeat and the CID equipment must be integrated into the uplink transmission chain.

Checking The Equipment

Most modern modems and modulators already support DVB-CID; however, they are often shipped with CID switched off and the user simply needs to enable it. To start, you must confirm with your manufacturer whether CID is already integrated. If it is, they can tell you how to enable it, generally by a simple flip of a switch. In other circumstances, you may find that you can add DVB-CID support with a firmware upgrade. Your manufacturer can inform you as to the product's capabilities.

If the equipment is older, chances are good that you will need to upgrade before CID can be implemented. Look into this sooner, rather than later, in order to have the time to test and get comfortable with CID before the FCC deadline. Make certain the modem or modulator is fully compliant with DVB-CID.

The equipment may equally be quoted as Digital ATIS FCC 25.281(b) or ETSI TS 103 129. Avoid buying new equipment that is only compliant with NIT-CID. This is an older technology and will not meet the FCC guidelines.

Transmitting CID

Once you have the correct equipment in place and have ensured CID is enabled, transmitting is the easy part—the equipment will handle that for you. The unique ID code is automatically inserted and will not have to be entered and, generally, you can't change the code anyway.

You may wish to enter additional information to make the process of resolving interference faster, such as the latitude or longitude of the transmitting Earth Station to help satellite operators determine your exact location and phone numbers so they can easily reach you.

Tell your satellite operator you have enabled CID so they can verify the ID and help if any problems arise.

Detecting CID

In general terms, the satellite operators take the responsibility of detecting CID, but it makes sense for users to be able to validate their own, as well. If you are setup to detect, you can ensure you are transmitting the correct ID. This is key for SNG and other live events coverage, as trucks will clearly move to a new location depending on what is being covered.

Each time you move, there is risk in pointing to the incorrect satellite, at the wrong time, and using the wrong frequency. If the CID information is customized, you'll also need to update the location and contact phone number.

Satellite Access Centers lease portions of satellite spectrum on an ad-hoc or scheduled basis to news gathering entities or other remote or mobile applications, such as concerts or sporting events. In these scenarios, there are a number of entities involved, many moving parts as well as a greater chance for unintentional interference. The ability to detect the CID information of a newly uplinked carrier ensures that it is correct at the start of operations.

With the FCC rulings, uplinkers must be certain their CID information is correct and being properly displayed.

Once setup to transmit and detect CID, the next step is to ensure integration with the central CID database. Without the database, the use of CID information is limited. Satellite operators have the responsibility to ensure the CID information is submitted to the central CID database for all of their customers.

For Crystal customers, ***Crystal Carrier ID*** automatically adds an entry to the central database making that portion easy to accomplish and helps to ensure the population of the database occurs.

There continues to be a certain misconceptions and apprehensions surrounding the database. The database will only house a customer's unique CID information and the satellite operator that reported that information. Should interference occur, the database is used to find out which satellite operator needs to be contacted in order to resolve the issue with their own customer.

Meeting The Deadlines

Many uplinkers remain unsure of Carrier ID; however, with FCC deadline rulings looming, those under the FCC footprint need to ensure they are ready by June 1, 2016.

For others, it makes sense to use that as a deadline, as well, because everyone's participation will make a huge difference to interference resolution.

The process of getting on board with CID is relatively simple and a lot of uplinkers will find they already have equipment capable of handling CID or that the required upgrades are easy and cost-efficient to acquire.

CID detection is best if consistent and constant to ensure accuracy and effectiveness. Crystal launched Crystal Carrier ID to support the growing demand for easy-to-use detection systems. If the industry is to succeed in combating interference, CID detection must be cost effective and time-efficient.

www.crystalcc.com/

Every day, billions of dollars of content flow through systems that rely on Crystal technology. Mr. Franklin's unique background as both a software engineer and a business owner drives Crystal's use of leading edge technology to solve real world business problems.

Roger specializes in identifying operational inefficiencies and designing intuitive, responsive, and reliable solutions to correct and capitalize on these opportunities. He has been involved with Crystal since its founding in 1986 and holds a Bachelor of Science in Applied Mathematics from the Georgia Institute of Technology. Since early 2009, Roger focuses on ways to mitigate and prevent RF Interference, which includes chairing the IRG Carrier ID working group and developing a Carrier ID Detection System.

Crystal's roster of customers includes News Corp/FOX, Time Warner / HBO / CNN, Disney / ESPN / ABC, CBS, NBCU, Discovery, PBS, Starz, Viacom, Lockheed, Intelsat General.

The Emergence Of The First Commercial Spaceline

By Jason Andrews, Chief Executive Officer, Spaceflight Industries

The global space industry is on the cusp of a major revolution. Accessing space is transitioning from something that was only available to an exclusive club that was comprised mainly of government entities, to a new, democratized era in which smaller organizations with smaller budgets are becoming increasingly active. These developments are the result of a fundamental shift in the launch industry.

With routine access to space rapidly improving, a positive feedback loop is forming. As barriers to entry are reduced, more and more organizations are pursuing missions in space. Innovators in the new space economy are offering new customer-centric, cost-effective solutions—from new space services to satellite constellations.

Historically, if an organization wanted to launch a satellite, the only option available was to purchase a rocket from a manufacturer. The old space model required a staff of scientists for research and development, a team of engineers to build and operate rockets, and the build-out of ground stations and control centers to communicate with space vehicles and retrieve data.

To put things into perspective, the cost of building NASA's Space Shuttle Endeavour alone was about $1.7 billion. Clearly, the costs involved in the old system prohibited participation for all but an elite few, but thanks to recent innovations in technology, a growing field of commercial space companies are reducing barriers to entry and driving a shift from the old space model to a new era, open to new players pursuing new opportunities.

In recent years "commercial rideshare" has become a reality. Today, spacecraft operators no longer have to buy and operate their own rockets and ground stations in order to access space and operate successful missions for commercial or scientific purposes. Instead, they can now purchase a "seat" on the next ride to orbit.

