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PerúSAT-1 and SkySat-4 to -7 launch photo is courtesy of the Arianespace infocast.

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PerúSAT-1 and SkySat-4 to -7 Satellites Pushed By An Arianespace Vega To Their Slots

PerúSAT-1 and SkySat-4 to -7 satellites have been successfully launched by Arianespace, with the push occurring from the Guiana Space Center in Kourou, French Guiana.

The Peruvian space agency CONIDA owns and will operate PerúSAT-1, while the Google company, Terra Bella, will manage the SkySat -4, -5, -6 and -7 smallsats.

Designated Flight VV07, this was Arianespace's seventh launch of the year and also the seventh consecutive successful launch by Vega, the latest member of the Arianespace launcher family, introduced at the Guiana Space Center in 2012.

According to Arianespace, Vega is especially well suited to the dynamic Earth observation market. With this launch, the company starts full-fledged commercial operation and has already nine future launches in their order book.

With the complete family of three launch vehicles, Arianespace can launch any type of Earth Observation (EO) or meteorology satellite.

Arianespace has already launched 59 satellites for these markets and fully one-fourth of th firm's future launches also target these applications.

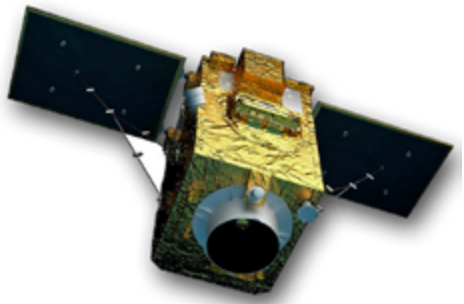
PerúSAT-1 is Peru's first EO satellite and was ordered within the scope of an agreement between the Peruvian and French governments—this launch was carried out under a turnkey contract with Airbus Defence and Space for the Peruvian space agency CONIDA.

This optical observation satellite features very high resolution (0.7 meters) and will operate from Sun-synchronous orbit at an altitude of 695 km and will acquire images from across the planet.

PerúSAT-1 is the 115th satellite built by Airbus Defence and Space to be launched by Arianespace.

The Arianespace order book includes 13 other satellites from this manufacturer, along with an order for the OneWeb constellation (which will be composed of more than 600 satellites).

The PerúSAT-1 satellite was built by Airbus Defence and Space



Artistic rendition of PerúSAT-1, courtesy of manufacturer Airbus Defence and Space.

in Toulouse, France, using that company's AstroBus-S platform and their NAOMI instrument.

PerúSAT-1 weighed 430 kg at liftoff and offers a design life of 10 years.

The satellite was injected into Sun-synchronous orbit at an altitude of 675 km and will be positioned at an operational orbit of 695 km to acquire images of the entire planet.

SkySats-4, -5, -6 and -7 are the first four satellites launched by Arianespace for new customer Terra Bella, a Google company that is a commercial operator of EO satellites.

Injected into Sun-synchronous orbit at an altitude of 500 km, these

Arianespace VV07 launch.

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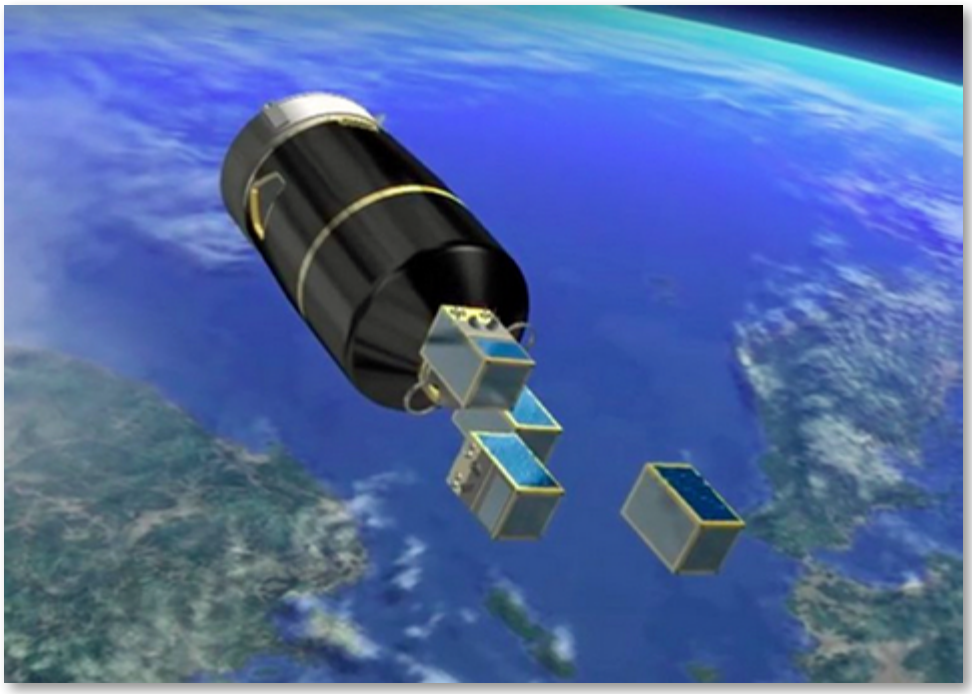

SkySat satellite separation from the Vega fairing. Image is courtesy of Arianespace infocast.

smallsats will provide very-high-resolution (less than one meter) maps of the entire planet.

Designed by Terra Bella, the Skysat-4 to -7 satellites were manufactured by SSL (Space Systems Loral) using a dedicated SkySat platform that was produced in SSL's Palo Alto, California, facility. SkySats-4 to -7 are the 55th to 58th SSL satellites launched by Arianespace.

The Arianespace order book includes five more geostationary communications satellites built by SSL.

Vega is a European Space Agency (ESA) program that is jointly funded by Italy, France, Spain, Belgium, the Netherlands, Switzerland and Sweden. Avio is the launcher design authority and industrial prime contractor, operating through its Italian subsidiary, ELV (in which the Italian space agency ASI has a 30 percent stake).

Arianespace markets and operates Vega from the Guiana Space Center alongside the firm's two other launchers, Ariane 5 and Soyuz, enabling the company to address the full range of market needs.

Vega's six previous missions prior to Flight VV07 were all carried out for institutional customers (European Space Agency-ESA / European Commission / national space agencies / governments).

These six missions, all successful, fully demonstrated the launcher's operational capabilities and versatility, with missions to low Sun-synchronous orbit (Sentinel-2A), a ballistic trajectory (IXV), and transfer orbit to the Lagrange point L1 (LISA Pathfinder), for a wide variety of applications (Earth observation, science, education, defense).

The successful LISA Pathfinder mission for ESA in December of 2015 marked the end of the Vega development phase and the start of commercial operation.

There are currently nine Vega missions in Arianespace's order book, a majority of them for EO. One-third of the backlog is for institutional customers and two-thirds for export customers.

The nine missions include two contracts signed in 2016: the CERES mission for French DGA defense procurement agency and French space agency CNES, along with the ADM-Aeolus mission for ESA's Earth observation directorate.

The upgraded Vega C, slated to make its first flight in 2019, will provide a significant performance increase over the current version in terms of payload capacity (weight and volume).

This means the rocket will be able to carry out an even wider range of missions, thus improving the launch service competitiveness. Arianespace should be able to start marketing Vega C launches by the end of this year.

Arianespace Chairman and CEO Stéphane Israël said, "*With the first Vega launch of 2016, and the seventh since its introduction in the Guiana Space Center, Arianespace has proudly served—on a single mission—both the Peruvian government, through its space agency CONIDA, and the operator Terra Bella, a Google company.*

"*I would like to thank our long-standing partners, Airbus Defence and Space, our direct customer for PerúSAT-1, and also the manufacturer of this spacecraft; and SSL, manufacturer of the SkySat satellites.*

"*I would also like to congratulate the industrial prime contractor, ELV/Avio, for Vega's excellence and availability, along with the European Space Agency and national space agencies, especially ASI of Italy, for their critical support for the Vega program.*

"*And, of course, thanks to CNES-CSG and all companies and staff at the launch base, always by our side for new successes. Lastly, congratulations to Arianespace's own teams for this seventh successful launch of the year: launch after launch we make a difference.*"

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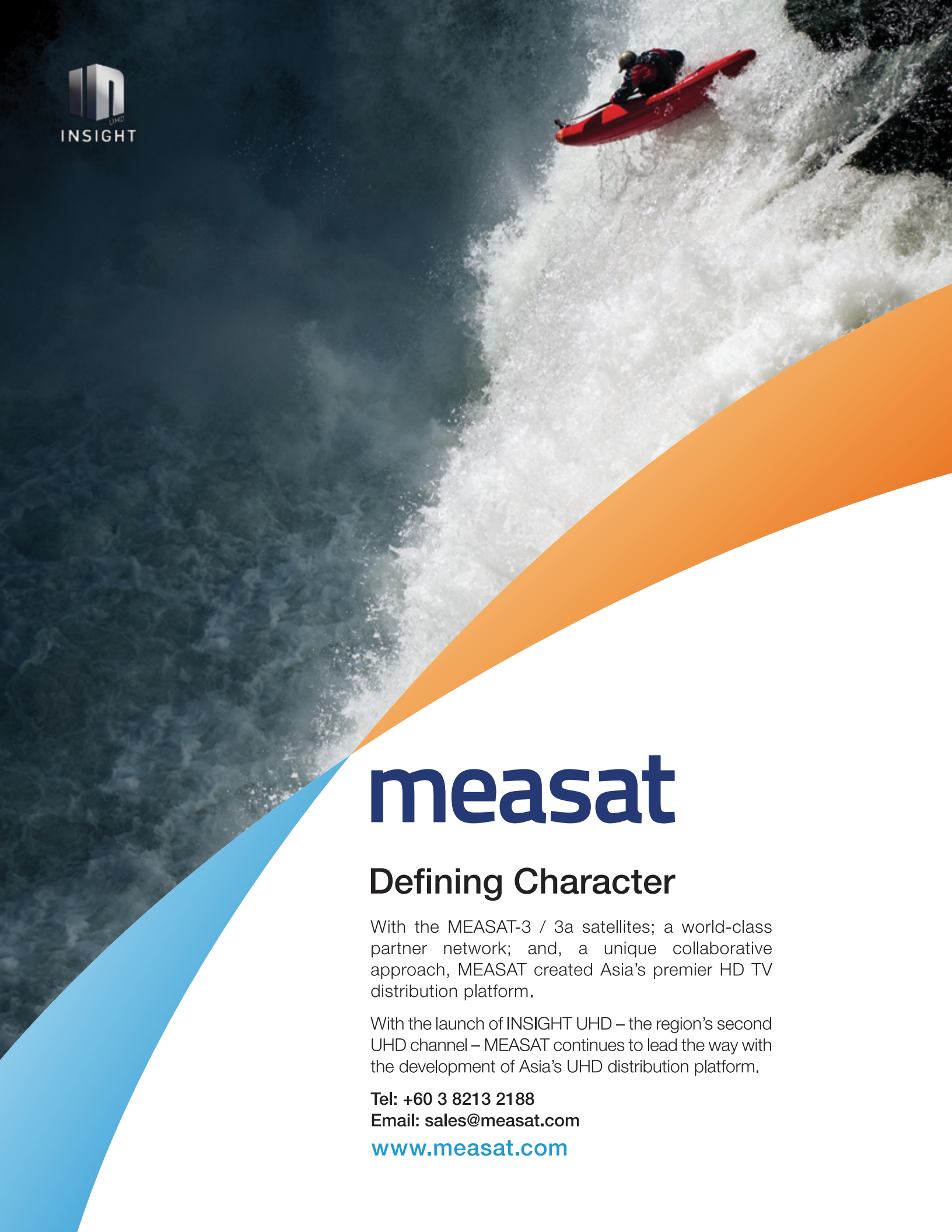

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Israel Injects Ofeq-11 Into orbit

The launch of the Ofeq-11 satellite. Photo is courtesy of the Space Manager at Maf'at, Israel Defense Ministry.

A new intelligence satellite was launched on September 13th by Israel whose basic purpose will be to gather intelligence on that nation's regional adversaries, according to various online infosite reports.

The afternoon launch of Ofek-11, also known as Ofeq-11, occurred from Palmahim Air Base south of Rishon Lezion several weeks ago.

However, according to an Israeli Defense Ministry announcement post-launch, even though the Ofeq-11 satellite entered the planned, retrograde LEO for pre-planned testing, the satellite was not acting in an "expected manner."

Some of the satellite's crucial systems did not appear to be functioning correctly, according to a report in the *Jerusalem Online* infosite.

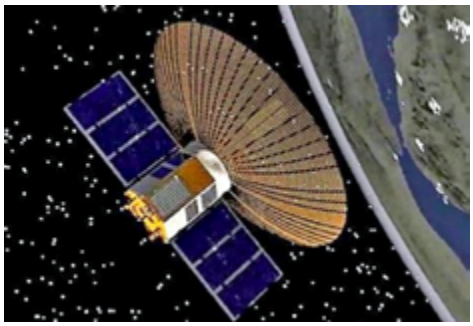
The cost to build the satellite was around $300 million and Ofeq-11 will be joining Ofek-9 and -10. According to the IDF (Israel Defense Forces), these satellites are engaged in approximately 800 annual sorties to film areas of interest, which amounts to about 64,000 minutes of footage.

This launch occurred nearly two weeks after the AMOS-6 communication satellite destruction in an explosion of the SpaceX Falcon launch vehicle at Cape Canaveral.

Then, a news story in the *Jerusalem Post* indicated that Israel's Ofek-11 satellite may have stabilized.

More than a week after the satellite was launched and ran into serious technical difficulties, the Ofek-11 spy satellites began sending "great images" back to the ground control station, the Defense Ministry of Israel announced.

Amnon Harari, head of the Space Administration in the Defense Ministry, and Ofer Doron, head of Israel Aerospace Industry's MBT Space Division, said the satellite's transponder and image broadcasting system began kicking in on Thursday and that ground control officials were now seeing "*operational results.*"



Artistic rendition of Israel's Ofek-11 satellite.

Harari and Doron said the images they were now receiving "*are what we hoped for*," though they declined to provide further details on the overall health of the satellite.

Since the launch, engineers have been working to stabilize the satellite and the craft's on board systems, the Defense Ministry and IAI said in a joint statement.

The teams systematically checked all of its systems from the moment of launch, and maintained continuous communication and control with it.

Ofek-11 is part of the Ofek series of satellites, is Israel's sixth active spy satellite and carries a SAR (Synthetic Aperture Radar), which has advanced day and night imaging capabilities.

Two years ago, the Defense Ministry and IAI launched Ofek-10 successfully into space on board a Shavi launch vehicle.

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Award Win For Artel's Demod & Sat Scanner

The NewBay Media Best of Show Award was awarded to Artel Video Systems at IBC2016 for that firm's DLC510 Dual-Port L-Band Demodulator and Satellite Scanner.

The DLC510 adds new satellite scanning and carrier ID functionality to the company's media transport portfolio.

Presented by *TV Technology Europe* magazine, the Best of Show Award is one of the industry's most prestigious technology honors. Products nominated are evaluated by an independent panel of judges on a wide range of criteria including ease of use/maintenance, performance against the category standard, richness/relevance of the feature set, value/ROI, versatility, anticipated reliability, and originality.

Artel's DLC510 functions as an L-band satellite demodulator and as a fully automatic L-band satellite scanner. As a scanner, the device enables satellite operators and engineers to scan and locate quickly and accurately active signals on a satellite without complicated test equipment and clearly displays signals in an easy-to-read list with other essential data. End users can then highlight the required signal, and the scanner immediately locks on to the demodulated signal for broadcast. The DLC510 is fully integrated into Artel's Telco grade DigiLink Media Transport Platform and the newly introduced InfinityLink broadcast media transport solutions, enabling ASI to IP conversion and ASI routing using other DigiLink or InfinityLink modules or FiberLink® product for transport over IP or fiber networks.