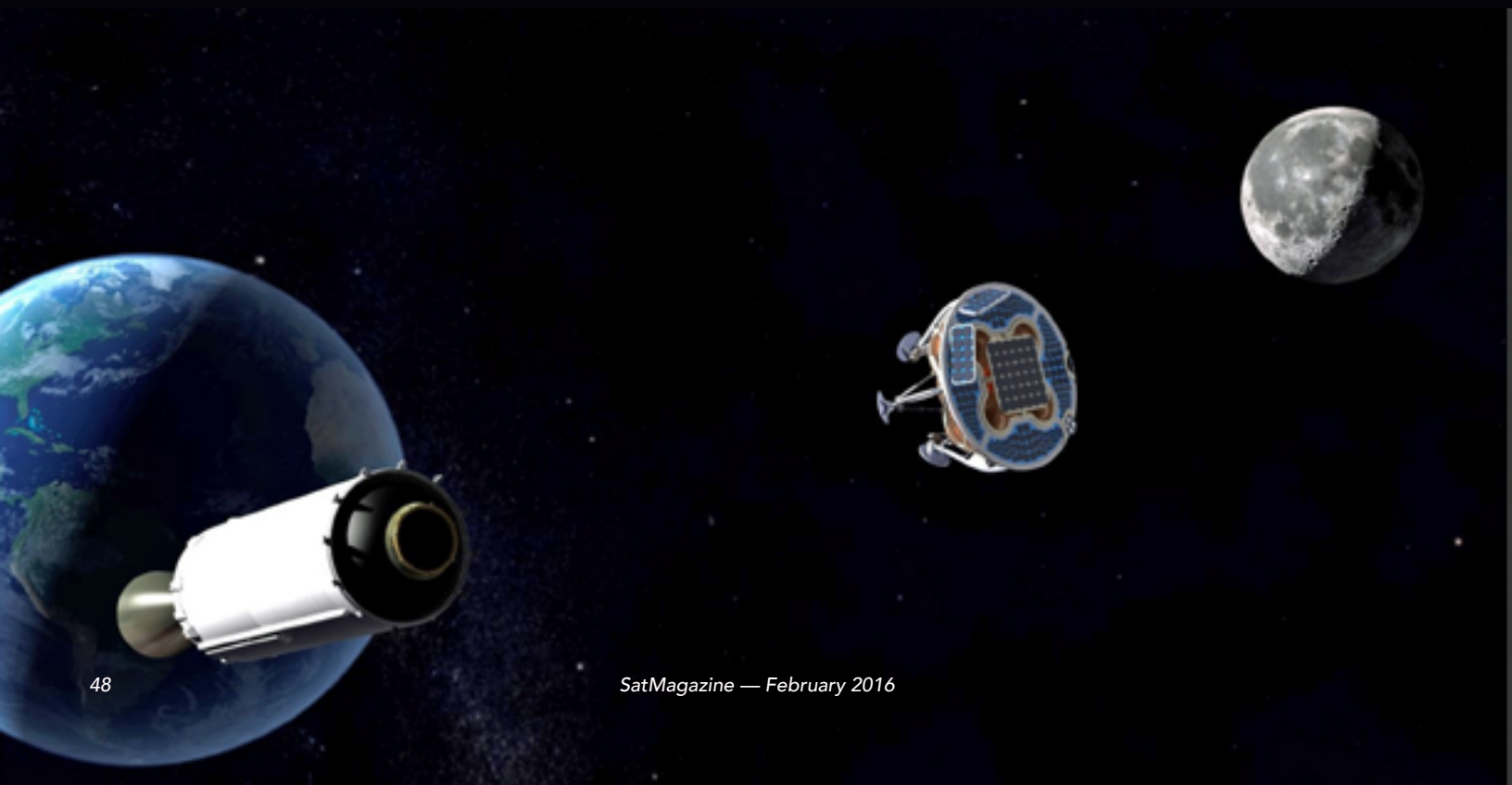
This may seem like a simple evolution of a business, but this does represent a titanic shift. A new space industry model is emerging, one resembling that of the airline industry and it's allowing organizations to operate space missions for a fraction of the traditional model's price.

Consider the business model of the airline industry; there are three main parties involved: the airplane manufacturer such as Boeing or Lockheed Martin, the airline service provider such as Delta or American Airlines, and the customer. With this model, customers are not required to purchase the entire plane.

Nor are they required to coordinate the logistics of their flight or own the runways the plane takes off and lands upon. Instead, they, along with a couple of hundred other travelers, reserve a seat for themselves and room for their luggage to get from point A to point B safely and efficiently.

I believe that the new space model will operate more like the airline industry model, with companies from the manufacturing and launch sectors, such as SpaceX, Arianespace and Orbital ATK, collaborating with full-service logistics and communications providers to provide a seamless experience for small satellite operators.

Airlines don't build airplanes, and at Spaceflight, we are proud to be the first commercial spaceline to offer regular transportation on a wide range of rockets, which we don't build. We've been proving this new model for the past five years, creating new opportunities for smallsat rideshare



launches and offering full-service launch logistics and communication services. To date, we've negotiated the launch of 81 satellites on behalf of our customers and have contracts to deploy more than 135 satellites through 2018.

In response to the tremendous demand from commercial and government entities to gain access to space, last year we purchased an entire SpaceX Falcon 9 rocket and expanded our services beyond rideshare launch to include dedicated rideshare missions. This new launch alternative blends cost-effective rideshare pricing with first-class service typically associated with buying a private rocket. It also gives us—and our customers—more control of the launch schedule.

Like any good airline that sells seats and ensures that you and your luggage arrive at the correct destination safely, our goal is to coordinate the launch and deployment of payloads on behalf of customers without requiring any effort on their part. The customers tell us where they need their spacecraft to go and whether it's to the moon or dropping a satellite at LEO, we do the work to make it a reality. We negotiate rideshare space on launch vehicles around the world including India and Japan or on our own dedicated launch vehicle and coordinate all the required logistics to ensure payloads arrive at their correct destination.

Getting to space is one thing, but it's the significance of the missions served by the new space economy that will have great impact on every industry from energy to agriculture, finance, government, human rights, defense and more. For example, our 2017 dedicated launch mission will feature a co-lead payload from SpaceIL, an Israeli nonprofit organization aiming to land the first Israeli spacecraft on the moon.

This is also the first private lunar mission and SpaceIL is the first competitor in Google Lunar XPRIZE, a competition in which a privately-funded team must successfully place an unmanned spacecraft on the moon's surface, explore at least 500 meters and transmit high-definition video and images back to Earth, to secure a launch date.

Whether for commercial or scientific purposes, satellites are launched with the objective of gathering information that can help us better understand the world we live in. Communications systems are critical to successfully retrieving data and information from space missions, but building a ground communications system is typically too expensive for small satellite operators.

Fortunately, the new space era allows innovative startups to provide solutions like any good airline would. For example, Spaceflight offers out-of-the box communications solutions for smallsat operators who are seeking the most comprehensive global coverage at the best possible price. Our network of ground stations has been sighted to minimize communications latency and maximize data throughput, but more importantly, it was designed to be simple to use. The system operates similar to a cellular carrier network making communications as easy as owning a mobile phone or logging into an in-flight WiFi system.

Fifty years ago, no one would have ever imagined private companies would partake in the exploration of space, let alone take the lead in driving innovations in the space industry. Yet, here we are in the midst of a new space renaissance driven by commercial, scientific and non-profit entities rather than a handful of world leaders.

As this still young, commercial space industry continues to evolve and fashion itself as a service available to all, we look forward to an era of collaboration among providers that will enable new journeys for more organizations and a growing understanding of the planet and our universe.

spaceflight.com/

Mitigating Risks With Hands-On Training

By Genah M. Burditt, EyasSat — with contributions by Dr. Jerry Jon Sellers, TSTI

In the aerospace business risk is impossible to eliminate; but, it can be managed. Risks abound and fall into numerous categories. For purposes of this article, the focus will be on technical risk, cost risk, and risks associated with potential mishaps.

NASA, DoD, and many other organizations characterize technical risk using Technology Readiness Levels (TRL)—see ***Figure 1***. TRL's are used to evaluate and manage the inherent risk in adopting emerging technologies. Lower TRLs require further development before they are accepted for use in space systems.

For decades, small satellites and, most recently, cubesats, have proven themselves as low-cost test beds for advancing new technologies up the TRL ladder, reducing the risk of adoption by larger, more expensive programs. Thanks to the small satellite phenomenon, the cost is lower and the task is easier than ever before to get into space.