A host of other features, such as the dual RF inputs, DVB-S2X support, and the recently adopted ETSI Carrier ID transmission coding, make the DLC510 a must have for any satellite or operations department. Also, the module functions as a test-and-measurement system for busy satellite operations or engineering departments.

www.artel.com

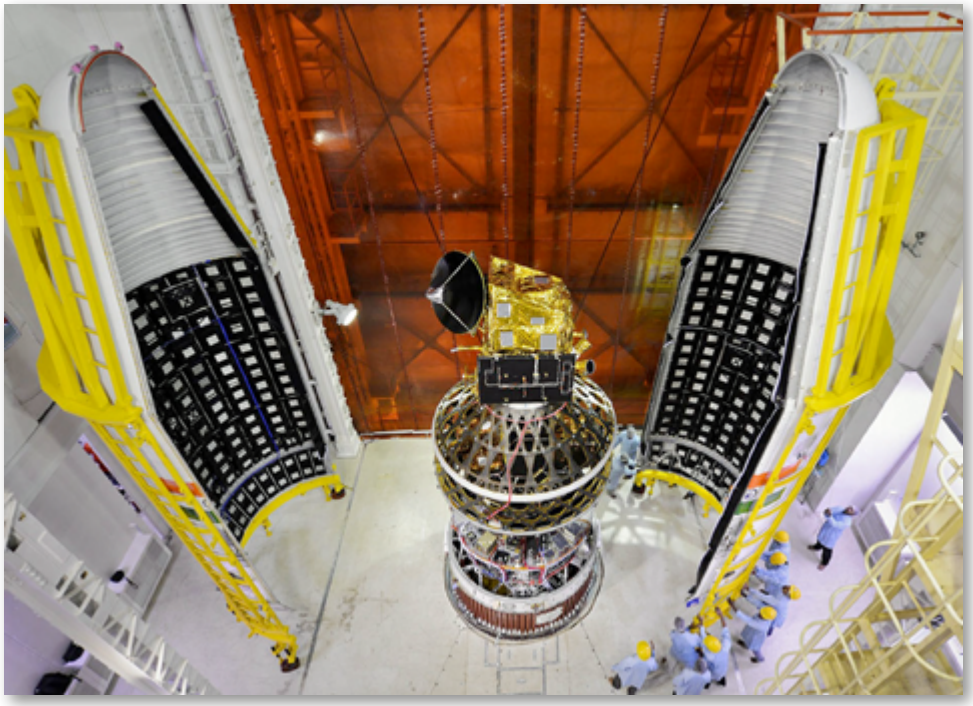
SCATSAT-1 & Seven Smallsats Travel With Alacrity To Their Slots

Launch photo is courtesy of ISRO.

The Indian SCATSAT-1 satellite and seven smallsats have been successfully placed into orbit by the ISRO, being impelled to their designed slots by the organization's PSLV rocket.

SCATSAT-1, a weather satellite with a five year mission life, is a follow-on mission for the country's Oceansat-2 and improvements were made in this craft's hardware configuration. The improvements were based on the lessons learned while operating the instruments aboard Oceansat-2.

SCATSAT-1 has the goal of achieving reliable and viable data for Climate Data Records in addition to the facilitation of routine meteorological applications such as providing wind vector data products for weather forecasting, cyclone detection and tracking services for users.



The SCATSAT-1 satellite integrated with the PSLV-C35 launch vehicle, with two halves of the heat shield. Photo is courtesy of ISRO.

The satellite carries a Ku-band scatterometer similar to the one onboard Oceansat-2.

Seventeen minutes into the flight, The 371 kg SCATSAT-1 was injected into a 730 km polar sun synchronous orbit after 17 minutes of flight time.

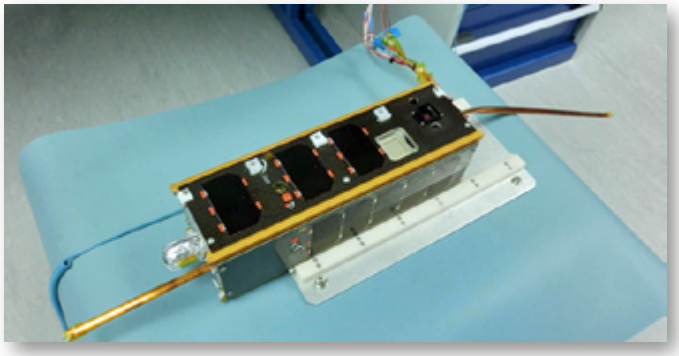
The remaining seven satellites will be placed in a 689 km polar orbit later and they include five foreign satellites: three from Algeria (Alsat-1B 103 kg, Alsat-2B 117 kg, Alsat-1N 7kg), and one each from Canada (NLS-19, 8 kg) and US (Pathfinder-44 kg). Two additional Indian satellites were also aboard: Pratham (10 kg), built by Indian Institute of Technology-Bombay (IIT-B), and Pisat (5.25 kg) from PES University, Bengaluru and their consortium.

The Pratham mission is to estimate the total electron count with a resolution of 1 km x 1 km location grid, while Pisat is for remote sensing applications.

After placing SCATSAT-1 into orbit, the rocket's fourth stage was restarted one hour and 22 minutes into the flight and then cut off approximately 20 seconds later.

Two hours and 11 minutes into the flight, the fourth stage was restarted to be cut off one minute later.

Following that, in three minutes, all seven of the satellites were ejected closing out PSLV's longest mission to date.



The AlSat 1N, AKA AlSat Nano. Photo is courtesy of Surrey Space Center.

1N is a technology demonstration smallsat for Algerian students.

The US satellite Pathfinder-1 is a commercial, high resolution, imaging smallsat.

The Canadian NLS-19 satellite is a technology demonstration smallsat for experimentation in helping to reduce space debris and for tracking commercial aircraft.

The PSLV rocket is 44.4 meters in height and weighs 320 tons.

www.isro.org

The PSLV rocket is a four stage engine rocket powered by solid and liquid fuel alternatively.

Vikram Sarabhai Space Centre (VSSC) director K. Sivan stated that the long time gap between the cutting off of the engine and the engine restart was not an issue.

Sivan said the first time the multiple burn technology was first tested by ISRO was while flying the PSLV rocket on December 16, 2015, and then in June of 2016, the technology was again demonstrated.

About this challenge, Sivan stated that after cutting off the engine, its condition was brought to an appropriate stage to enable the restart.

The next challenge is to control the engine and bring it to the correct position to eject the remaining satellites into a different orbit.

He added that the rocket has a GPS aided navigation system so that data generated by the rocket's inertial navigation system and the GPS system could be blended to erase any errors and to generate precise data.

According to the ISRO, the two Algerian satellites Alsat-1B and Alsat-2B are remote sensing satellites, while Alsat-

Sound Reasoning Leads To An Impactful, But Forced, Retirement For Rosetta

Artistic rendition of Rosetta is courtesy of European Space Agency.

The decision to end the Rosetta mission was derived on September 30th and ultimately came as a result of the spacecraft's ever-increasing distance from the Sun.

Comet 67P/C-G, and therefore Rosetta, are heading out toward the orbit of Jupiter, resulting in significantly reduced solar power with which to operate the craft and its instruments.

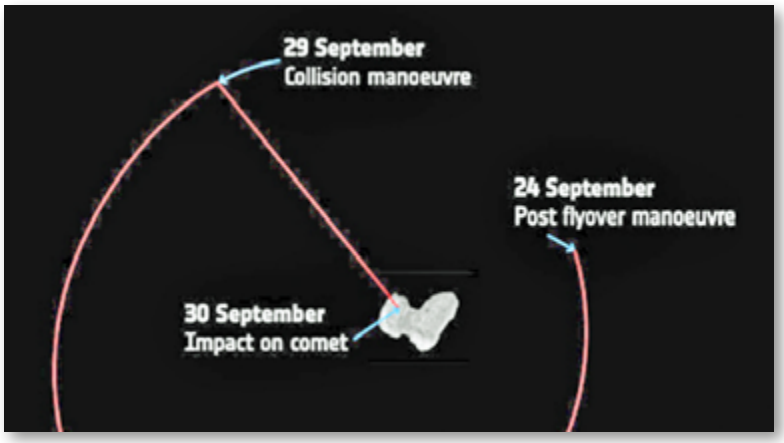
In addition, by early October, the teams would be faced with a month-long solar conjunction—when the Sun lies between the Earth and Rosetta and the comet. This would result in significantly reduced communication capabilities (including downlinking science data) for around a month.

Combined with an aging spacecraft and payload that have endured the harsh environment of space for over 12 years—at least two years close to a dusty comet—this means that Rosetta is reaching the end of its natural life and so September 30th was the optimum date to conclude the mission.

Rosetta descended to the surface of Comet 67P/C-G in a controlled impact at more than 14 kilometers, or nine miles, per second—the craft's 32 meter wide solar arrays took the brunt of the contact with the comet, thereby softening the blow to Rosetta itself. The mission was declared as conclued at 7:20 a.m. ET.

During the descent, unique scientific observations were made, including very high-resolution images and sensitive measurements of gas and dust, at distances closer than Rosetta has ever been before.

Unlike in June 2011, when Rosetta was placed into a 31-month hibernation for the most distant part of its journey, this time it is riding alongside the comet. Comet 67P/Churyumov-Gerasimenko's maximum distance from the Sun (over 850 million km) is more than Rosetta has ever journeyed before.



The result is that there is not enough power at its most distant point to guarantee that Rosetta's heaters would be able to keep it warm enough to survive. Instead of risking a much longer hibernation that is unlikely to be survivable, and after consultation with Rosetta's science team in 2014, it was decided that Rosetta would follow its lander Philae down onto the comet.

Rosetta ended its mission with a controlled impact in the Ma'at region, on the small "head-shaped" lobe of the duck-shaped Comet 67P/Churyumov-Gerasimenko. The region was selected because this area is scientifically quite exciting: this region is home to a number of active pits, measuring more than 100 meters across and 50 meters deep, from which a number of dust jets that emerge from the comet have been traced as their origination.

The pit walls also exhibit lumpy structures called 'goosebumps,' with sizes of a few meters, which could be the signatures of early cometesimals that merged together to create the comet in the early phases of the Solar System formation.

Therefore, scientists obtained close-up images, along with information on the dust, gas, and plasma environment very close to such pits, which will help them understand their connection to the comet's observed activity, and as well, to learn more about how they relate to the formation and evolution of the comet. Thus, a trajectory was executed for Rosetta that saw it fly over a region of pits, with

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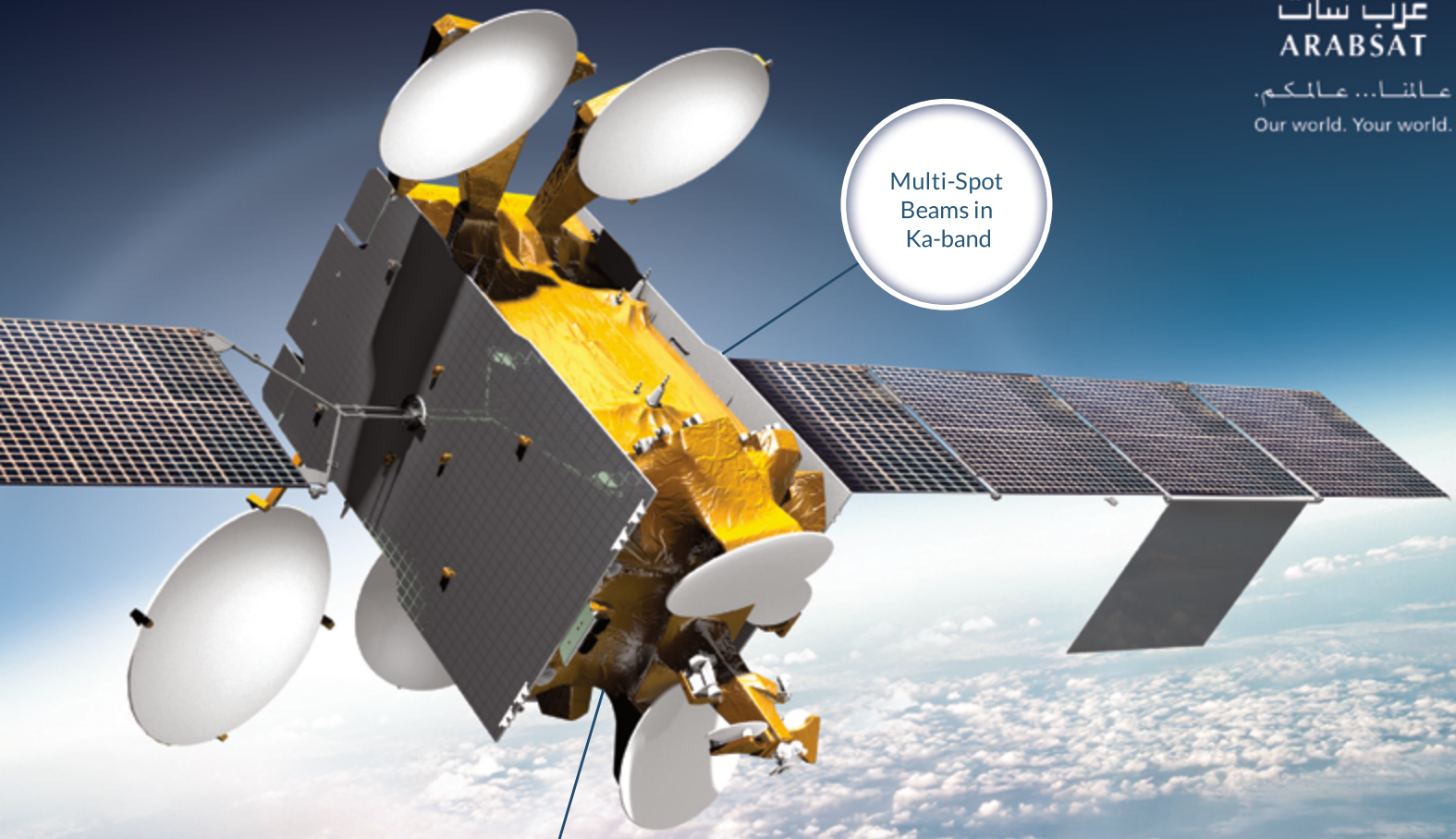

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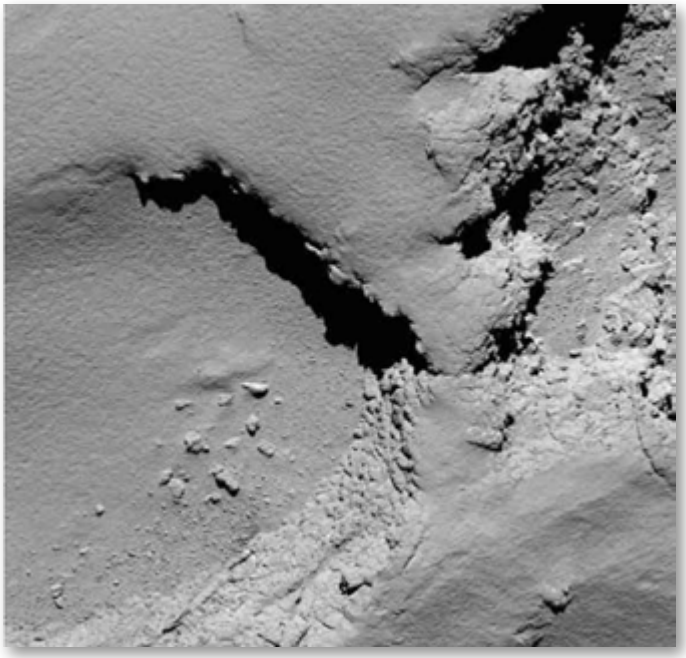

This image was captured of Comet 67P/Churyumov-Gerasimenko at 08:18 GMT from an approximate 5.8 km altitude by Rosetta's OSIRIS narrow-angle camera during the spacecraft's final descent on September 30th.

Photo credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/ IAA/SSO/INTA/UPM/DASP/IDA

a touchdown point a smooth area between two of them.

There were a number of uncertainties associated with Rosetta's descent, including the precise timing and duration of the final maneuver burns, the distance from the comet at that time, the non-uniform gravity of the comet, and the effects on the spacecraft of outflowing material from the comet. A large set of trajectories were calculated, taking into account plausible variations in each of these parameters, each resulting in a different touchdown point.

In order for Rosetta to take the best possible images during the descent, the spacecraft and targeted touchdown point need to be in sunlight, in order to generate power and be illuminated, respectively. The interiors of the pits on Comet 67P/C-G are dark when not directly in sunlight.

Plus, in order to ensure that the final data are sent back to scientists, the spacecraft needs to be in line-of-sight visibility until touchdown. While the pits were targeted for imaging during the descent, the actual crunchdown occurred adjacent to one of them.

On September 24th, Rosetta departed its current close, flyover orbits and was transfered into the start of a 16 x 23 km orbit used to prepare and line up for the final descent.

During the evening of September 29th (20:50 UTC), a maneuver placedRosetta on a collision course with Comet 67P/C-G, initiating the descent from an altitude of 19 km above the surface.The spacecraft fell freely toward the comet, without further maneuvers, collecting scientific data during the descent.

The final sequence of observations included images and measurements of the gas, dust, and plasma properties.

The Flukey Incidents That Delayed The Launch Of ULA's WorldView-4 Satellite

Updates from various sources now indicate that the next approximate launch date for WorldView-4 won't be until some time later this month [October]—the exact date is unknown, as of this writing.

The first delay came during countdown on September 16th, when the launch was scrubbed due to a liquid hydrogen leak in the ground support equipment that resulted in an ice ball forming on an umbilical cable. The launch was then rescheduled for September 18th, to allow for the replacement of a fill-and-drain valve, which was determined to be the cause of the leak.

Then, what should happen but the Canyon Fire, a wildfire that burned over 12,000-acres on the southern section of Vandenberg. This resulted in a further launch delay so that the base could "concentrate [their] resources on the situation at hand." At the peak of the fire, 1,052 fire fighters from more than 50 agencies and multiple aircraft were involved in a battle to save life, property, and national defense facilities.