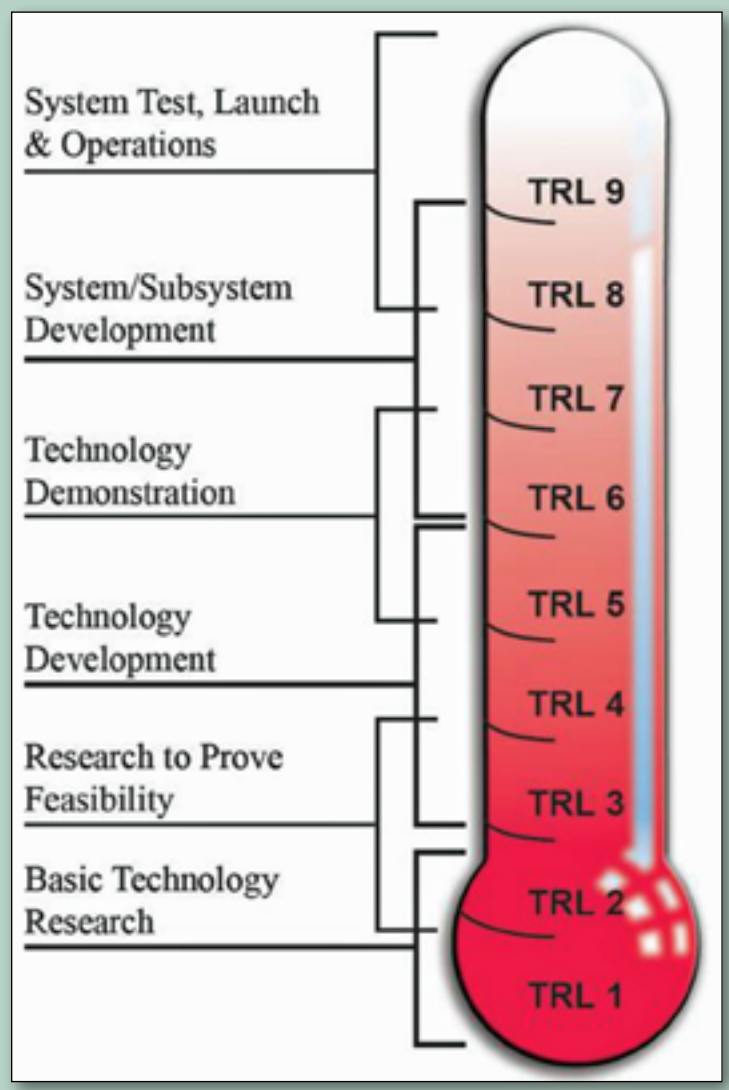


Figure 1. NASA's Technology Readiness Levels Scale, image taken from Understanding Space: An Introduction to Astronautics, 4th Edition, copyright 2014 CEI. Used with permission.

Another risk, which must be mitigated, is the potential for human error to cause a mishap. Whether a novice or lifelong aerospace professional, humans make mistakes—some have led to the most costly incidents in aerospace history.

Consider, the units calculation error that led to the loss of the Mars Climate Orbiter, in 1999, to the tune of $125 million dollars; or, the $1.7 billion dollar, AEHF-1 Comm Satellite that was nearly lost because a piece of cloth was left in a critical fuel line.

The Falcon Sat Program at the United States Air Force Academy (USAFA) is a program in which cadets and instructors work together to design, launch, and carry out missions aboard small space-craft.

As the USAF Academy took on the challenges of building and operating small satellites with undergraduate cadets, they recognized the high risk of failure in having inexperienced students assemble flight hardware. Having a mishap with real flight hardware is not an option.

With this concern in mind, leadership began to look for ways to reduce the risk of human error while "jump starting" the systems engineering experience of the students. What if students at the Academy, or in any organization, could gain experience on a low-cost "practice satellite?" One that would give them experience with "flightlike" hardware, but where failure (while not invited) would not set back the flight program. From this concept, EyasSAT was born.

In the late 1990's, USAFA[1] formed a Cooperative Research and Development Agreement (CRADA) with a privately held company, Colorado Satellite Services (CSS), and commenced R&D on "EyasSat."

The name EyasSat comes from the Latin word for baby falcon, Eyas. The falcon is the Academy mascot; hence, the Falcon Sat Program. In 2004 EyasSats began to be integrated into the USAFA academic program, starting with A331: Introduction to Space Mission Design.

The EyasSat desk-top satellite has all of the subsystems of a typical spacecraft, including Power, with a solar array for Direct Energy Transfer, Thermal, Data Handling, Comm, ADCS, with control about a single axis (Z) using a reaction wheel and/or magnetorquers, and Ground Control Systems. While the look of EyasSat Trainers has evolved over the years), the basic functions remain the same.

Over the last decade, EyasSat has proven to be an essential tool for teaching a wide range of space systems engineering concepts to a variety of audiences. From teaching robotics and basic Newtonian 1 Physics to middle and high school students, fundamental spacecraft design, requirements, and constraints, at the university level, basic spacecraft design and operations to Space 200 at the National Security Space Institute at Peterson AFB, to teaching NASA professionals and international space agencies "Space System Verification and Validation."[2]

Photo to the right:

The reaction wheel box for EyasSat 3, with three wheels and three magnetorquers for three axes attiude control.

Photo is courtesy of EyasSat.

A screen shot of the telemetry softwre interface for the GEN 5 Nanosatellite. Image courtesy of EyasSat.

EyasSat Simulators have even been used to teach spacecraft operations concepts to an Indonesian Bank that purchased its own communications satellite.[3]

As one of the original conceivers of the simulator, Dr. Jerry Jon Sellers, said, "it gives them a chance to earn some scars with hardware/software and build relevant experience that translates directly to large projects where even small mistakes can have large and expensive consequences."

The intellectual property for the simulator was sold to EyasSat LLC in 2009 and, since that time, additional research agreements with USAFA have led to development of a beta, 3U cubesat simulator and a fully 3DoF air bearing test bed. EyasSat LLC is currently working to bring these designs up to commercial grade and cost-effective manufacturability.

The basic differences between the 3U EyasSat and GEN 5 are the option for 3 axes control and conformity to the cubesat form factor; which, could be an advantage for those organizations where understanding the constraints of this form factor are critical.

The test bed allows in-depth attitude control studies in three axes. Single axis control, whether in EyasSat3 or GEN 5, is sufficient for to demonstrating key attitude control concepts like torque, pointing, PID control, and wheel desaturation.

Regardless of the simulator format or the training context there is nothing comparable to hands on experience at any stage in the education and development of an aerospace professional. The visceral experience of seeing and handling hardware is invaluable.

In example, after seeing an EyasSat demonstration, an anonymous Attitude Control Specialist said, "I've been controlling satellites with reaction wheels for 20 years. Now I really understand how they work."

Fortunately, this person had been successful to that point by following protocol. Consider the value added to this team member's skill set now that s/he can think more critically about the task at hand.

When each team member can understand multiple aspects of a project it streamlines the process and increases the probability of catching a potentially fatal or costly mistake.

Take the following scenario during system design: The payload requires more power than originally budgeted. The team goes to power and asks for more. The power team puts a bigger solar array and more batteries into the design.

Fortunately, the structural team catches the system critical change, and in understanding the launch vehicle's constraints, concludes that the center of mass of the system is now out of compliance. Back to the drawing board...

Does every member of your team have a systems engineering or space background? The most brilliant engineers in the world will not comprehend the unique constraints of designing a system for the space environment without the proper training and experience.

Even with a solid design team in place, new personnel and technology innovations are coming onto the scene every day, making ongoing professional development crucial to mitigating risk.

Whether USAFA cadet, a post doc at John Hopkins University, an officer at The School House at Vandenberg AFB, or an IT professional at an Indonesian Bank, all can benefit from hands-on training.

For more information about EyasSat LLC or TSTI, please visit ***eyassat.com*** and ***tsti.net***.

EyasSat, LLC offers two classroom satellites and accessories for practical, economical training purposes, for high school through graduate-level education and research and professional development throughout the smallsat industry.

Users obtain practical experience in:

- *Systems, Structural, Electrical and Thermal Engineering*
- *Attitude Determination and Control in a simulated microgravity environment*
- *Satellite Communication*
- *Command and Data Handling*
- *Systems Integration*

References

[1]The original development team from USAFA included, Gen. (Ret.) Robert Giffin, Lt. Col. (Ret.) Jerry Jon Sellers, Lt. Col. (Ret.) David Barnhart, and Lt. Col. (Ret) John Clark.

[2]Teaching Science and Technology, Inc. (TSTI) offers space systems courses, like "Space System Verification and Validation" to customers around the world. For additional information, please visit ***www.tsti.net****.*

[3]Bank Rakyat Indonesia is the world's first bank to own its own communications satellite. TSTI is the training provider for this project.

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www.BetterSatelliteWorld.com

GHGSat Taking On Climate Change

By Stephane Germain, President + Founder, GHGSat Inc.

A smallsat owned and operated by GHGSat Inc. of Montreal, Canada, will soon offer a revolutionary new way to measure greenhouse gas emissions from industrial sources around the world.