As a result of scheduling availability on the Western Range, the flight was rescheduled for September 26th; however, continued efforts in fighting the Canyon Fire caused an indeterminate delay of the launch to October 2016.

The fire is now controlled and teams are accomplishing the mop-up actions.

WorldView-4, previously known as GeoEye-2, is a planned third generation commercial Earth observation satellite scheduled to launch in October 2016. The spacecraft will be operated by DigitalGlobe. With a maximum resolution of 31 centimeters (12 inches), WorldView-4 will provide similar imagery as the sister satellite, WorldView-3—this is the highest resolution commercially available at the time of this launch.

When WorldView-4 launches from Vandenberg Air Force Base Space Launch Complex 3E, the satellite will launch aboard an Atlas V rocket in the 401 configuration, serial number AV-062, provided and administered by United Launch Alliance.

The rocket has been erected at the Vandenberg launch pad since December 16, 2015, and the WorldView-4 payload was fixed atop the rocket during the second week of September 2016.

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Thuraya Highlights SATCOM Investments Save & Improve Lives

Thuraya Telecommunications organized a lecture and workshop at Lockheed Martin's Center for Innovation and Security Solutions at Masdar City in Abu Dhabi.

This event was held for participants of the recently launched *Generation Space: The Space Fundamentals Training Program* by the UAE Space Agency and Mubadala.

The lecture, delivered by Amal Ezzeddine, Thuraya's Senior Director for Government and Corporate Affairs, demonstrated the long term value of investing in satellite communication and its impact on saving and improving lives.

Ezzeddine highlighted recent studies indicating that by 2022, the use of satellite communication will rapidly increase globally with a maximum growth expected from countries in the MENA region.

Participants were taken through a series of examples that shed light on Thuraya's mission and purpose and how it harnesses expertise and technology to deliver essential tools and improve connectivity for underserved communities that fall within its coverage area.

Additionally, Ezzeddine cited recent examples of the crucial role satellite communication plays during crises and relief missions in the aftermath of natural disasters and emergency situations. She added that Thuraya has signed the United Nation's Crises Connectivity Charter last year.

The lecture included a review of Thuraya's strategy and how innovation is applied throughout its product development, business model and distribution channel plans.

Using their platform, Thuraya encourages employees, partners and developers to create solutions that serve various sectors by incorporating feedback from the market and looking at the needs and requirements of end users. One example is the current trend that is prompting some within the satellite industry to focus on addressing IoT, smart cities and M2M needs to serve humanity.

The session included a hands on workshop that encouraged participants to apply the concept of innovation creatively, and come up with satellite communication solutions relevant to different sectors, such as marine, defense and media. This resulted in an array of ideas and positive feedback proving that this group of Emirati engineers possess the required innovative skills and capabilities to achieve the program's objectives.

Ezzeddine said, "*At Thuraya, we understand the importance and value highly specialized local talent for the satellite industry. It is challenging to find, employ and sustain individuals who can deliver the right amount of innovation. This program to develop and nurture home grown talent is timely. We would like to thank the UAE Space Agency, Mubadala and Lockheed Martin for inviting us to play our part in launching the next generation of Emiratis, who will lead the nation's space program in the coming years.*"

Nabil Azar, Regional Director of Lockheed Martin's Space Systems Company, said, "*The new generation of young Emiratis is one of the main pillars for the development and progress of the UAE's space program. It is important for them to understand and benefit from existing local expertise in the space and satellite sector. Therefore, we were happy to work with Thuraya, the UAE's space sector pioneers in organizing this lecture. This collaboration allowed participants to rub shoulders with and benefit from professionals already working in the industry and inspired them to think creatively and innovatively.*"

Earlier last month, and as part of the Generation Space program, Thuraya hosted participants at its primary gateway in Sharjah. There, they enjoyed a guided tour by Sultan Al Mehrezi, director of system engineering and gateway development and Abdul Rahman Al Ameeri, director of satellite communications and control.

The guests were shown the operations control center, and the antennas serving Thuraya's satellites. They were also given a detailed presentation and lecture about the satellite communication industry and the sectors it serves.

The presentation also included a brief about Thuraya's network and portfolio of products and services since the company's inception.

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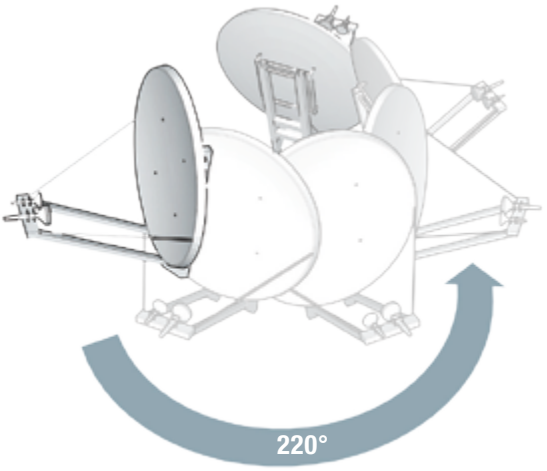

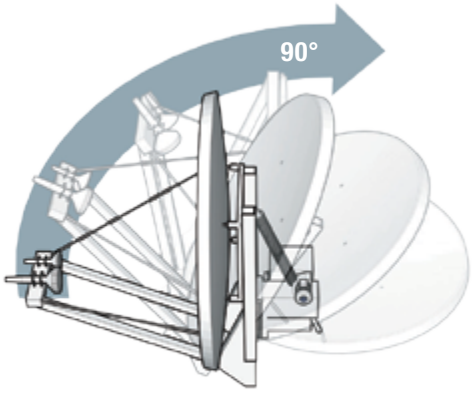

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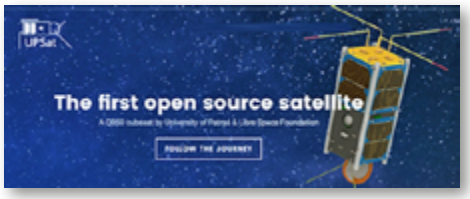
InfoBeam

Open Source Smallsat Makes Headway For A December Launch



The UPSat team of engineers has just delivered, for launch integration, the first completely open source software and hardware satellite.

This is a major step toward UPSat's launch—the successful delivery was to Innovative Solutions In Space (ISISpace) and occurred on August 18th in Delft, Netherlands.

UPSat is the first complete delivery to ISISpace as part of the QB50 project.

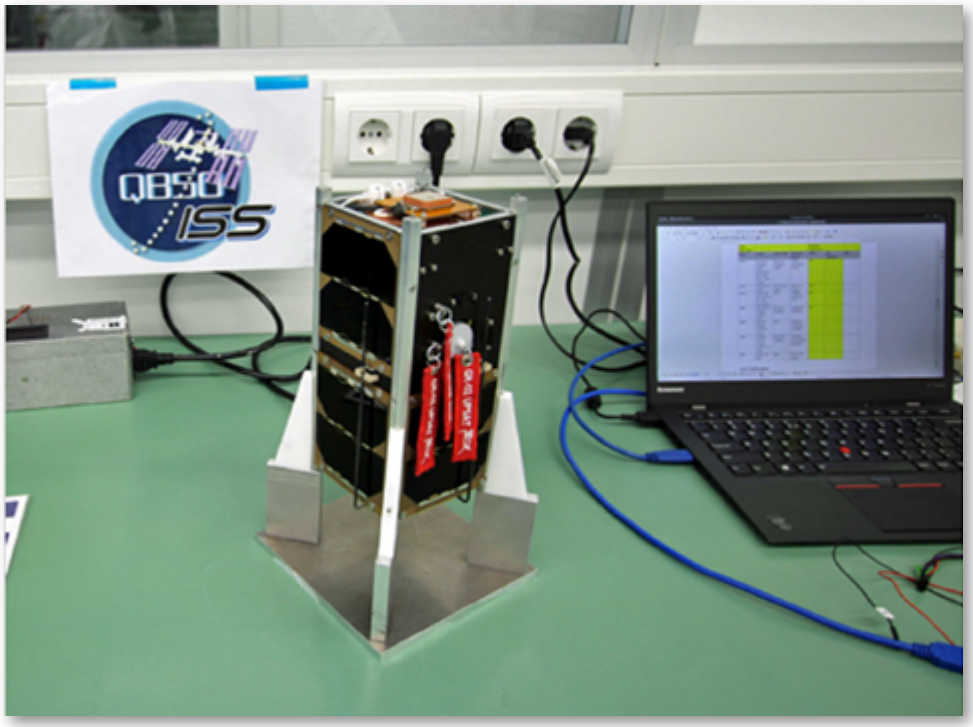
Engineers from the University of Patras (Department of Mechanical Engineering and Aeronautics & Department of Electrical Engineering and Computer Engineering) and Libre Space Foundation, the makers of UPSat, in cooperation with Von Karman Institute and ISISpace engineers, have successfully concluded all checkout tests and delivery procedures, which now enable UPSat's integration into the NanoRacks launch system.

UPSat will be delivered to Orbital ATK and then launched to the International Space Station via a Cygnus automated cargo spacecraft, with that launch scheduled for December 30th.

After successful docking to ISS, UPSat will be launched by the NanoRacks deployment pod aboard ISS.

This delivery marks a major milestone toward the realization of University of Patras and Libre Space Foundation vision for the first Greek designed and manufactured satellite within an open source ecosystem in space for space.

UPSat (***https://upsat.gr***) is the first open source hardware and software satellite, designed and integrated by Libre Space Foundation and the University of Patras to participate in the international QB50 Research mission.



The QB50 mission (***https://www.qb50.eu***) is an international research mission of 50 satellites aiming to collect data on thermosphere, the highest part of Earth's atmosphere. The project is coordinated by the Von Karman Institute of fluid dynamics.

-+University of Patras University of Patras (***http://www.upatras.gr***) is a public university in Patras, Greece. The Department of Mechanical Engineering and Aeronautics together with the Department of Electrical Engineering and Computer Engineering started the UPSat project since 2010.

Libre Space Foundation Libre Space Foundation—LSF (***https://librespacefoundation.org***) is a non-profit organization aiming to promote, advance and develop open source technologies for space. LSF designed, manufactured and delivered UPSat subsystems (hardware and software) as open source projects.

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InfoBeam

Kymeta Reveals The Future Is Flat At The Monaco Yacht Show

September 28th through October 1st was quite a gathering for superyacht enthusiasts, all of whom assembled in Monaco for the Monaco Yacht Show, where crafts of all sorts and sizes were be on display for attendees to view.

Companies were demo'ing their superyacht related wares... and this included Kymeta® who presented what is possible when SATCOM solutions become flat, thin, lightweight, quiet, and scalable.

Live demonstrations provided owners, captains and designers the opportunity to see how a satellite antenna without any moving parts can deliver a reliable, quiet and seamless solution that eliminates satellite communication domes.

The thin profile of Kymeta's mTenna technology means it can be embedded into the superstructure of a vessel as opposed to having the unsightly domes associated with mechanically steered antennas.

In addition, Kymeta mTenna technology gives superyacht owners scalable connection options to increase throughput to meet requirements for large bandwidth.

Joined by partners Intelsat, Panasonic, iDirect, Intellian and e3 Systems, the maritime market will be among the first to benefit from Kymeta's technology when the technology becomes commercially available in 2017.

The Kymeta satellite antenna design provides a secure, scalable and future-proof system that will meet the needs of owners and crew while delivering on the promise of global, mobile connectivity and entertainment.

Through the use of software pointing and steering, Kymeta has increased reliability and eliminated noisy and unreliable gimbaled satellite communication systems.

Kymeta's antenna combiner is designed to allow multiple antennas Rx signals to be combined for demanding environments where throughput scalability is critical. Available in 2017.

According to Håkan Olsson, the Vice President, Maritime, Kymeta, currently, satellite communication on superyachts requires large, mechanically-steered satellite dish technology that relies on moving parts to make and keep a satellite connection.

Kymeta's thin, flat, metamaterials-based satellite technology eliminates the domes, noise and reliability issues because uses product uses software to connect and track a satellite.

Superyacht owners, designers and builders can now have access to a solution that will redefine the profile and design of superyachts.

www.kymetacorp.com/

InfoBeam

Sea Launch Acquired

The first push off of a near Earth orbit slotted satellite that was completed from the ocean floating launch platform known as Odyssey, operated by Sea Launch, occurred in 1999—with this equatorial venue in the Pacific Ocean, the Earth's rotation was effectively harnessed to bring optimal launch conditions into play.

However, since mid-year in 2015, Sea Launch has been rather inactive, due to the political ramifications surrounding Russia's aggressive positioning in the acquisition of Crimea, resulting in a business stalemate between the various national partners involved in Sea Launch endeavors.

The Odyssey floating launch platform has a new owner... Russia's S7 Group. Photo is courtesy of Victor Kataev, ITAR/TASS.

The CEO of Russia's S7 Group, Vladislav Filen, flew to the IAC in Guadalajara, Mexico, to sign papers that would find his company acquiring Sea Launch, with an estimated $150 to $160 million expected to be invested, with a closing occurring over the next six months via various contracts with five jurisdictions in a variety of currencies. A joint statement concerning this acquisition was released by Roscosmos, RSC Energia and the S7 Group. Vladislav indicated that the hope is Sea Launch will be responsible for from 15 to 20 launches with their Zenit rocket.

Filen stated that the acquisition of Sea Launch was the ticket S7 needs to enter into the space industry. S7 is a private aviation company that operates 21 Boeing and 45 Airbus aircraft that serves 27 countries with 145 routes throughout CIS, Europe, the Middle East, South-East Asia and the APAC regions of the world. The firm's revenue in 2015 was more than $1.3 billion.

www.s7.ru/

Executive Spotlight: Dr. Ko Ogasawara, Vice President & General Manager, Business Development Department, Space Systems Division, Mitsubishi Heavy Industries

Dr. Ko Ogasawara is the Vice President and General Manager and is responsible for the business development of the space business at Mitsubishi Heavy Industries, Ltd. (MHI).

Dr. Ogasawara obtained a Master of Engineering degree from Kyoto University in 1988 and worked at Nagoya Aerospace Systems, MHI, as a structure engineer for the Japanese primary launch vehicles, N-II, H-I and H-II as well as the Japanese Experimental Module "KIBO" for the International Space Station. In 2008, he was assigned to manage the launch vehicle performance analysis section of the company's Space Systems Engineering Department. Since 2014, he has been the Vice President & and General Manager, Business Development Department, Space Systems Division, Integrated Defense & Space Systems, MHI.

Mitsubishi Heavy Industries (MHI) has been Japan's main developer and a manufacturer of liquid fueled launch vehicles since the early phases of Japanese space development. The history of MHI's space development goes back to 1971 when MHI first took part in the development of the N-I Launch vehicle. Since then, MHI has played a central role in every phase of Japanese space development. Currently, MHI is working on the development of the next generation launch vehicle, H3. With the H3, MHI expects to obtain more launch service orders from overseas customers.

SatMagazine (SM)

MHI entered into the commercial launch services business thanks to an initial contract from Telesat Canada in 2013. What are your thoughts regarding MHI's latest space activities? And what is the company's latest news in this area?

Dr. Ko Ogasawara

At first, MHI, as a launch services provider for the Japanese Flagship Launch Vehicle Family H-IIA/H-IIB, had the role of satisfying Japanese government demands, which were stringent. The company intended to proceed beyond the government mission and has a strong intention to expand our launch services business to the international commercial satellite market, taking full advantage of the capabilities of the company's H-IIA/H-IIB heritage.

This year, MHI was awarded the contract from the UAE government, or MBRSC (Mohammed Bin Rashid Space Center), for their national, high-level EMM (Emirates Mars Mission) project, which is scheduled to be launched in

Liftoff of Telstar 12 Vantage of Telesat Canada, November, 2015.

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2020. The spacecraft will reach Mars orbit in 2021, which happens to coincide with the 50th anniversary of the UAE. This means that the schedule assurance for the EMM launch is of the highest priority which, in addition to launch vehicle reliability, led to the MHI contract award from the UAE.

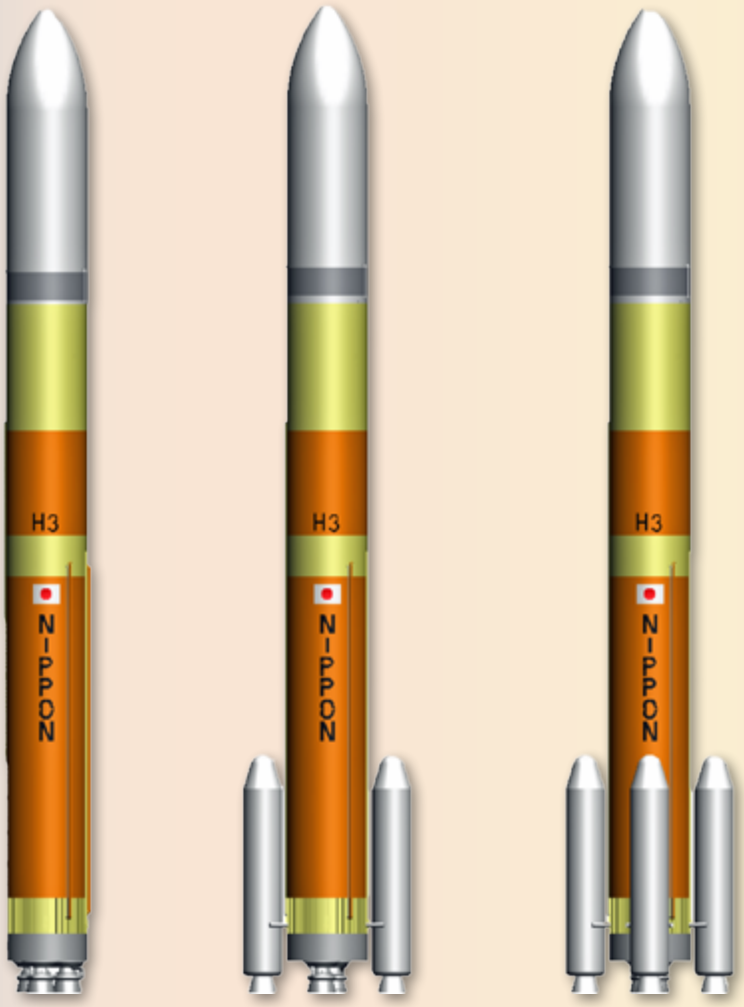
MHI has continuously received contracts from overseas customers for three years. Meanwhile, we understand that the commercial launch services market is currently getting far more competitive. MHI wants to contribute to the space community by offering our services using the current H-IIA and next generation H3 launch vehicles.

SM

Given that MHI is the prime contractor for the H3, what is the development status of this project? And, after the planned debut of this vehicle in 2020, how will MHI offer H3 launch services to the commercial market?

Dr. Ko Ogasawara

Yes, H3 will be the new flagship launch vehicle in Japan—the Japanese government has already decided to develop H3 and MHI was selected as the prime contractor. MHI is working with JAXA on the design, development and manufacture of H3.



MHI's H3 launch vehicle family.

The development of this vehicle is progressing on schedule. One of the main development items is the higher power, more robust, lower cost first stage engine. Combustion tests will start within this year as scheduled. We are focusing on a more customer-oriented feature on H3, as well as supporting the H-IIA/H-IIB heritage. This means that pricing will also be more attractive and the launch capacity will be greater than that available for the H-IIA. For example, the maximum launch capability of H3 will be around 7 metric tons to GTO.

With H3, our goal is to more than double the launches per year, which currently stands at between 4 to 5, including domestic and overseas missions. To attain this goal, MHI has started to appeal the international market very actively. As a result, we have already received positive responses and inquiries from customers and from the insurance community from all over the world. MHI will continue to push our utmost efforts on the development and the sales and marketing activities for the H3, and our goal is to become a major player in the global launch services market.

SM

There are a number of 'Giant Competitors' in today's marketplace. How do you plan to offset and position MHI as a viable alternative to launch services?

Dr. Ko Ogasawara

We know that the current market is getting more and more intense as far as competition is concerned. We plan to offset our competitors by ensuring the market knows of the strengths of MHI's H-IIA launch services, which are on-time launches and highly reliable. Additionally, we aim to promote the value of H3 through the following points…

- *Price competitiveness*
- *Better mechanical environment, such as shock and vibration reduction, small load factor from liftoff to separation, and more*
- *Quick launch response—the plans are to accelerate the launch process from the current market standard of 24 months to 12 months*

Coincidentally, 2020 is a year when many new launch vehicles from other launch service providers will be (expected to be) rolled out. Through the H3, MHI aims to secure a considerable share in the commercial satellite launch market.

SM

SpaceX is planning to launch their first reusable launch vehicle—'Falcon 9R' — in 2016. Does MHI have any plan of developing such a reusable launch vehicle?

Dr. Ko Ogasawara

MHI fully understands that Space X has aggressively been proceeding with the creation of their reusable launch vehicle, the Falcon 9R.

Reusability will definitely be one of the upcoming technological paths for next generation launch vehicles. MHI started the reusable launch vehicle research over 10 years ago. For reusability, the key technology is not only reusable components and sub-systems, but total system reusable operation. MHI has developed reusable components including reusable small sized liquid hydrogen/oxygen engine and tested successfully with variable thrust repeatedly.

Moreover, by the experience of consecutive operations of small sized vertical take-off and landing reusable vehicle, MHI continues to learn the essential technologies for reusable operations. Reusable technologies acquired through our research process will be reflected to full-sized reusable launch vehicle that will succeed to expendable H3 launch vehicle.

SM

The smallsat market is exploding for large and small satellite operators and manufacturers—what are MHI's vision and plans for this market segment?

Dr. Ko Ogasawara

MHI understands that LEO constellation ideas have been prevalent in the space community and LEO constellation system might cover a large portion of the conventional commercial broadcasting and communications satellite environments.

However, there remain issues to be resolved, such as the mass production of smallsats and their launches—I believe that the current, major players within the satellite manufacturing and/or launch services providers are trying to resolve such issues.

That being said, the smallsat market is highly attractive for us. In H3 development activity, we are going to ensure compatibility for LEO constellation satellites reflecting our experiences to launch small co-passenger satellites on current H-IIA launch service. I believe this will certainly expand our service offerings.

Smallsats, with such a wide variety of possibilities, are indeed a market-changing product and MHI is extremely interested in their development. To prepare for future market needs, MHI is strongly considering how to make significant contributions to this market as well as to commercial satellite launch services.

We do realize this is not an easy place for us to enter this market and immediately obtain success, so we are looking for other solutions, such as collaborations with existing manufacturers and satellite operators.

SM

Please advise our readers as to the activities MHI will engage in over the next several years.

Dr. Ko Ogasawara

MHI has been playing a major role in Japanese space programs for over 40 years and this position will remain the same.

In 2015, the Japanese government issued the "Space Basic Plan," which illustrates the comprehensive roadmap for national space activities. In this plan, we find that the Japanese space policy has placed more importance on the industrial use of space rather than scientific R&D.

With full understanding of such policy, MHI will aim to obtain more contracts from overseas customers via our core launch vehicles. The company will also be taking part in the nexgen space programs, such as the upcoming enhanced HTV and other international space probes.

Finally, MHI develops and manufactures approximately 700 products in various fields—these technology solutions and a highly skilled workforce will enable the company to resolve any challenging issues presented and to create preferable solutions. Also, through the interactive collaboration, we aim to provide new business models and unique added values to the space business.

I firmly believe MHI will become one of the most productive players within the space business community.

h2a.mhi.co.jp/en/index.html

The Challenges Of Launching A Real-Time UHD Channel By Satellite: An AsiaSat Perspective

By Captain Ip, Communications Systems Engineer, AsiaSat

Ultra HD (UHD) broadcasting via satellite is becoming increasingly popular, especially as satellites operated by AsiaSat, SES, Intelsat and Eutelsat continue to demonstrate the feasibility of delivering content to viewers using this advanced technology.

These initiatives also help validate that satellites have an advantage over other distribution means in handling high data rate of UHD content delivery particularly in rural and remote areas where terrestrial networks are inadequate. Moreover, satellite links are more reliable than terrestrial connections due to its simple infrastructure. Most of these channels are free-to-air (FTA) for promoting UHD in different countries and regions. However, among these channels, only a few are real full-time, UHD channels, *i.e.*, without repeating the content for at least 24 hours. This article examines some of the challenges that broadcasters and content providers face in launching a full-time, UHD channel via satellite and offers some recommendations and solutions that have been experienced by the industry.

Modern Workflows For UHD Broadcast Networks

UHD content can be encoded either off-line or in real time. The two workflows use different equipment that offer distinct interfaces and possess their own pros and cons, as summarized in *Table 1* on *Page 29*.

Challenges

The challenges in launching a full-time UHD channel, especially over satellite are:

Lack of UHD content

At least several hundred hours of content is required to sustain a full-time channel. Although native UHD shooting has been available for some years, producing enough UHD content remains quite difficult. UHD improves the video quality for a better viewing experience. However, this is not the only factor required to retain audiences. One of the lessons learned during the transition from SD to HD was, and is, that "*Content is King.*"

The best way to attract and retain audiences is to produce unique and interesting content, such as special live events, music concerts and large sports competitions. As these events require long production times to create attractive content, a great deal of time to gather sufficient UHD content for the deployment of a full-time UHD channel is necessary.

Expensive UHD HEVC Set-Top Box (STB)

HEVC is a new encoding technology and only a few models of STBs are available to support HEVC with UHD resolution. As a result, the price of UHD HEVC STB is much higher than that of an ordinary HD STB. Currently the price of a UHD HEVC STB varies from a hundred to several hundreds of USD. Moreover, the requirement to customize middleware and conditional access solutions for DTH operators further increases the cost. As a result, the prices of a UHD subscription would be much higher than that of HD, significantly affecting uptake of UHD service. For example, Videocon d2h, one of the major DTH service providers in India, has approximately 15 million of subscribers in total[1] but only 8,000 to 9,000 of them are UHD subscribers[2].

Inefficient UHD Monitoring Device/System

To launch a full-time UHD channel over satellite, encoding equipment and decoding devices are necessary. DTH service providers should monitor their channels to make certain all the programs are operating smoothly. In the past, UHD STBs and TVs were used to monitor the UHD channel, with a pair of STB and TV for each channel/program. This, however, failed to provide any alarms or event logs for error checking or bug fixing when the channel went abnormal. Moreover, this process consumed a lot of resources, including manpower and physical space to monitor UHD programs. Inefficient monitoring methods have limited the growth of UHD services on satellites.

Dearth of Professional UHD IRD/Decoder

Professional IRDs (PIRDs) are widely used in the broadcast networks, especially for cable TV headend operation in order to provide a reliable and stable service. HEVC is the latest compression method which provides higher compression efficiency than MPEG 4. Many vendors integrate HEVC into their PIRDs to support HD/SD service. However, only a few PIRDs in the market can support UHD resolution, and

Encoding Method	Off-line Transcoding	Real Time Encoding
Pros	• Allow preview before on-air • Low cost	• High flexibility, allow real time graphics such as adding logo, live scrolling text, subtitles and even data rate • Ability to support different live applications, e.g. SNG, linear TV • Allow statistical multiplexing
Cons	• Longer time required to transcode file (e.g. 4 – 8 hours are needed to transcode 1 hour of UHD content) • Cannot change/insert information (e.g. logos, subtitles) to the transcoded file • Fixed data rate • A streamer is needed • Long QC time	• Expensive • Cannot preview before on-air

Table 1: Pros and Cons of Different UHD Encoding Methods —*Off-air means transcoding UHD programmes in HEVC format first, and the transcoded file is stored and will be playout as scheduled. Off-line transcoding is usually software based. Real-time means encoding the UHD programmes in HEVC and the encoded stream is immediately put on-air. There are two different ways of UHD playout to support the workflows: playout outputs the uncompressed UHD signal via 4 X 3G-SDI for real time case and MPEG transport stream (T.S.) by IP for off-air.*

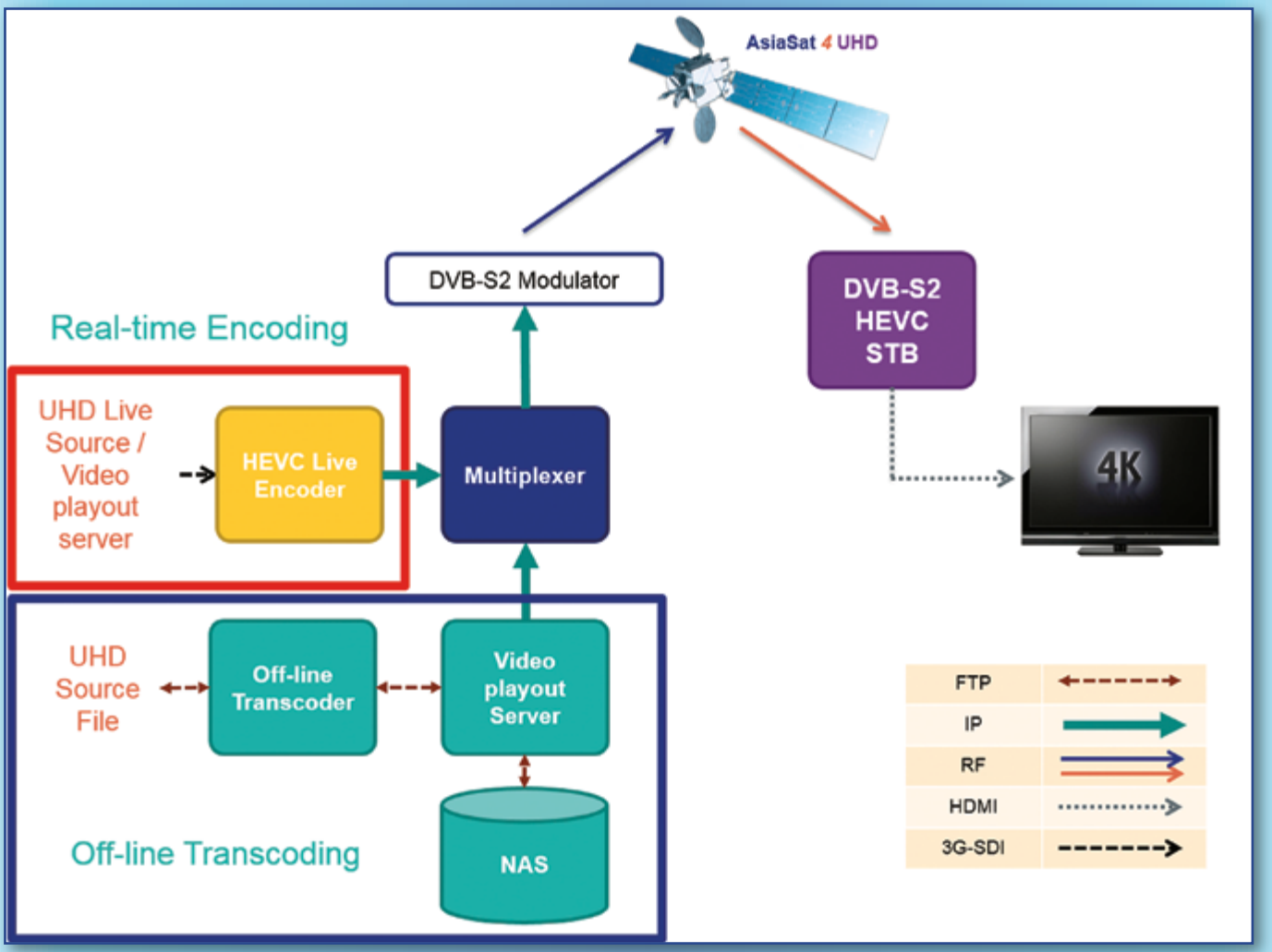


Figure 1. Block Diagram of Different UHD Encoding Methods

none of the HEVC PIRDs support both UHD and conditional access features. As a result, the expansion of UHD channels over satellites has been restricted.

UHD Video Security

One of the major concerns in launching a commercial full-time UHD service is the immaturity of UHD content protection. Despite being widely recognized by many industry practitioners and the introduction of a series of security guidelines, this still needs time before vendors can design and implement chipsets and devices that fully meet the UHD security requirements.

Solutions From The Industry

The operators and vendors of the broadcasting industry have done a lot of work to promote UHD content development and for the deployment of UHD channels.

Upscaling HD To UHD

Upscaling the existing valuable HD content to UHD is one of the most generally adopted solutions to expand the UHD content database. There are different products to upscale the content for both real-time and pre-record HD content.

Real-Time

Benefiting from the latest computer hardware and GPU capabilities, we can upscale the HD live content to UHD through software. HEVC encoding could be applied as well in the T.S. over IP output. A typical example is ArcVideo Live[3] from ArcVideo.

Pre-Record

Unlike the live content, there are many solutions to upscale the pre-record HD content to UHD before broadcasting. For example, we can upscale the HD content to UHD, encode the content with a file transcoder and play via a playout server. One of the examples is the ProMedia Xpress[4] and Sapphire playout server[5] from Harmonic. Another way of upscaling is to use rendering software: we can render the HD to UHD without HEVC encoding, store it in the playout server which outputs 4X3G SDI, then play and encode it when necessary. Real time HEVC encoder is required for this solution. An example is the UHD solutions fromRohde & Schwarz.

Launch Of UHD HEVC Professional Decoders

Many UHD HEVC decoders are available in the market, including the VH-4000 model from VILLAGE island[6]; BMM-810 from Rohde & Schwarz[7] and UHD-1000 and UHD-1500 from NTTAT[8]. These decoders can output UHD signal via 3G SDI (uncompressed) or ASI (compressed). In addition, as HEVC is still under development, most of the available decoders are software based. However, the decoders mentioned above do not support any digital content protection technologies such as CA and DRM.