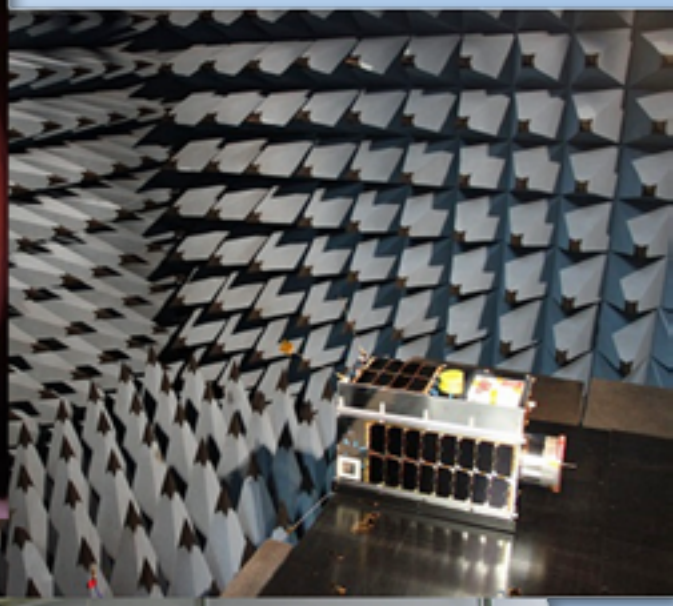
For the first time, a satellite-based instrument will measure emissions from targeted industrial sources. This will provide industrial site operators and government regulators with measurements that are far more precise and at a lower cost than existing, ground-based alternatives.

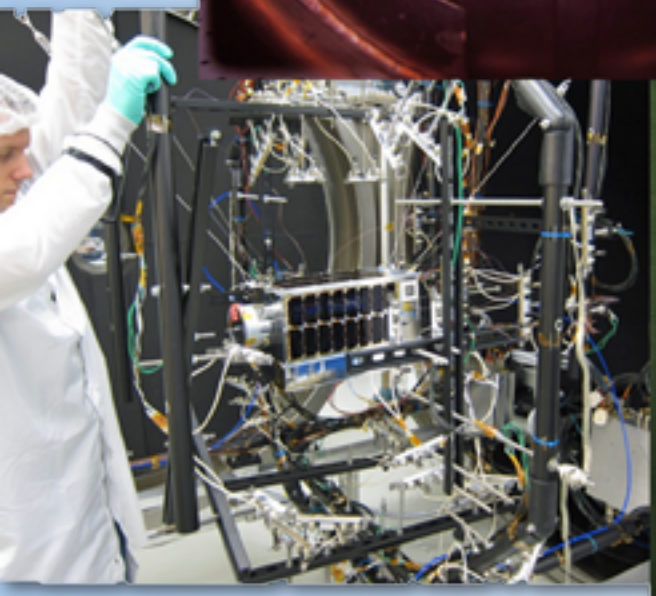
GHGSat is launching this system to serve a carbon market that is estimated by the World Bank to be worth just under US$50 billion in 2015. Industrial site operators around the world are increasingly subject to various carbon pricing instruments, such as carbon taxes, cap and trade schemes, or carbon credits, and must consider the cost of their greenhouse gas emissions as part of their business models. GHGSat's system will measure emissions from industrial facilities such as oil wells, gas plants, thermal power stations, coal mines and landfills.

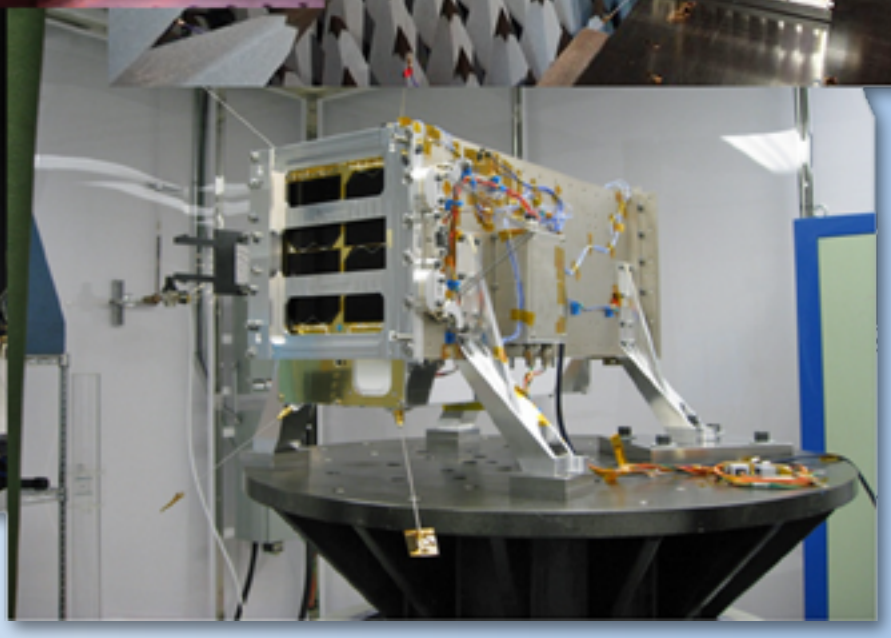
Background

In the summer of 2011, the state and provincial governments of California and Quebec, respectively, announced they would implement a market-based "cap and trade" system to attribute a value to each ton of carbon emitted by industrial operators. Industrial site operators would, therefore, be motivated to better measure their emissions in order to control and ultimately reduce such toxic discharges.

This announcement by these governments inspired GHGSat's founders to develop such a value system. They understood that where there was a value to a ton of carbon, industrial site operators and their government regulators







would need precise measurements of emissions from industrial facilities, to be obtained at attractive prices.

GHGSat's parent company had already been working closely with a partner company through the 2000's for the Canadian Space Agency (CSA) to develop key technologies to acquire such measurements from a satellite. The company began customer interviews, technical evaluations and financial analyses to determine whether a profitable solution could be developed.

They discovered an existing multi-billion dollar market for carbon emissions, one that is growing steadily as ever more jurisdictions impose taxes or implement carbon trading mechanisms, all being served by a vast array of measurement products and services. GHGSat believes their technology could disrupt this large and growing market by offering a single solution with greater precision and lower cost than the alternatives, capable of use across a wide range of industries, anywhere in the world.

Within three months of the announcement, the company located two blue-chip launch customers, architected a technical solution, recruited a core set of vendors, and then developed a business plan. GHGSat was incorporated in December of 2011, secured initial financing through 2012, and started project development in the spring of 2013.

Technology

In a little over two years, from the spring of 2013 to the summer of 2015, GHGSat followed a streamlined development process to design, manufacture, integrate, assemble and test their first satellite system.

- *The underlying science leverages similar satellite measurement technologies pioneered by NASA, the European Space Agency (ESA), and the Japanese Aerospace Exploration Agency (JAXA) over 30 years. Those missions were generally designed to measure the absorption of sunlight at specific wavelengths that corresponded to molecular transitions of certain greenhouses gases. The system then analyzed these measurements to determine regional and global greenhouse gas concentrations and their influence on climate change. GHGSat performs a similar measurement, but on a different scale.*
- *The primary instrument was designed to provide comparable precision to these larger missions, but with 100x better spatial resolution to measure emissions from targeted sites. The heart of this instrument is a miniature 2D Fabry-Perot imaging spectrometer, which provides measurements with spatial resolution on an order of tens of meters. These local, or "microscale," measurements from this instrument will complement regional and global scale measurements that are provided by larger missions. Expert external reviewers were recruited to evaluate the design as well as to support development.*
- *In order to meet a reasonable budget and to reduce risk, the primary instrument was designed to fit in a smallsat of < 20 kg with proven space heritage. This resulted in a total satellite cost on order of 1 percent of that for comparable missions.*

The system was built and tested at component, sub-system, and integrated levels. External references were used where possible to verify performance.