Launch Of UHD Chipsets That Support UHD Protection Specification By MovieLabs

A growing number of UHD chipsets are available to support the Specification for Next Generation Video and Enhanced Content Protection set by MovieLabs (Motion Picture Laboratories, Inc.). SoCs (System-on-chip) from chipset vendors such as Broadcom, Marvel, MStar and HiSilicon fulfill protection specifications and have received the Verimatrix ViewRight Security Certification for UHD-capable chipsets[9]. With the launches of these new UHD chipsets, STB and TV manufacturers can design their own systems/solutions that fully support full UHD security.

Availability Of UHD Monitoring System

UHD monitoring systems available in the market are providing more flexible and better features. For example, Kaleido-MX 4K multiviewer from Grass Valley[10] and the IP based multiviewer called Supervisor from ArcVideo[11] are but two of these systems. Their products support HD/SD videos and can downscale the UHD video to HD or even SD, which can reduce the cost of monitoring devices. Furthermore, they integrate with alarm servers which can provide complete monitoring service for full-time UHD channels.

There is no doubt that full-blown, commercial UHD services will be the future trend of the satellite TV market. NSR's latest report on ***UltraHD via Satellite*** forecasts there will be 785 UHD channels on satellites by the year 2025. The additional leasing revenues of these intensive UHD channels will top $280 million annually[12]. However, rapid growth of UHD channels over the next couple of years is not expected to materialize. As the specification of UHD-1 Phase 2 has not yet been finalized by ITU, the current UHD format is just a milestone for the UHD-1 standard. Broadcasters are expected to launch their UHD full-time commercial services only after the finalization and implementation of the UHD-1 standard to minimize the migration cost.

www.asiasat.com

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Innovations In Smallsat Ground Architecture: A Kratos Perspective

By Matthew Prechtel, Business Area Director, RT Logic—a Kratos Company

[This is the second of two articles on smallsat ground systems, by Matt Prechtel. The July/August issue dealt with cost reductions in ground system design. This article contrasts smallsat and traditional satellite ground system architecture.]

Small satellites (smallsats) are finding new and disruptive opportunities in today's space industry. Space applications that were once the domain of big satellite systems are finding that they are being augmented and, in some cases, displaced by lower cost smallsats.

The term "smallsat" can mean multiple things to different people; however, for the sake of this article, a smallsat is nominally a satellite under 500 kilograms. Applications such as Earth Observation (EO), space to ground communications and weather monitoring have requirements that can be met with these newer, smaller platforms.

The benefits of using smallsats (when applicable) are significant—lower costs to acquire and launch plus a higher refresh cycle that supports rapid technology insertion as programs and technology evolve. Big satellites programs can take decades to procure, build, launch and operate in today's space climate at price tags in excess of a billion dollars.

Smallsat projects can shrink those timelines to a couple of years by leveraging COTS (Commercial-Off-The-Shelf) bus architectures, launch ride shares, commodity flight processors and flight software, software radios, optics, and so on. In some cases, smallsat programs have become assembly efforts versus custom development programs to realize the program goals. However, until now, the ground systems have not kept up with this rapid rate of innovation and reduction in cost. Software based ground systems can both influence spacecraft program design as well as be cost effective when compared to traditional architectures or building ground systems in house.

Figure 1. Capabilities Required by a Space Ground System

Ground System Requirements

Generally speaking, a ground system possesses three major groups of capabilities: Command and Control (C2), Baseband and Radio Frequency (RF), as shown in *Figure 1*.

Typical Ground System Architectures

In a typical ground station, the architecture follows the pattern shown in *Figure 2* located on the next page. Of the elements depicted in the architecture, the antenna systems tend to be more expensive and inflexible than the other elements, due to their size, power requirements and physical location constraints.

In order to mitigate the need for every satellite program to build their own antenna farm, shared antenna systems, such as the Air Force Satellite Control Network (AFSCN), were created to provide a common, distributed antenna system through which multiple Department of Defense (DoD) programs could interface for antenna uplink and downlink services.

The basic elements required to implement a traditional satellite ground system include:

- *Telemetry, tracking, and command (TT&C) systems used by operators to issue spacecraft commands and view Telemetry*
- *Red side Front End Processors (FEPs) that proxy cryptographic gear from the TT&C engine*
- *Encryption for command link protection*
- *Network gateways used for deterministic wide area networks (WAN) transport and black side crypto interfaces*
- *Terminal side gateway equipment to bookend the network*
- *Modulator/Demodulator systems for narrowband and wideband links*
- *Up/Down frequency conversion to the antennas and the antennas themselves*

Not all satellite programs will require the same architecture; however, at some level, each program must address all of the functional requirements of the ground system that are listed in *Figure 1*.

For example, not all space programs will encrypt their telemetry links. For the National Aeronautics and Space

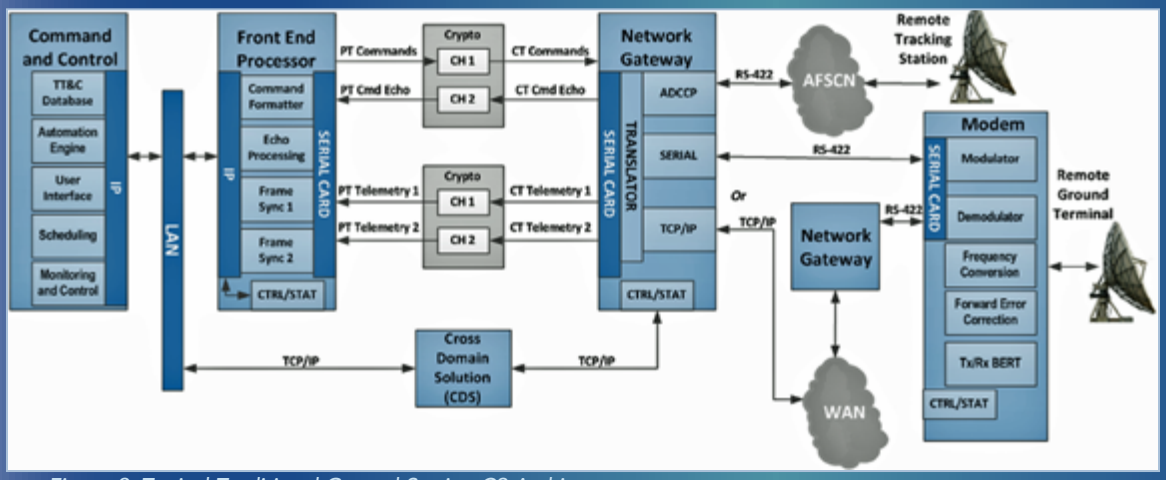

Figure 2. Typical Traditional Ground Station C2 Architecture

Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) programs, where the missions are science based, the data is intended to be shared with other institutions and the encryption of the downlinks would only get in the way of sharing science data.

This architecture in ***Figure 2*** can work equally well in smallsat operations in all areas save for cost and scalability. The architecture shown tends to drive significant hardware investments, datacenter floor space, and cost associated with procurement, integration, test and sustainment.

Scaling to hundreds of spacecraft as some smallsat programs are proposing can become unwieldy as additional hardware is required to add additional spacecraft contacts. Cabling alone can take significant amounts of installation time as the equipment strings are all pieced together using legacy serial cables.

Figure 3. quantumGND Components

The required set of functions and capabilities of a traditional ground system were distilled into the software applications that make up quantumGND, which consists of three discrete and separate components, all of which feature Generic Equipment Model (GEM) and Representational State Transfer (REST) compliant status and controls, and multi record, archival and playback points.

quantumGND takes into consideration the needs of smallsat programs and bundles the necessary features and functions into a suite of modular software components that comprise an integrated ground station from C2 to RF. Each component is a software application provided as a hypervisor ready virtual machine appliance, complete with operating system and application.

Figure 4. SpectralNet Lite Front End Digitizer

quantumGND does include one element of hardware; a SpectralNet™ Lite digitizer that converts analog signals at RF frequencies up to S-band into digital IF packets and is shown in *Figure 4*.

In all cases, the received RF analog signals from the smallsat must be captured and converted into digital waveforms.

Command and Control

quantumCMD™ performs Command & Control (C2) for a single smallsat or a smallsat fleet and manages contact scheduling and execution on all passes, provides a single portal for viewing all ground and space status, consolidates data and assists with system administration tasks. quantumCMD's powerful capabilities feature:

- *Fully web-based, HTML5 user interface*
- *Powerful automation tools to minimize ops resource requirements*
- *Scalable architecture for single satellites to constellations with future growth potential*

Baseband CMD / TLM & Protocol Processing

qFEP is a baseband front end processor (FEP) that provides basic command and telemetry packet processing for smallsat applications. qFEP includes command and telemetry Framesyncs, commercial grade 256 bit AES Encryption and Key management, CCSDS Packet Processing Support, Reed Solomon and Network I/O for data interfaces.

RF Mod/Demod & Forward Error Correction

qRADIO provides the RF signal processing including; common modulation schemes, convolution encoding/decoding, TCP, PCM encoding and Reed Solomon. Supporting a wide range of uplink/downlink frequency bands and low to high data rates, qRADIO is specifically designed to meet smallsat ground requirements:

- *Digitizing front-end supporting IF to S-Band (50 – 2500 MHz) direct RF generation*
- *One hundred percent software Modem*
- *Compatibility tested with several spacecraft radio manufacturers*

quantumGND is not tailor made for a particular spacecraft bus or processing function—the product focuses on the most common standards, protocols and waveforms needed by the smallsat world. Compliance with industry standards dramatically shrinks the time to full operations and provides maximum flexibility for future enhancement.

quantumGND Scalability

quantumGND is designed to support individual spacecraft missions, spacecraft tests, and spacecraft fleet operations. Like traditional ground equipment, quantumGND can be utilized in strings of software. Each single string is intended to support contact with a single spacecraft, through a single antenna as shown in ***Figure 5***.

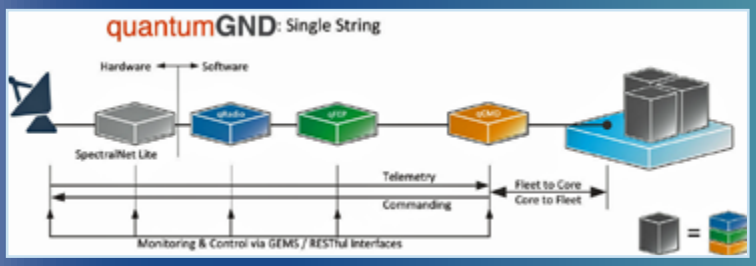

Figure 5. quantumGND Single String

quantumGND has the flexibility to expand to support consolidated smallsat space operations as well as support multiple ground antenna sites. ***Figure 6*** shown below reveals how quantumGND can be used to support small, local installations as well as larger, multi-site fleet operations.

The benefit of using this approach over the architecture shown in ***Figure 2*** is a significant reduction in physical equipment (and cost) as the constellation grows. As quantumGND uses a virtualized approach, software runtime instances can be stacked on a single piece of high density computing equipment; a blade center for example.

The only hardware in quantumGND that must be scaled linearly for additional contacts is the SpectralNet Lite digitizer. The end result is a satellite ground system that, using previous architectures, would have required tens of racks of equipment can be consolidated down to a single small footprint set of equipment that still supports dozens of simultaneous contacts to fleets of smallsats.

Most importantly, quantumGND allows you to focus on your smallsat mission while we focus on the ground system.

quantumGND moves traditional processing out of hardware into modular software, reducing integration costs, time to readiness and operational costs.

As traditional ground operators must reduce costs to remain profitable in an increasingly competitive environment, they are beginning to adopt many of these smallsat ground innovations.

Mr. Prechtel has more than 20 years of experience in management and engineering positions in the satellite and radar industries. At RT Logic, he manages the company's space control center product lines and their integrated small satellite ground system offerings.

Before joining RT Logic, Matt was a Project Manager at ITT Exelis Corporation leading service life extension projects for space track and missile warning phased array radar systems. Matt's education includes a BS in Electrical Engineering from the University of Pittsburgh, an MS in Electrical Engineering from Temple University and an MBA from the University of Colorado at Colorado Springs.

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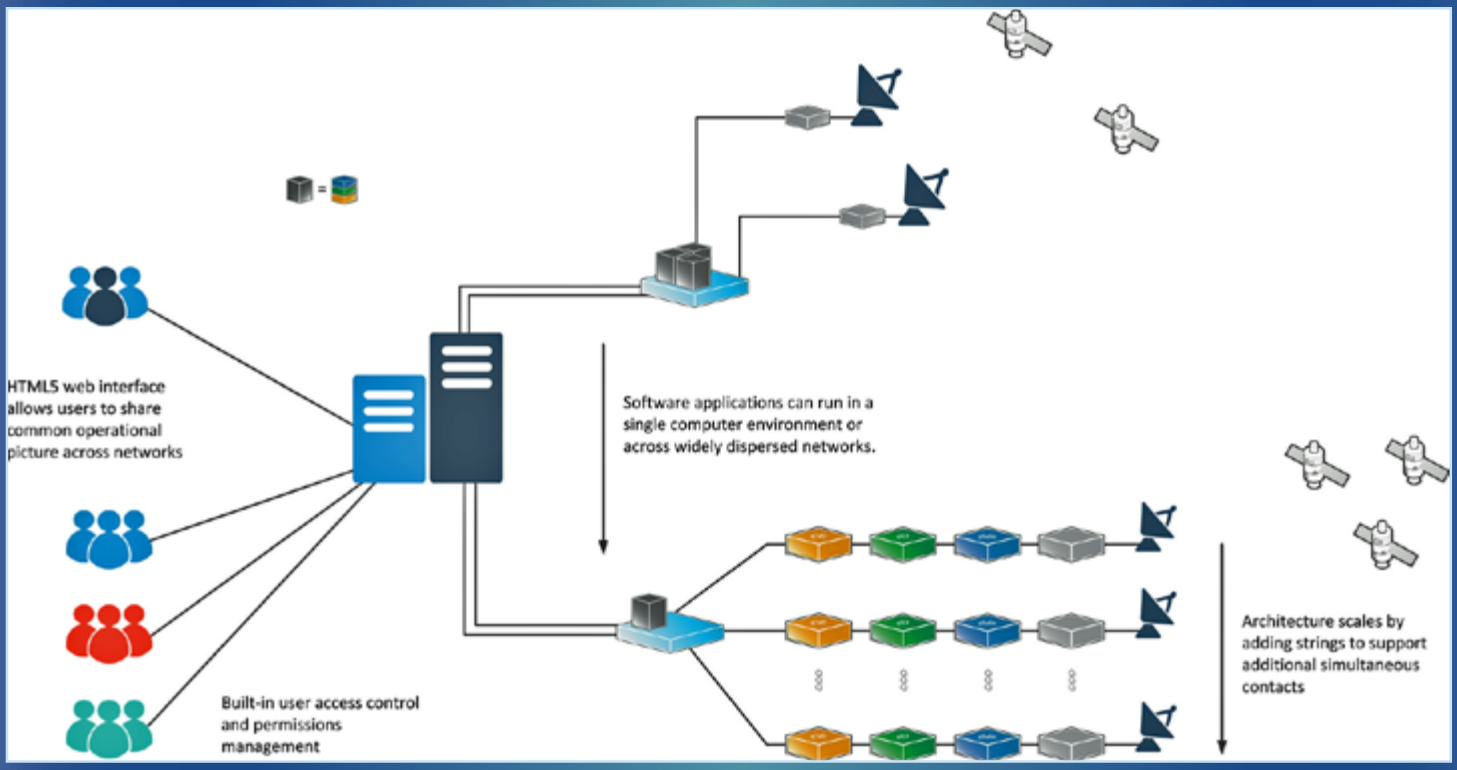

Figure 6. quantumGND supports both small and multi-site fleet operations

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As technology continues to move forward, what challenges does this pose to the industry, and how can it be used to our advantage? From strategies for cost reduction, unmanned ships and the Internet of Things, sustainable innovation in shipping is becoming more important than ever.

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Throughout this one-day high-level forum industry leaders will share their strategies to address the challenges presented by the new maritime landscape, and the key roles played by innovation and the drive for sustainability.

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- Chief Operating Officers (COOs)
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Partnership With Understanding: Your Network Intelligence Status Check

By Rajanik Mark Jayasuriya, Vice President for the Satellite Networks Business Group (SNG), ST Electronics

Is your VSAT network built for business intelligence?

Amid the excitement these days of higher volumes of capacity and expanding market opportunities comes a new reality for satellite service providers: the need for greater network intelligence. That's because with growth comes more capacity to manage, more technologies to integrate, more applications to support, and more data tied to critical business decisions.

Today's communication networks are increasingly diverse. A growing range of equipment must seamlessly work together to deliver the service levels required by end customers. Further, these networks generate a high volume of data across disparate sources that must be constantly monitored, integrated and analyzed.

Providing and maintaining a high quality of service requires an in-depth understanding of how all of the pieces of a network interoperate. A network management system (NMS) must be able to intelligently analyze the entire network to provide deeper visibility and control of operations. When the network is operated with a higher level of intelligence, the end result is better management of the overall business—a stronger ability to pre-empt service degradation, resolve issue in real-time and optimize network capacity.

An Intelligence Assessment

Today, service providers must run an intelligence status check on their current network management capabilities. Focusing on key priorities, an intelligent NMS must accomplish the following:

- *Provide a comprehensive view of all systems and equipment across all access technologies. This includes satellite, fiber and microwave networks, power supply units, air conditioning systems, security cameras and the myriad other components that comprise the total network.*
- *Understand how different pieces of equipment depend upon each other and how to switch between different pieces of equipment to ensure that the quality of service is maintained.*
- *Serve as a single platform that integrates asset management, troubleshooting and performance monitoring.*
- *Enable staff to monitor and access the network 24x7 wherever they are located using a modern, web-based interface that accommodates any language.*
- *Focus on what the end-user needs in real-time to make a decision—targeted exactly what matters within an expansive network environment.*

- *Allow end customers to analyze network usage to optimize performance.*

A Network Case Study

Last month, Agilis introduced the idea of a **Partnership with Understanding**—the importance of forming market relationships around the unique challenges you face as a satellite business operating in this new era. Determining success in the years ahead depends on a level of understanding that must be achieved from a technical and business perspective as well as having a partner that understands the full breadth and depth of the marketplace as well as the unique business drivers.

An examination follows of how a Partnership with Understanding can make a difference from a network perspective through the Agilis partnership with SpeedCast—and how having a VSAT network built for intelligence can help guide a business forward with confidence in this new era of satellite.

SpeedCast operates a highly complex communications network with multiple access technologies that support numerous applications for a range of customers and uses more than 70 satellites around the world out of 39 strategically located teleports. As the network footprint increases, complexities escalate and customer demands intensify.

Pierre-Jean (PJ) Beylier, CEO of SpeedCast International Ltd, describes this condition best when he states, "*Every day, the demands of our customers are growing, and it's our duty, our role, our mission, to help them with those demands.*"

With such level of growth and complexity, the idea of having a system that simply monitors and manages the network is merely step one for what is required to be truly in tune with the company's network. The understanding today is that the network must be equipped to drive true business value. This comes only through deep visibility into all pieces of that network—complete network intelligence.

As Beylier added, "*The need today becomes how to be more productive in network management.*"

For SpeedCast, such a scenario looks like this: Running deep-level analysis at specific points within the network, being instantly alerted on network service degradation regardless of technology or platform, and having the ability to tap into historical data in order to study and analyze network usage.

The ability to ensure that network infrastructure is monitored from the perspective of the customer—and that service providers can better manage service level agreements (SLAs), produce customized reports, and become more proactive in the process of service provisioning is truly what is meant by the phrase "optimizing network performance."

Betting on Business Performance

The key to success for SpeedCast is in finding ways to maximize the use of satellite capacity in order to provide the correct level of efficiency, performance and user experience to customers.

This fact became very apparent to Agilis in the development of the Agilis RealTime Advisor™. This web-based software provides satellite service providers a complete view of the entire communications network, along with intelligent analysis that improves quality of service and reduces operational costs across the business. The product enables deep visibility and analysis into hundreds of systems and equipment across the entire network.

SpeedCast was among the first to embrace this system. This technology sits right at the heart of its world-class teleport in Singapore. The company calls the technology "instrumental" for their operations, allowing for the provisioning of the best quality service for customers around the world.

Next Up

In an upcoming issue of *SatMagazine*, the need for multiple pieces of equipment operating across mobile, fixed and satellite networks and how all must all be integrated in a manner that addresses application-specific needs while providing value to the core business will be examined.

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Rajanik Mark Jayasuriya is currently the Vice President for the Satellite Networks Business Group (SNG) of ST Electronics. Mr. Jayasuriya has extensive knowledge in the satellite industry having worked in the field for over 20 years. Mr. Jayasuriya holds multiple patents for technology advancements. In addition, his vast experience in the commercial and government satellite and telecommunications markets range from product design, engineering, operations, sales and system integration.

In his current role, Mr. Jayasuriya's team delivers backbone communications solutions to key global defense and commercial organizations. Under his leadership, SNG has distinguished itself in the industry for supplying sophisticated, customized solutions to solve unique business challenges. Previous to this position, Mr. Jayasuriya held the title of Regional Vice President for iDirect Asia (an ST subsidiary). In this role, he managed sales operations across Asia resulting in opening the key markets of China, India, and Vietnam for iDirect products.

Wideband Satellite Gbit/s Over DVB-S2X With Annex M A TeamCast Focus:

By Philippe Hostiou and Gérard Faria, TeamCast

For a number of years now, all realize that the data-rate for Internet consumers will need to support connectivity anywhere, any time, and for everybody.

Smartphones, tablets and/or PCs are being used on the road in mobile applications as well as at home over Wi-Fi or fast broadband connections.

This demand is illustrated in the schematic of *Figure 1* below where the overall data-rate is forecast to increase by a factor of 2 (up to 600Gbps) over the next five years[1].

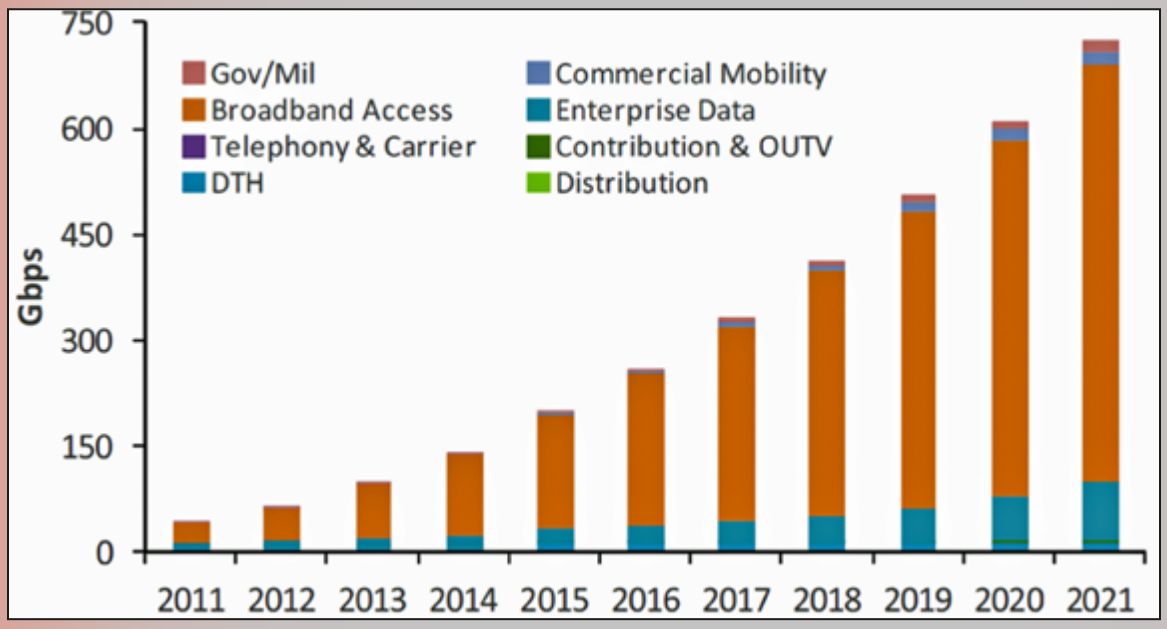


Figure 1. Forecast data demands

Currently, terrestrial 3G and 4G telecom networks with one-and two-way satellite backhaul networks are implemented to cover the demand. However, the available data-rate is not enough, especially in the satellite segment.

As satellite networks have the great advantage of being able to provide cover quickly to any part of the world, this lack of data-rate is becoming more and more of an issue. That is why some companies that depend on full connectivity (*e.g.*, Google, Facebook and Amazon), but are traditionally not involved in satellite technology, are seeking novel approaches to participate in the New Space sector. The satellite world/eco-system has to react to this growing data-rate demand; ***but how***?

This article presents the current status of satellite architecture and the technology's future technical evolution toward greater bandwidth and focuses on one particular solution—wideband operation as per Annex M, introduced in the DVB-S2X[2] standard.

With 20 years of experience in digital modulation techniques for RF transmission, TeamCast presents their vision of the markets and the technologies associated with the evolution/revolution required by the satellite environment.

The Current Status

The current architecture for satellite transmission for broadcasting, DVB-S, has remained the same, ever since the introduction of the first digital transmission systems. This means that, since 1994, the architecture has

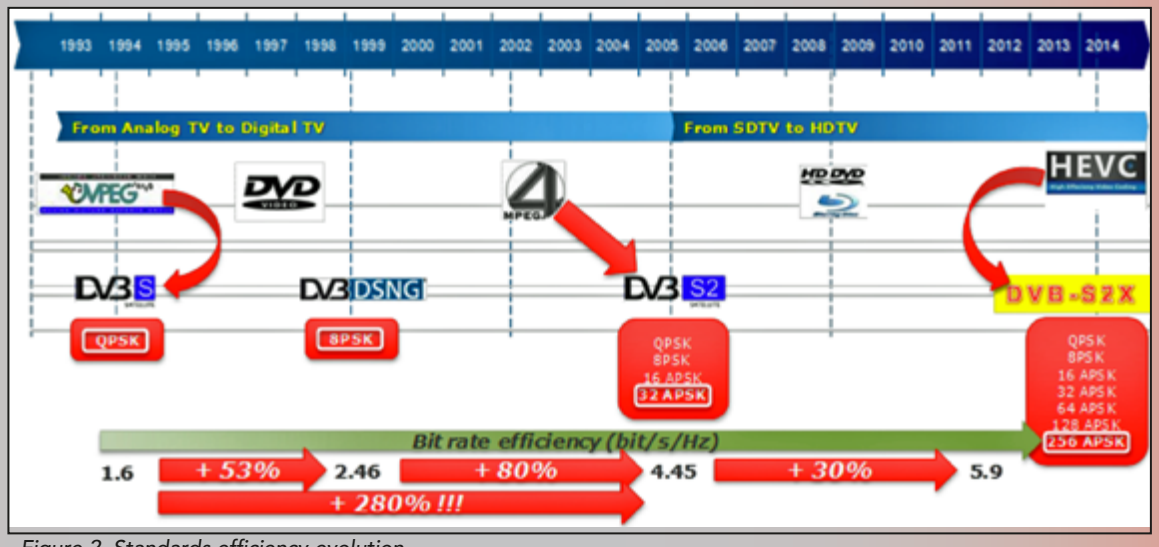


Figure 2. Standards efficiency evolution

been based on decomposing the 500 MHz typical frequency allocation of a satellite into 'N' 36 MHz transponders.

Sometimes wider transponders with 54 MHz or 72 MHz bandwidth are available, but this is not common, mostly due to performance limitations of the on-board amplifiers. Based on this architecture, the efforts in recent years have mostly been to improve the spectral efficiency of the transmission which has led to many improvements of the standard: from DVB-S, to DVB-S2 and DVB-S2X. ***Figure 2*** on the previous page is an illustration of the efficiency evolution of these standards.

The Technology

The embedded technologies inside modulators and amplifiers make it possible to achieve the highest efficiency by reducing the signal roll-off down to 1 percent without deteriorating the signal outside the useful band (no out-of-band spurious). The out-of-band spurious is kept under control in order to be compliant with the satellite operators' requirements (better than -65dBc level).

However, it seems that these implementations are now all well-established, and therefore the data-rate bandwidth efficiency ratio (measured in bits/s/Hz) remains almost constant. Note that currently approximately 40 percent of the transponder traffic is still in MPEG-2/DVB-S, and there remain many opportunities to optimize these current networks: In most cases, however, it is in the broadcast applications (DTH—Live TV), the STB upgrades and their associated costs which limit the migration to the DVB-S2 standard and, therefore, bandwidth efficiency improvement.

This is not applicable for broadband applications (Internet—IPTV), where everyone wants to be connected anywhere, any time with a high data-rate, and to be able to watch a video, play on-line, connect to their social network, search for information, read a newspaper article, etc. Spectral efficiency is increasing in the telecom segment, with its 4G networks now and its 5G networks tomorrow, based on LTE modulation schemes. Which technology can the satellite segment embrace to at least be able to provide the same service (data-rate and Quality of Service) as offered by the telecom networks?

The Satellite Ground Equipment

The satellite ground equipment has improved exponentially but remains based on a transponder bandwidth of 36 MHz or, in some cases, 72 MHz. Why? Could this be a limitation of the satellite capacity? Is it a technology challenge for the satellite manufacturers?

No, the reason is that DTH satellite transmission is based on a 36 MHz architecture and DTH is the 'cash cow' of the satellite market: as highlighted in the Satellite Industry Association (SIA) report[3], the Satellite TV (DTH) market is increasing with an average of 4 percent every year and represents roughly 80 percent of the total satellite service revenue, so there is little motivation to change.

The Satellite Onboard Technology

However, the technologies that are available to the satellite manufacturers for the on-board payload have significantly improved: new filtering and new onboard amplifiers are now almost 100 percent linear. Another technology, introduced in 2005, could almost be seen as revolutionary: High-Throughput Satellites (HTS).

The idea is relatively simple: instead of covering an entire country with a single spot, the HTS satellite covers the same area with a multitude of spots, as shown in ***Figure 3***. The goal is to increase the granularity to create small cells, similar to the concept for LTE in mobile networks where the two-way exchange in each cell covers only a few dozen square km and a few thousand consumers.

Indeed, in a typical HTS configuration, the multi-spot beams cover an entire country or several thousand square km and, therefore, potentially several millions of customers. Although it seems inefficient to share data-rate capacity in a 36 MHz bandwidth over the entire area, in the last decade HTS has become a technology that has been really boosted by the demand for broadband connectivity: bidirectional, point-to-point, with each client initiating their own request.

Is there any other area of development for HTS satellites? The answer is yes: increased transponder bandwidth. In the latest satellites that will be launched, such as VIASAT 2 and JUPITER 2, on-board technology has improved dramatically,

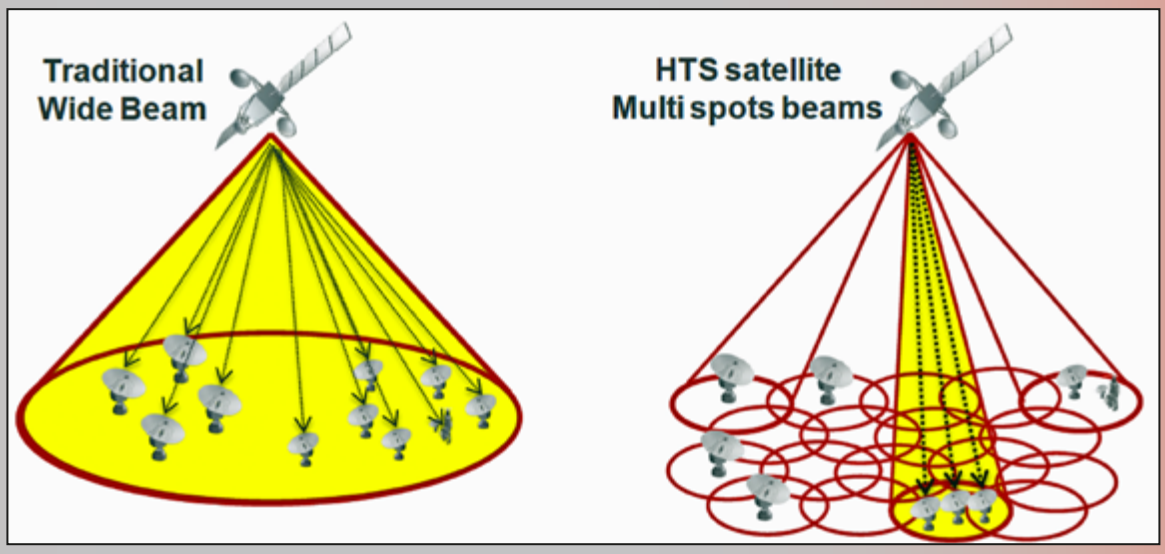


Figure 3: traditional beam versus HTS beams

offering filters and almost transparent amplifiers with bandwidths of up to 500 MHz.

This yields two major improvements:

- *Reduced CAPEX: only 1 modulator with a bandwidth at 500MHz is needed instead of 10 modulators at 36MHz*
- *Reduced OPEX: 1 satellite carrier of 500MHz instead of 10 carriers at 36MHz with their lost 10 percent bandwidth for the guard band*

The schematic of ***Figure 4*** demonstrates the OPEX savings: the "traditional" architecture contains several transponders with a maximum usable bandwidth of 36 MHz, plus a guard band inbetween each carrier.