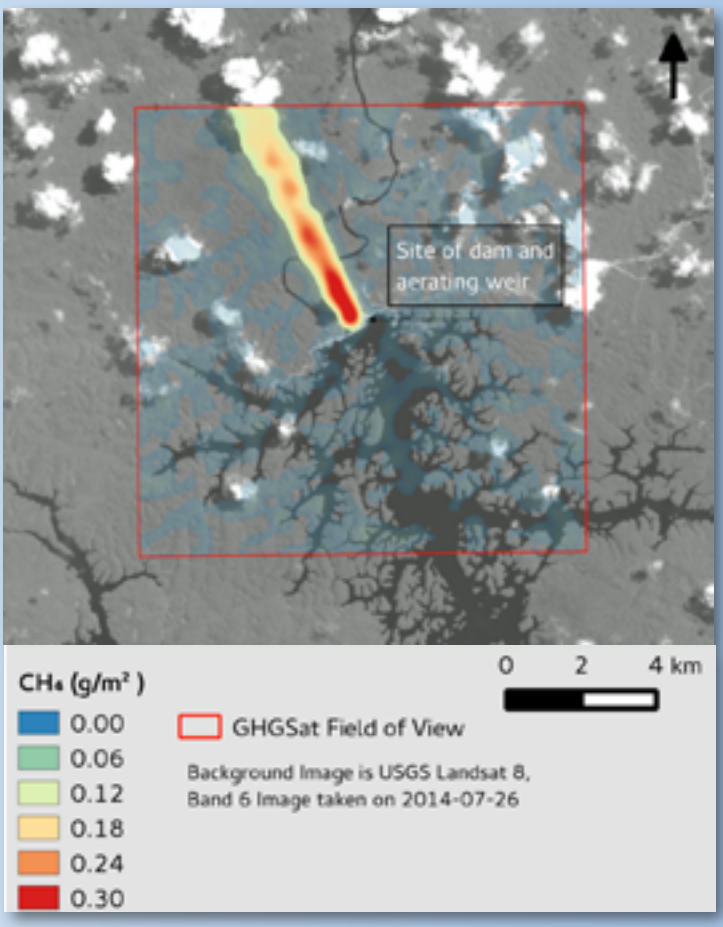
Products + Services

GHGSat will serve targets markets with (i) commercial satellite imagery products, and (ii) value-added services based on its own imagery products.

Commercial Satellite Imagery

GHGSat imagery is acquired in the short-wave, infrared band. The imagery combines a pseudocolor representation of measured concentrations of greenhouse gases (specifically, carbon dioxide and methane) in the atmosphere immediately above a targeted industrial facility, with a surface reflectance map of the same field of view at full spatial resolution.

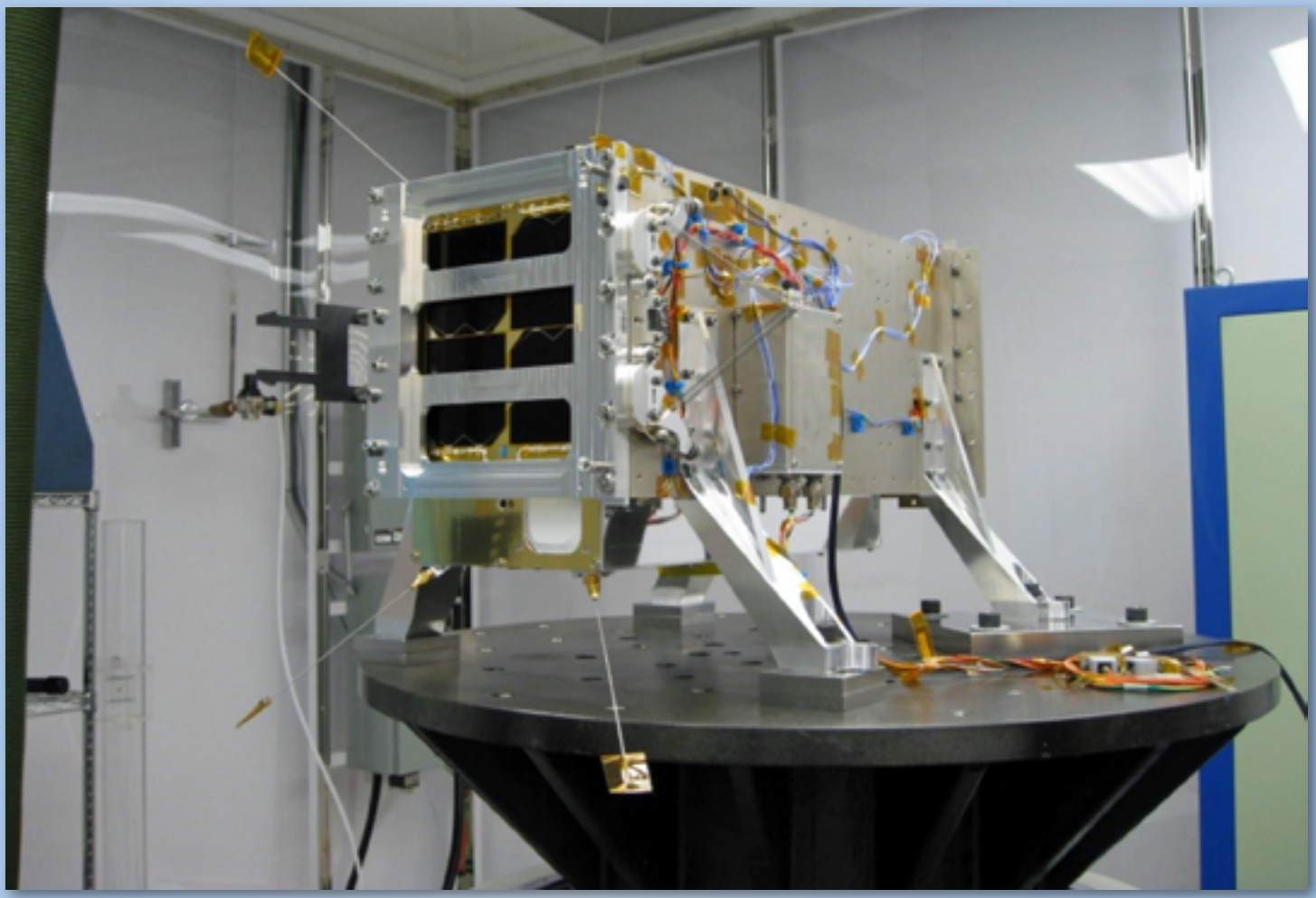
A simulated example of GHGSat satellite imagery is shown below for a hydro-electric power station in South America. GHGSat will have spatial resolution comparable to the Landsat image used as background for this simulation. The plume emitted from the hydro-electric dam in this simulation is methane (CH4).



Value-Added Services

In addition to commercial satellite imagery, GHGSat will offer technical services based on its own, unique satellite imagery products, including, but not limited to:

- *Estimates of site-specific emissions rates from targeted industrial facilities, using microscale inverse dispersion modeling techniques*
- *Source identification, using image processing techniques*
- *Leak detection, by using change detection techniques*
- *Regulatory enforcement, by monitoring emissions from targeted sites over sustained periods*



The first smallsat from GHGSat. Photo courtesy of GHGSat.

What's Next?

GHGSat's first smallsat is ready for scheduled launch in Q2, 2016, from India's Satish Dhawan Space Centre. The image above shows the satellite in its separation mechanism undergoing vibration testing.

GHGSat's first satellite will initially serve to validate the performance of the instrument. A full year of demonstrations is planned for this effort. Once validated, the same satellite will be used to offer commercial services.