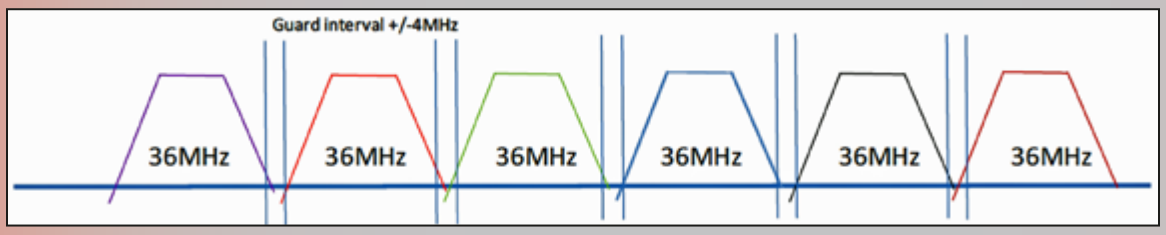


Figure 4: traditional 36MHz transponders

In case multiple small bandwidth carriers need to be combined into one transponder, a global power back-off is required to avoid saturation of the satellite amplifier (multi-carrier effect). This means that any modification of one of these carriers requires a new calculation/adjustment for the satellite transponder.

In a wideband configuration (as per Annex M), only one channel is uplinked, as the individual small band-width carriers are combined at the modulator level. This means that guard intervals are no longer necessary and this bandwidth can also be used to transmit useful data. As shown in ***Figure 5***, there is now only one channel, which:

- *Increases the global data-rate since the power back-off can be reduced*
- *Improves the C/N margin, the C/N coverage of the spot beam*

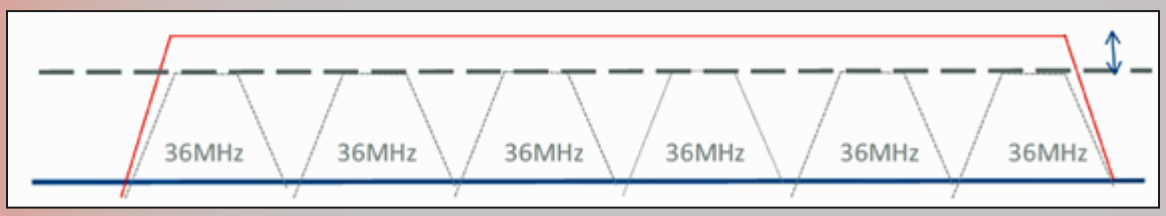


Figure 5. Wideband transponder

Using wideband is the key for CAPEX and OPEX; but what about the resultant data-rate per service? Defining a service with 1 or 2 Gbits/s does not seem feasible. However, Annex M was introduced in the DVB-S2 / DVB-S2X standards to answer this challenge.

What Is Annex M?

First of all, the question is ***why*** Annex M? Regarding the EN 302 307 standard, Annex M specifies the implementation of DVB-S2 and DVB-S2X profiles suitable for operation in wideband mode, without requiring a full-speed decoding of the total carrier capacity, by suitably mapping the transmitted services in time-slices.

As introduced previously, the wideband configuration is a way to transmit over a single carrier a data-rate of some Gbits/s. On the reception side, of course, the user doesn't want to demodulate so large an amount of data.

The user is only interested in one service available among the various other services. Annex M, at the service level, is an aggregation process for a number of services, following a rule which allows, on the reception side, the user to select easily one service out of several.

Annex M is a tool to give the opportunity for wideband operation to be available economically and arriving soon into the market, and also to give an answer to this question: How can one increase the data-rate today, by limiting the CAPEX and reducing the OPEX?

There is also another feature available in the DVB-S2/S2X standard which is used in another context: the multistream process. The idea is conceptually the same (reduction of CAPEX/OPEX) but the process is not done at the same level. As the plan is, at the first step of the demodulation, to select only the correct service, the process introduced by the Annex M is simple: add a label at the beginning of each DVB-S2/S2X frame at the physical layer level.

How does that work? Both these standards are based on the LDPC FEC process which works in frame mode. A frame can be sized either at 64800 bits or at 16200 bits.

To give the possibility to detect the beginning of each frame, at the modulator level, dedicated information must be added at the front of each frame: the PLHEADER or Physical Layer Header.

This PLHEADER is intended for receiver synchronization and physical layer signaling. PLHEADER starts with a sequence Start Of Frame (SOF) which allows, by correlation, the detection of the beginning of each frame as shown in ***Figure 6*** on the next page.

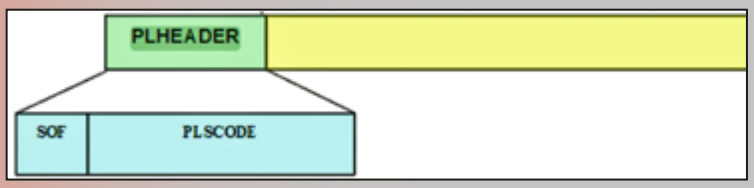


Figure 6. Traditional DVB-S2/S2X PLHEADER

The SOF + PLS CODE represent a "*Golden Sequence*" which exhibits some dedicated mathematical properties and which can be detected with a very low Signal to Noise Ratio. Thus, at the front of each DVB-S2/S2X frames, a PLHEADER is added containing the *Golden Sequence*, which allows easy detection of the start of the frame on the reception side, as illustrated in *Figure 7*.

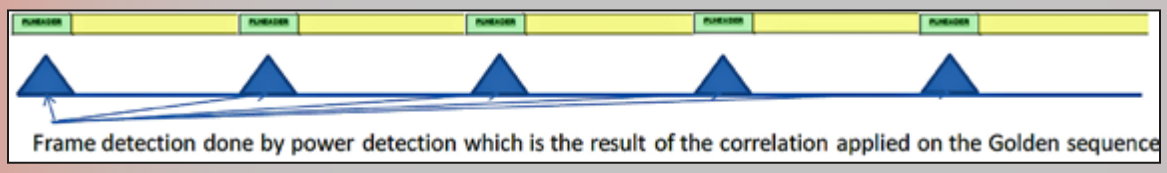


Figure 7. Frame Detection

Annex M also extends the PLHEADER by adding a Time Slice Number (TSN over 8bits), which identifies the service to be extracted by the receiver. When a wideband modulator is used with Annex M, the modulator generates this new PLHEADER, as shown in *Figure 8*.

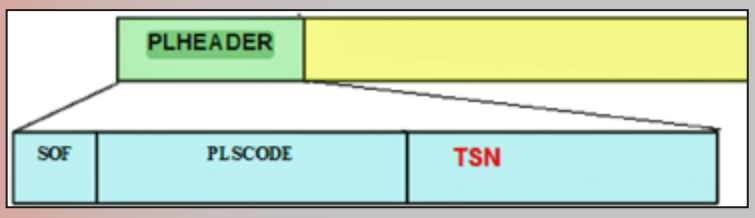


Figure 8. Wideband Annex M PLHEADER

Teamcast provides this kind of modulator (Tyger) where the input services can be either over ASI (traditional audio/video format over MPEG-TS) and/or over IP with the GSE encapsulation.

Due to the PLHEADER construction, the maximum number of services carried, at present is limited to eight. However, the idea of Annex M is to support service data-rates around the current data-rate capacity available on the DVB-S2 chipset, which is around 200 Mbps; with eight services, the global wideband data-rate would be nearly 1.6 Gbps. With an 8PSK constellation, this corresponds approximately to a satellite bandwidth of 500 MHz being required.

To summarize, wideband operation is possible if configured with Annex M. Annex M gives providers the possibility to introduce STBs onto the market with just a "small" step difference between a wideband STB and a current legacy STB. As shown in *Figure 10*, on the next page, the wideband process is introduced at the RF level, just after the tuner:

The complexity is at the tuner level, which must be wideband compliant up to 500 MHz. Note that this means a standalone wideband tuner would be not practical because of the close connection required between the tuner and the base band demodulator is mandatory.

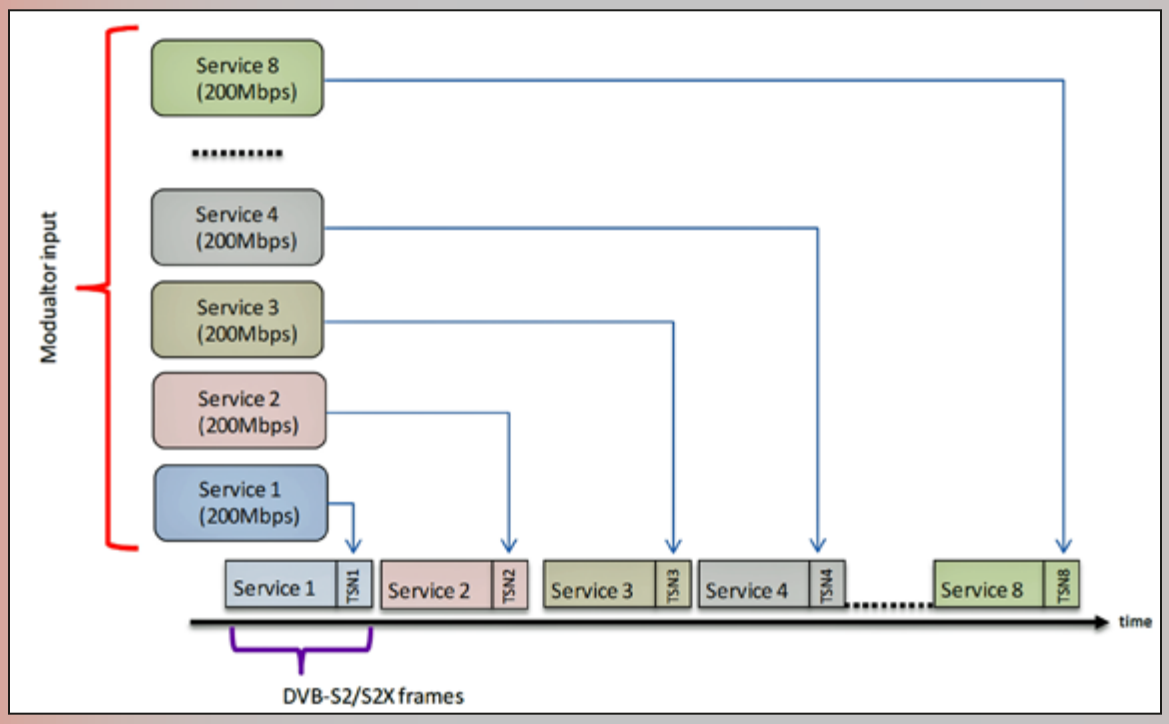


Figure 9. This represents the process that is applied to link a service with a TSN number:

What About The Receiver?

Can the receiver support a data-rate associated with a 500MHz bandwidth? Yes, such could be possible.

However, from an economics point of view, such a chipset would be too expensive—today, that is—but perhaps not over the next couple of years. That is why the DVB-S2/S2X standards with their Annex M is an advantageous solution which keeps the wideband demodulator

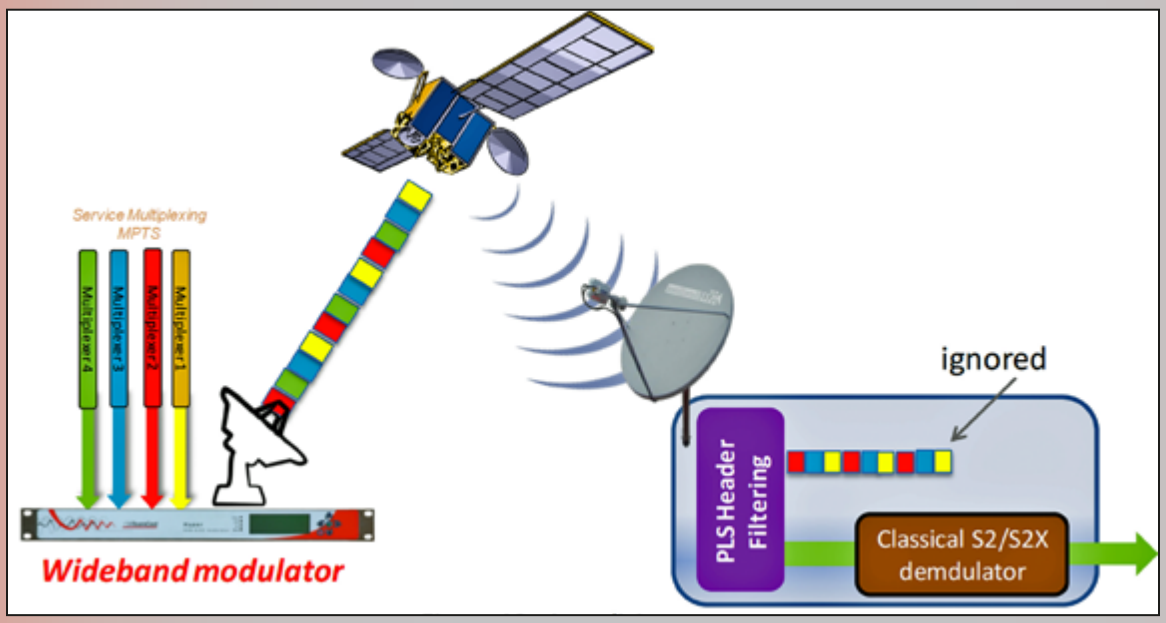


Figure 10. Time Slicing process.

chipset quite closely aligned to the current demodulator chipset used in the STB.

At the lowest physical level, the chipset just selects the needed service and then demodulates only that service. This means a modification "just" at the receiver input tuner and keeping the rest of the receiver at the current performance and complexity level becomes possible.

On the reception side, one could make an analogy between the DVB-S2/S2X multistream process and the Annex M process. Basically, the idea is more or less the same: aggregation of services to reduce CAPEX and OPEX. However, there is a big difference between these two processes: the multistream receiver needs to demodulate all the full incoming data-rate streams and then select which service is needed, as shown in the schematic of ***Figure 11a.***

In the Annex M receiver, the selection of the service is completed at a very low physical level, just after the tuner component, where the demodulator is looking for the beginning of the DVB-S2 or DVB-S2X frame. Each frame is identified by its Golden Sequence, with a different value for each service.

The Physical Layer Scrambling (PLS) sequence is different for Service 1 compared with Service 2. Therefore the service selection is made based on the PLS Header as shown in ***Figure 11b***.

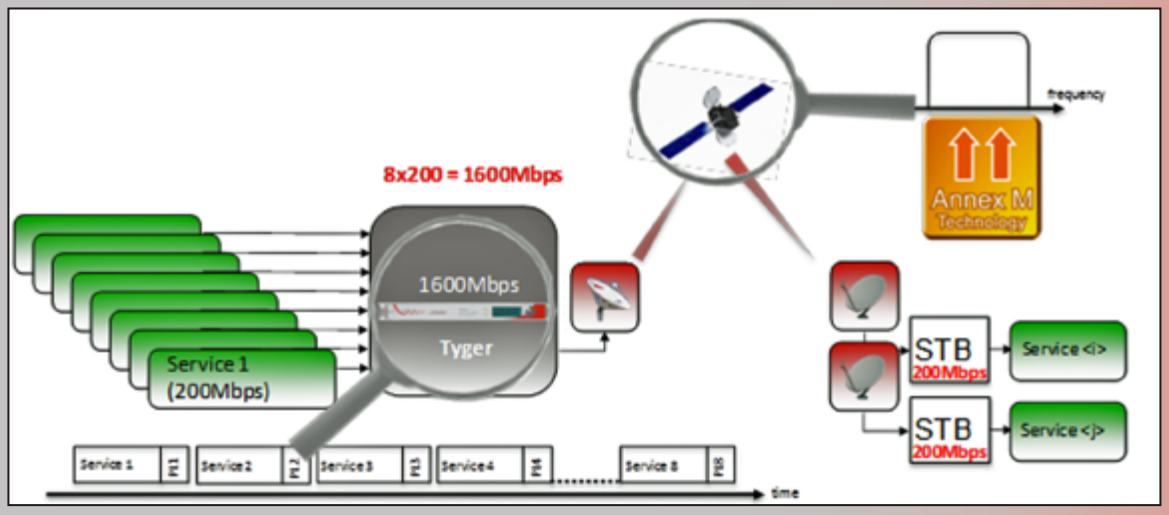


Figure 12. Wideband & Annex M on the system level

The big benefit is that the LDPC decoder needs only to handle the same data-rate as is already currently available on the S2/S2X chipset: roughly, 200 Mbps. At the system level, the DVB wideband-with-Annex-M technology could be deployed as shown in ***Figure 12***.

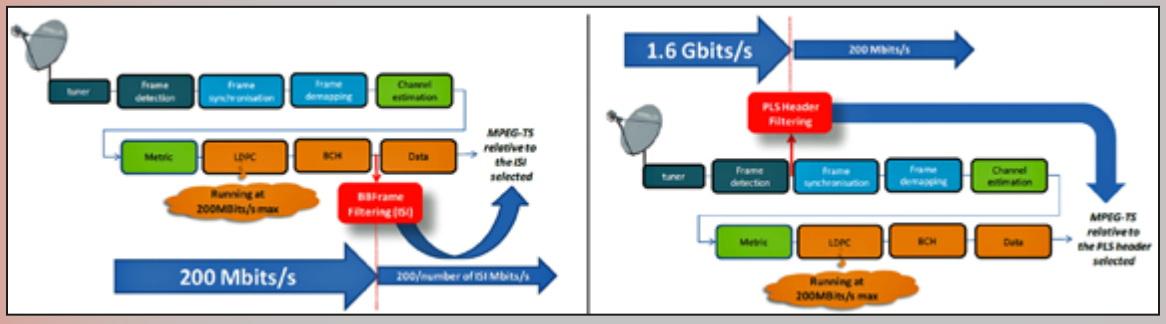


Figure 11a. multistream process

Figure 11b. Annex M process

What Is Currently Available On The Market?