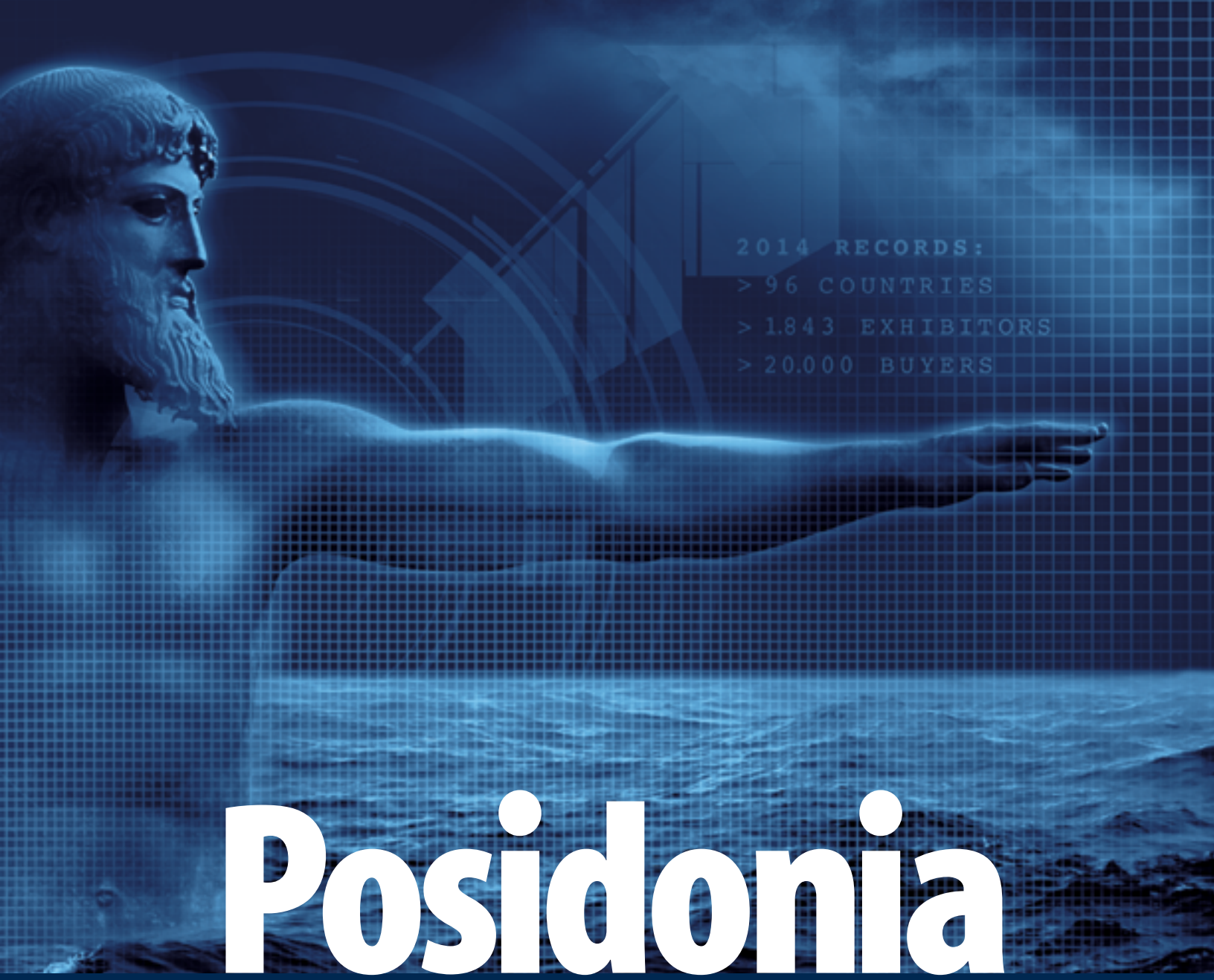
As many of GHGSat's target customers report annual emissions, only a small number of site measurements are necessary, in most cases. This single satellite has sufficient capacity to acquire thousands of measurements per year and can serve a modest number of initial customers over an expected lifetime of five years.

GHGSat will scale satellite capacity with demand and, within ten years, expects to operate a constellation of approximately 20 instruments/satellites. Follow-on satellite decisions will be made based on system performance and market reaction during the first year of operation. GHGSat's technology can also be used for complementary applications or adjacent markets. Initial designs have already been considered for satellite-based air quality measurements (sulphur oxides and nitrogen oxides, for example), and for aircraft-based measurements of various trace gases.

ghgsat.com

Bulletin

GHGSat has been selected as one of the "Top 10" in the Production category for the international GreenTec Awards. GHGSat will be launching its first greenhouse gas monitoring satellite (named "CLAIRE") in April 2016. The satellite will measure carbon dioxide and methane emissions from individual industrial facilities, anywhere in the world. GreenTec Awards have been hosted in Germany since 2008. Germany is the world's #1 exporter of clean technology, and these awards are an example of the country's commitment to environmental issues. The GreenTec Awards Jury is supported by leading European experts (including the heads of the European Space Agency and the German space agency – DLR), as well as popular artists and public figures.



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Beyond The Limits Of Traditional Interference Mitigation Solutions

By Erwin Greilinger, Sales + Product Line Manager, Siemens Convergence Creators

The advent and growth of data-hungry media such as HDTV, mobile services and satellite radio have made satellite links indispensable for global communication.

Revenues in the satellite industry are expected to increase significantly over the coming years. As an immediate side effect, however, the growing number of services will also increase the amount of interference and anomalies, with negative impacts on data transmission. Other sources of interference include potential acts of terrorism, political unrest, and censorship.

Today, only 30 to 40 percent of all satellite interference issues are ever resolved in a timely way, which can lead to damage claims and the risk of losing customers who demand the highest levels of service quality. As a result, there is an urgent need for more effective interference mitigation solutions.

This article describes current available solutions and focuses in on the future of satellite interference mitigation solutions.

Currently Available Solutions

One step in the correct direction was definitely set by the Satellite Interference Reduction Group (sIRG), who had suggested a mandate that by January 1, 2015, all new transmission equipment will have Carrier ID capability. Carrier ID is a technology developed to guarantee immediate identification of the source of satellite signals.

Carrier ID creates unique identification numbers that can be reliably detected and recognized in each carrier. By accelerating the identification of unauthorized or inaccurately configured transmissions, Carrier ID is a significant measure for improving signal integrity.

It's understood that this solution will not work for intentional interference—though such behavior only represents a minority, they can lead to significant problems for satellite operators just because they are intentional. Also, expect that some years will be required until the majority of satellite signals will have Carrie ID implemented.

Traditional satellite geolocation systems can localize the transmit station of an interference signal within a few kilometers. This is not bad, given the fact that they are working by just receiving the interference signal. However, these systems can only work if some prerequisites are fulfilled.

One main requirement is that they need to receive the interference signal via at least two geostationary satellites which have to be in close proximity to each other in order to obtain sufficient crosstalk for reliable geolocation signal processing. Even though there are hundreds of them out there, many of these satellites are isolated in terms of using different uplink frequency ranges, polarization and footprint coverage. This is especially true for military satellites and satellites working in Ka-band. In these cases, crosstalk is either not applicable or too small to be measurable.

In addition, even if a suitable adjacent satellite is within reach, such systems also need to know the exact positions and velocities—or ephemeris data—of both satellites for accurate geolocation. This can only be guaranteed if the affected and the adjacent satellite are operated by the same provider, or if providers share their satellite operation parameters. The crosstalk on the adjacent satellite will still have to be within the same frequency range and polarization as the interference signal on the affected satellite.

With all of these preconditions, traditional geolocation tools have reached their limits and operators are searching for alternative solutions.

Siemens—Engineering The Way Forward

Siemens is one of the leading suppliers of satellite monitoring and geolocation tools. Especially over the past five years, Siemens has done an enormous effort in developing interference mitigation tools. In the meantime, Siemen's product SIECAMS® is the most complete toolbox that supports operators in fighting against interference. SIECAMS® consists of...

- *A powerful carrier monitoring and interference detection tool SIECAMS® CMS*
- *A Carrier-Id detection tool SIECAMS® CID*
- *A traditional geolocation system SIECAMS® ILS*
- *And, last but not least, the world's first real working single satellite geolocation system—SIECAMS® ILS ONE*

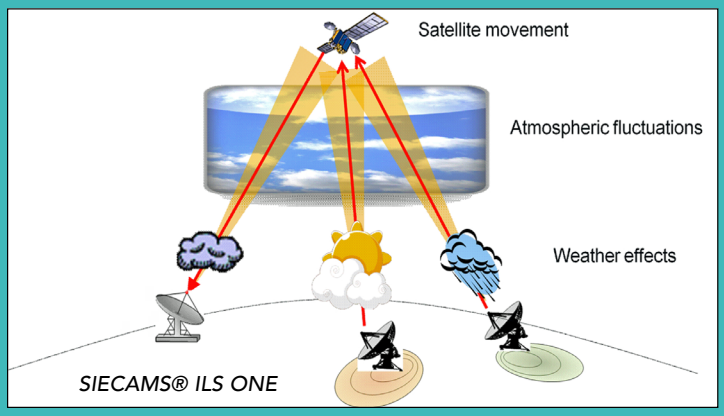
The Single Satellite Geolocation System

One of the company's latest developments was the first, real, working single satellite geolocation system—SIECAMS® ILS ONE. As outlined above, the main drawback of traditional geolocation systems is the necessity of receiving the interference signal via two adjacent satellites, which are often not available, especially for military satellites and satellites working in Ka-band. There have been some attempts in the past to develop a geolocation solution which requires reception of the interference signal only from a single satellite, but they could not achieve an acceptable accuracy. Siemens has, therefore, selected a completely different approach:

SIECAMS® ILS ONE works by analyzing signal distortions that are primarily caused by satellite movement, atmospheric or weather influences and many other environmental factors. By comparing such signal distortions of the interference signal with known signals, and by applying our patented quantum correlation algorithms, SIECAMS® ILS ONE is able to identify the precise area of the interference source. This results in a significant increase in resolved interference issues well beyond the limits of traditional satellite interference localization systems.

The next generation in fighting against interference:

The above described solutions represent the actual status of available tools in fighting against interference—but that's not the end of the road. Siemens is continuously trying to improve the actual solutions and also



seeks alternative solutions. Siemens is partnering with research institutes in Austria and is also working closely with the European Space Agency (ESA).

As a result, we are able to provide the satellite industry with more and more improved powerful tools to address the interference problem, to restore signal quality to the levels customers of satellite operators are expecting, and at the same time saving both time and money.

The following two sections describe briefly two ideas we are working on and are expected to be released in the next few years.

Automatic Geolocation

The first of these ideas is to provide a fully automated geolocation system. This is not far away to become reality as we have from the beginning designed a fully integrated solution of the carrier monitoring system SIECAMS CMS with the traditional geolocation systems SIECAMS ILS and the single satellite geolocation system SIECAMS ILS ONE.

From our point of view, both are an inevitable duo as you first have to detect interference before you can start localizing it. Carrier monitoring systems are generating an alarm whenever they have detected an anomaly like an interference signal. Such an alarm can trigger a geolocation system to start localizing it. If the systems, like SIECAMS, are fully integrated, the geolocation system has all the necessary parameters for performing a geolocation measurement. This is especially true for using the single satellite geolocation system as there is neither an adjacent satellite necessary nor any ephemeris data.

Even when it's necessary to use the traditional two satellite geolocation system, a fully automated geolocation measurement will be possible. The only parameters which are missing are at least one suitable reference carrier and accurate ephemeris data. Here, the Space Data Association (SDA) comes into the game, as this organization is currently working on a RF interference tool which shall provide exactly these data for external geolocation systems. That means in the (hopefully) near future, there will be an interface between SIECAMS and the SDA database for importing such data on a case by case basis which would enable automatic geolocation in all cases.

Benefits for the operator:

- *No need to setup a separate geolocation system*
- *No need to invest in geolocation specialists*
- *Reduce the time for performing manual geolocation measurements*

Big Data

The other idea is that the data of satellite signals is being stored in real time for later post processing (*e.g.*, signal analysis, geolocation, and so on). Satellite operators are frequently faced with short term issues such as interferences which are only up for a couple of minutes and then disappear and, perhaps, come back again later on. Such situations are difficult to handle as it usually takes more time to properly configure a geolocation system as the interferer is on air.

Modern geolocation and monitoring systems work by acquiring the data from sampling cards which digitize the analog satellite signal. These digitized samples are usually first stored in the memory of the sampling card and afterwards transferred to the memory of the computer for immediate processing (signal analysis, geolocation, etc.).

Some of these sampling cards already provide functionality for streaming the acquired data directly to the memory of the computer respectively to the hard drive. This capability is currently limited by the HW performance of the chosen computer (PCI, internal bus, hard drive read / write speed, etc.).

Please note that we are talking about Commercial-Off-The-Shelf (COTS) equipment and not high end computers which are not affordable for customers. With the current crop of available COTS computers, streaming is only possible by limiting the bandwidth (and thereby the amount of acquired data) of the satellite signal to a few MHz.

Fortunately HW performance improves from year to year and gets cheaper and less inexpensive. The expectation is then that, in a few years, affordable HW components become available, enabling the possibility to store in real time the data of the complete L-band signal to the hard drives of a computer. Monitoring and geolocation systems could then perform their signal analysis and geolocation measurements by using those stored samples from the computer's hard drive.

If this becomes possible, any kind of anomaly on a satellite transponder could be analyzed, any kind of interferer could be localized—nothing would get lost.

convergence-creators.siemens.com/siecams-ils-one1.html

Erwin is Sales and Product Line Manager for the Siemens CVC (Siemens Convergence Creators GmbH) Satellite Communication and Monitoring Solutions. Thus he is responsible for the definition of products for monitoring and troubleshooting the quality of satellite communication systems, product marketing, technical and commercial sales activities. Prior to joining the Siemens Space Business, Erwin was section head for Broadband Management Systems and Fast Internet Solutions. This business sector handled projects in the area of Cross Domain Management Systems especially for Broadband IP and ATM networks.

Erwin holds a degree in Electrical Engineering from the Federal Secondary College of Engineering in Vienna, Austria.

Resolving A VSAT Interference Event

In 2015, VeriSat launched SatGuard, a unique tool with patent-pending technology for identifying the source of adjacent satellite interference (ASI) and cross-polar interference (XPOL) caused by VSAT (MF-TDMA) terminals.

By determining the ID of the specific terminals that are causing the interference, the VSAT network operator can be informed and can correct or shut down the interfering transmission(s).

Leading satellite operator SES developed the initial concept for a standalone system, operating independently from the VSAT network under test, to identify interfering VSAT terminals. SES approached VeriSat to develop and produce a system for all satellite operators, and this became SatGuard.

SES has worked closely with VeriSat during the development of this technology and has extensively tested the tool in operations across the world. At the satellite Interference Reduction Group (IRG) workshop in Washington in 2015, Steve Smith of SES presented the background to MF-TDMA interference as well as a case study of the SatGuard tool in action.

The Background

VSAT (MF-TDMA) networks and terminals are one of the greatest causes of RF interference (RFI) and the most troublesome to identify and mitigate. MF-TDMA interference affects all satellite operators and users globally and is time consuming and costly to resolve.

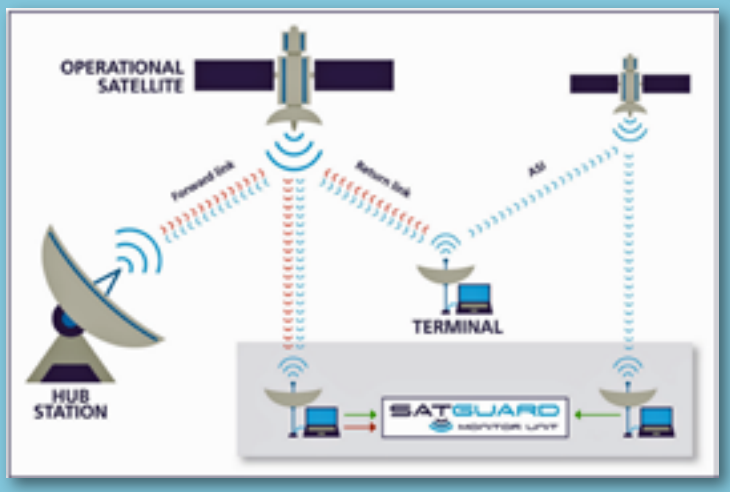
Problems with VSAT terminals generally include equipment quality and reliability, and particularly antenna misalignment, leading to cross polarization and adjacent satellite interference. Determining the source of interference has been a long standing problem for satellite operators. There is no standardized way to detect the identity of the interfering VSAT terminal, unlike the recently introduced Carrier ID technique for continuous carriers.

Due to the diverse protocols used by the VSAT MF-TDMA systems, a standalone system became the only reasonable way to come up with a unique tool that could recognize the protocols used by different manufacturers. The SatGuard product addresses this need.

The tool can be used by 'first responders' (satellite operators) non-invasively, without any connection to a VSAT network, to identify ASI and XPOL interference, correlate with network bursts, and decode the unique identification to help the network operator target the problem terminal(s).

An Interference Event

At the IRG workshop, Steve Smith highlighted an interference event that occurred between SES and another international satellite operator who experienced a case of adjacent satellite interference (ASI) originating from an SES satellite.



SES had already been using the SatGuard product and had characterized the MF-TDMA terminals in their network operating on Astra 3B.

As soon as the interference was reported, SES operations teams were able to use SatGuard to analyze and correlate the signals on Astra 3B and the adjacent satellite with terminals in the VSAT network. SatGuard was able to quickly identify the terminals causing the interference and decode the MAC address for each of the offending terminals.

This process required around ten minutes from the time the complaint was first received to interference suppression. As the MAC address is the identification of a physical terminal in DVB-RCS systems, this information allowed SES to easily locate the faulty terminals and immediately dispatch technicians to those locations to make the necessary corrective actions.

Proactive Use Of SatGuard

As highlighted in the presentation at the IRG workshop, SatGuard can also be used to proactively monitor for potential interfering bursts. By performing routine monitoring and trending, performance issues can be detected before they become harmful XPOL or ASI problems.

This means that action can be taken to rectify any faults with the terminal(s) before they have an impact on other services, or to an adjacent operator, thereby raising the overall quality of service, and reducing the time and effort in chasing VSAT interference.

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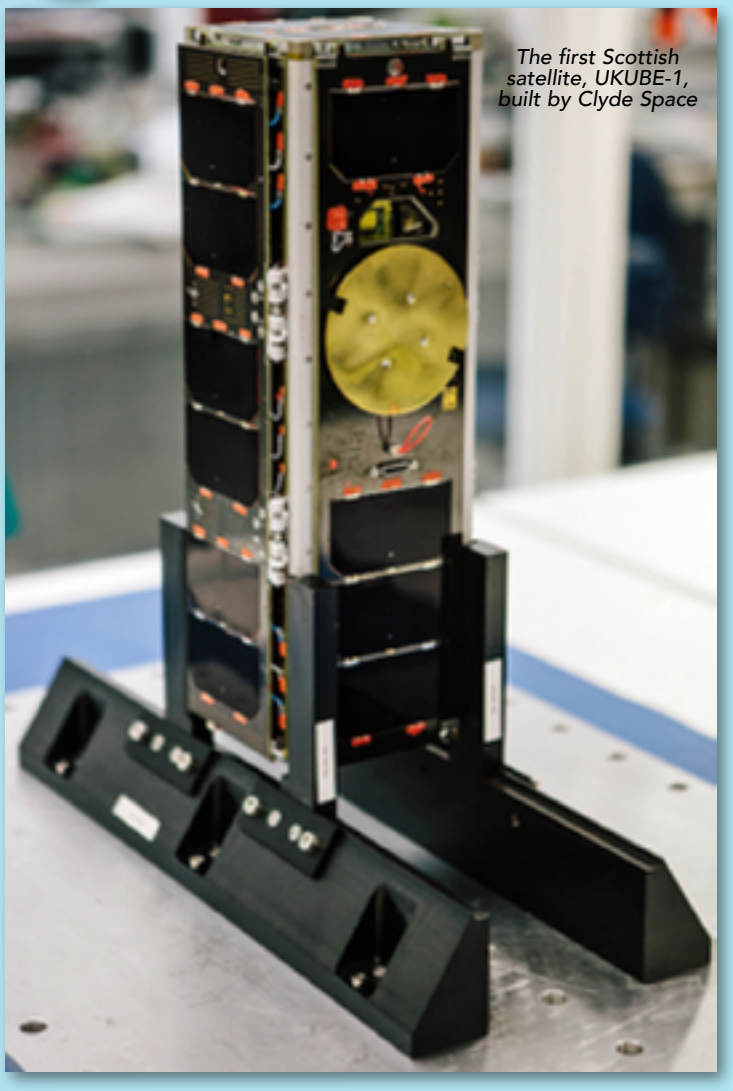
A Clyde Space Perspective: Specialty... Smallsats

By Craig Clark, Chief Executive Officer, Clyde Space

Clyde Space launched Scotland's first satellite, UKUBE-1, in July of 2014. UKUBE-1 is a 3U CubeSat carrying six individual technology payloads from a range of UK organizations.



The first Scottish satellite, UKUBE-1, built by Clyde Space

The mission has since completed its first phase of operations and is now used to support AMSAT activities across the globe. Following on from UKUBE-1, the company has developed off the shelf 1U and 3U spacecraft, with the range also extending to include 6U and 12U, or as required to suit specific mission needs. Examples of recent missions include:

SeaHawk

This mission is aimed at aiding food security and sustained ocean observations. This 3U Earth Observation Platform will support increased Maritime Domain Awareness across oceans, such as AIS based ship tracking and coastal Ocean Color Monitoring.

Clyde Space Seahawks will be used to help safeguard fish-farms and coastal food production zones from harmful algal blooms, while providing continuous sea observation.

Picasso

This 3U ESA funded science mission demonstrates that big data may, indeed, be obtained from smallsats. The mission focuses on the study of unexplored layers of the Earth's atmosphere and serves as an ESA in-orbit-demonstrator of CubeSat technology and a pioneer for smallsat missions.

Outernet

The 1U Outernet Platform will send emergency weather warnings, medical advice, as well as news and entertainment information to users at no charge. Funded through the UK Space Agency's International Partnerships in Space Program (IPSP), Clyde Space will develop a constellation comprised of three of these communication satellites, which is the first phase of the company's US partner's plan to deliver free Internet content globally from a constellation of hundreds of CubeSat's.

With an average of five, flight-ready CubeSats being produced each month from the Clyde Space nanosatellite production center in the UK, the capability to support high performance and a short time to orbit missions is second to none.

In January of 2016, the company announced the creation of our US company. Clyde Space, Inc. will meet the rising demand for innovative CubeSat and smallsat products in the quickly growing US market. Customers in the USA have been requesting an American office for a number years and the decision has been made... this is a great idea. This means US customers will be able to receive 'made in USA' products, made in America by Americans.

The company's first conference of the year will be the SmallSat Symposium in California, from February 23 to 24. Clyde Space CEO Craig Clark will be one of the speakers for the day two session. His presentation will be *Structuring Small Satellite Ops* at 2:3 p.m. on the 24th. Please stop for a chat at the Clyde Space stand and find out how your mission can be fully supported.

Clyde Space is recognized as a world leading innovator and supplier of small satellites and subsystems as well as for cutting-edge products for the smallsat market, in particular in the area of tiny satellites called 'CubeSats.' In the company's 11th year of trading, there are more than 70 highly skilled engineers and technicians who possess more than 100 years of combined industry experience.

If you would like to learn more about Clyde Space, the products, careers and plans for the USA, please visit ***www.clyde-space.com***—sign up for the informative newsletter, or, contact us at ***enquiries@clyde-space.com***.

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