Status Of The Ground Equipment

At this point in time, ground equipment and systems are typically focused on the traditional bandwidth of 36 MHz; however, TeamCast recently introduced a new modulator—Tyger4—which offers the capability to cover up to 500 MHz with different types of service—either traditional audio/video over ASI or Ethernet, or the new GSE-Lite protocol introduced in the DVB-S2X standard. With this product, TeamCast succeeds in proposing a new solution to reduce CAPEX and OPEX for the HTS satellite system integrators.

Status At The Projects' Level

On the receive side, it is important that chipsets supporting the Annex M (Time slicing) solution are readily available to keep the cost low for the consumer. The company has shown in this article that the effort required to be 'wideband compliant' is not too high: in fact, it is limited to the tuner section of the receiver.

Figure 13. Wideband transmission setup

The rest of the demodulation/decoding process remains the same as in use today, as the same data-rate is preserved (+/- 200 Mbps). Currently, there are ongoing projects where wideband and Annex M are used; for example, the THD-SAT project in France, and the Spacebus 4000B2 platform in Bangladesh. Furthermore, ESA projects are already involving chipset manufacturers: this was reinforced during the last Toulouse Space Show, where TeamCast, with CNES and ST Micro Electronic, demonstrated a wideband transmission setup as shown in ***Figure 13***.

The wideband modulator with the Annex M (time slicing) process together with HTS satellite technology is a major step for the satellite ecosystem toward delivering the extremely high data rates now required by the market, while meeting the time to market and cheap receiver demands of the consumer.

At present, the satellite transmission ground equipment is focused primarily on the traditional bandwidth of 36 MHz transponders. However, there are now wideband modulators coming onto the market that offer the capability to uplink using up to 500MHz wide channels.

TeamCast has introduced their new modulator, Tyger, which offers this capability, managing the Annex M implementation requirements for different types of services over a wideband signal up to 500 MHz.

With this product, TeamCast is providing the ideal solution to reduce CAPEX and OPEX for the HTS satellite system integrators.

HTS wideband with DVB-S2X Annex M is ready for commercial deployment.

Resources

[1]NSR Source 2015

[2]DVB is a registered trademark of the DVB Project

*[3]**http://www.sia.org/wp-content/uploads/2016/06/SSIR16-Pdf-Copy-for-Website-Compressed.pdf***

[4]http://www.teamcast.com/wp-content/uploads/2016/03/TYGER_Leaflet_MPD-151104E.pdf

TeamCast offers innovative technology offerings based on the firm's solid expertise in Satellite and Terrestrial Digital TV transmission.

*Created in 2003, and based at Rennes in France, TeamCast is involved in the development, definition and verification of numerous broadcasting standards, including DVB-S2X. TeamCast is an active member of the satellite Interference Reduction Group (iRG: **www.satirg.org**) and actively participates within the Carrier ID (DVB-CID) contribution in this group as well as in various exhibitions.*

Today, major clients in the broadcasting Industry from 50 different countries invest in TeamCast technology and products. TeamCast has offices in Elmira, New York, and in Singapore to support the development of their North American and Asian business operations and to provide local sales and technical support services to customers across the globe.

www.teamcast.com

Restored Cold War Era Satellite Dish Becomes A Princeton University Teaching Tool

By Catherine Zandonella, Office of the Dean for Research, Princeton University

In its heyday, the towering metal satellite dish located about three miles from the Jersey Shore's boardwalks hosted a number of historical moments: the dish tracked the flights of some of America's first space launches and, in 1960, collected the first images beamed to Earth from an orbiting weather satellite.

That feat was considered so amazing that the photos were rushed to President Dwight D. Eisenhower, ushering in the era of modern weather forecasting.

After a decade of scanning the skies, however, the dish fell into disuse and became immobilized by rust while weeds grew up around the base and wasps nested in the dish crevices. There the unit sat until four years ago when two Princeton University scientists set out to restore the dish as a way to bring students—both from the University and local communities—closer to outer space.

This spring, the now-functional satellite receiver hosted about 20 Princeton students from an undergraduate physics class who learned how to receive radio signals not just from orbiting satellites but also from astrophysical objects such as dying stars. The dish has also hosted scores of amateur radio enthusiasts and is open to the public each Wednesday and on weekends, when visitors can watch as the massive dish sweeps the sky.

Daniel Marlow, Princeton's Evans Crawford 1911 Professor of Physics, was one of two Princeton University scientists who set out four years ago to restore a Cold War-era radio satellite near the Jersey Shore. Now, the fully functional satellite is open to Princeton students, amateur radio enthusiasts and the public.

Video still courtesy of Lydia Cornett, Princeton University Class of 2016.

"*We didn't realize what we were getting into when we first decided to take on this project*," said Daniel Marlow, Princeton's Evans Crawford 1911 Professor of Physics, who led the refurbishment effort with Senior Research Physicist Norman Jarosik. "*Luckily we had a lot of cooperation from Princeton's Department of Physics and the University, along with terrific partners in the community.*"

The refurbished dish was activated in the winter of 2015 and was steered to look at a region of the Milky Way. A well-known signal of hydrogen gas in the Milky Way was detected. Soon thereafter, information streaming from weather satellites was intercepted.

Radio waves from dying stars were also detected and the researchers have beamed radio signals to the moon and intercepted them as they came back to Earth.

Reviving A Forgotten Dish

Built in 1958, the dish is 40 miles east of the Princeton campus and occupies the grounds of a former US Army base known as Camp Evans in Wall Township, New Jersey. By the mid-1970s, the dish was considered obsolete and all use was discontinued. The dish might have been torn down if not for the efforts of radio enthusiasts and other volunteers from a grassroots museum in Wall Township called the Information ***Age Science History Museum and Learning Center***, or ***InfoAge***.

The quest to restore the dish originated from Marlow's desire to build a radio telescope that Princeton students could use to study objects in the universe. A typical home-use telescope works through the lens collecting visible light whereas the refurbished dish collects radio waves. Both visible light and radio signals are electromagnetic waves, but visible-light telescopes need good weather and dark conditions, whereas the longer wavelengths of radio waves can travel through clouds and be detected at any hour.

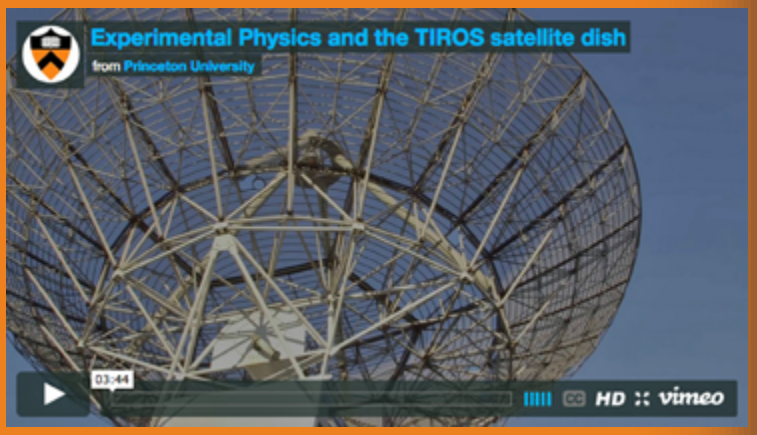
The dish's concave shape ensures that radio waves striking the dish surface reflect into a collecting area at the center of the dish called a feed horn. The feed horn processes the signals, which are then funneled via electrical conduits into computers in the control room next to the dish.

The idea to take on the refurbishing of the InfoAge dish—which spans 60 feet across and sits on a base that is 40 feet tall—was derived from a chance conversation between Marlow and Jarosik.

"*Dan told me he wanted to build a radio telescope on campus*," Jarosik said. "*I told him that there was already a large radio dish sitting idle down by the shore. We decided to go take a look at it.*"

Fred Carl, the chief operating officer of InfoAge, didn't know what to expect when he drove to the dish site to meet with the two Princeton physicists in 2012. "*My view of a Princeton professor was a guy in a tweed suit smoking a pipe*," Carl said. "*I didn't expect them to immediately put on safety gear and begin climbing the tower to inspect the dish.*"

From the exterior, the dish didn't look too bad. Thanks to funding secured by InfoAge, the structure had been painted in 2005. But the museum, which survives on donations and



Video by Lydia Cornett, Princeton University Class of 2016.

volunteer work, didn't have the resources to do much more than that fresh coat of paint.

Upon inspection, Jarosik and Marlow found that rust had jammed the motor and drive train that tilt the dish vertically. The motor would have to be taken down from the top of the tower and be repaired.

To fund the repairs, Jarosik and Marlow received grants from Princeton's 250th Anniversary Fund for Innovation in Undergraduate Education and from the University's Council on Science and Technology, both of which provide resources for the development of new courses.

"*Our idea was that non-science majors as well as physics majors would be able to use a working radio telescope*," Marlow said. Additional support came from Wall Township and the Ocean-Monmouth Amateur Radio Club.

Marlow and Jarosik engaged the help of engineer Geoffrey Gettelfinger, the department manager in physics, as well as department technicians Stanley Chidzik, James Kukon and

The satellite sits on the former site of US Army base in Wall Township, New Jersey, now leased to a grassroots museum called the Information Age Science History Museum and Learning Center, or InfoAge. InfoAge has supported the restoration and operation of the satellite. In the photo above, Fred Carl, chief operating officer of InfoAge, assists in lowering some of the dish's machinery to the ground for repair. Photo by Daniel Marlow, Department of Physics.

Richard Soden to help with the task. Princeton undergraduates Nathan Agmon, Class of 2017, and Joshua Wang, Class of 2018, spent a summer developing software to read and display data from the dish.

Just to get the motor down off the tower was a challenge. The Princeton engineers designed a special crane to lower the one-ton motor. The crane had to be lifted piece-by-piece and assembled in place at the top of the dish pedestal. After locating a company that could fix the motor package, the team eventually was able to restore full movement of the dish.

Many small tasks remained: replacing antiquated vacuum tubes with modern electronics, connecting the cables that carry the radio signals to the control room and replacing the feed horn with one that was left over from the dissertation project of another faculty member, Suzanne Staggs, Princeton's Henry DeWolf Smyth Professor of Physics.

The Dish Works

Finally, in the winter of 2015, the researchers were ready to try out the dish to see if radio signals from space could be intercepted. They turned the knobs that control the dish and steered it so that a region of the Milky Way was targeted. There they detected radio-wave signals at a frequency of 1420.4 MHz and a wavelength of 21 centimeters, a well-known signal of hydrogen gas in the Milky Way and a sure sign that the dish was operating properly.

Princeton Senior Research Physicist Norman Jarosik (left), and engineer Geoffrey Gettelfinger (right), the department manager in physics, view the dish shortly after its first change in elevation in more than 30 years. Photo by Daniel Marlow, Department of Physics.

Soon they were able to intercept information streaming from weather satellites operated by the National Oceanic and Atmospheric Administration (NOAA). The researchers could also detect pulsars, dying stars that give off regular repeating bursts of radio waves as they rotate. The researchers beamed radio signals to the moon and intercepted them as they came back to Earth.

On January 10, 2016, radio enthusiasts—along with InfoAge supporters, Jarosik and Marlow, who himself is an amateur radio operator—gathered at the dish to commemorate the first such "moon bounce," which occurred in 1946 on the site of the current dish and at the time was important proof of principle that radio waves could be harnessed for satellite communications.

The dish site has had many brushes with history. In 1914, the Marconi Company—founded by Italian inventor and pioneer of wireless communication Guglielmo Marconi—set up a station for sending transatlantic wireless telegraph messages to a receiving station in Wales. To house the employees who were needed to provide 24 hour service, the company erected a handsome red-brick building with a wraparound porch and sweeping views of the Shark River known as the Marconi Hotel, which today houses InfoAge and other programs.

The US Navy took over the site in 1917 for wartime radio transmissions—in 1941, the US Army became the owner. The military decommissioned the facility in 1993 and, in 2012, the National Park Service made the site a National Historic Landmark. The dish site is now owned by Wall Township and is leased to InfoAge.

A Large Learning Tool

The restored dish will now be used regularly to teach a new generation of students to use radio telescopes to learn about space. During the spring semester, Princeton students visited the dish as a learning exercise for the course "*Experimental Physics*" that Marlow teaches for physics majors. Marlow is also designing a course for use with non-majors that will be offered in 2017.

"*Princeton is now one of the few universities in the world where undergraduates can operate a 60-foot radio telescope*," Marlow said.

There is no actual need to travel to the satellite dish as remote operation can be achieved from a room in Princeton's Jadwin Hall. Still, most students take advantage of field trips to the dish where they can experience the scale of the device.

"*It is amazing to think that as a junior in college you can do experiments with equipment that has been at the forefront of science*," said Daniel Gift, a Class of 2017 physics major who made the trip to the dish. "*The ability to control a huge radio telescope to obtain data for a class assignment is something that is really unique.*"

Marlow hopes to be able to bring more students from local high schools to the dish to inspire them to study science and engineering.

"*Part of my motivation for wanting to study physics and astronomy is that, when I was a kid, seeing the Milky Way inspired me*," Marlow said. "*The refurbishing of this satellite dish provides students with a similar opportunity. This is the sort of thing that a great university can do.*"

www.princeton.edu/

Editor's notes:

The article's opening image is courtesy of **Robert Raia Photography:** ***www.robertraia.com/***

The closing Princeton satellite dish image is courtesy of **Timothy Flynn.**

An EARSC Case In Point: Satellites Benefitting Citizens Growing Forests In Sweden

By Geoff Sawyer, EARSC Secretary General and Marc DeVries, The Green Land

In EARSC's second report[1] on the economic benefit of satellite services, the impact of the use of satellite imagery on management of forests in Sweden is analyzed.

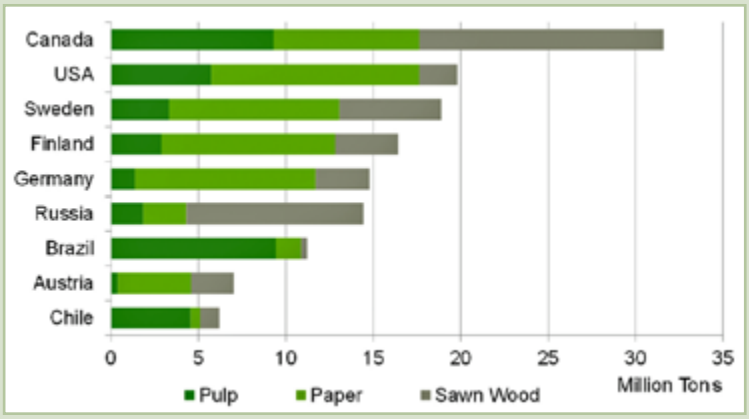
This report shows that the use of optical images, and particularly those from Sentinel 2, enables the Swedish economy to benefit by around 20 million euros per annum. In each of the cases, the EARSC consider the immediate value of the EO product or service as well as the extended impact through the value chain according to a methodology developed for this purpose. More information can be found in either of the published case reports.

Forestry plays an important role in the Swedish economy. Despite holding just below 1 percent of the world's commercial forest area, Sweden provides 10 percent of the world´s sawn timber. Forest covers roughly 70 percent of Sweden, extending more than 28 million hectares (ha). Of this area, almost 23 million ha are productive forest land.

Forest products generate an export value of 12 billion euros and employs approximately 90,000 people. Every year the forestland of Sweden produces a total of around 121 million m3 of wood. Approximately 50 percent of Swedish forests are owned by over 300,000 individuals or families; the other half by the government and industry.

The current Swedish Forestry Act, which took effect in 1994, has two main goals: one for production and one for safeguarding biodiversity. The Swedish Forest Agency (SFA) is responsible for ensuring effective implementation of this policy in what has become known as "*The Swedish Forestry Model*."

The result has been increasing forest and timber reserves while simultaneously preserving natural forest land, increasing its value for leisure and recreation pursuits. This light legislative approach is referred to as "freedom with responsibility" and keeps compliance costs low for the industry—all underpinned by satellites which can monitor the forests, giving rise to the benefits which EARSC can then calculate.



World's top exporters of forest products.

Before clearing, the land owner must notify the SFA of their intention to clear-cut (or harvest) the area of woodland. The SFA has six weeks to respond to the owner if there is any reason why the forest cannot be cleared.

However, forest-owners often notify several years in advance of their intention to clear-cut and the SFA has no easy way to validate when or whether the forest has been cleared and if this conforms to the notified area.

Hence, information on the forests is essential for the SFA to be able to detect as well as to control illegal activities and to educate the forest owners in best management practices.

While current forest owners can reap the benefits of their land, they have a responsibility to manage that land correctly; both for their next generation but also for the Swedish State. After clearing, the land should be replanted with saplings which will grow for about 80 years (average in Sweden) before the cycle restarts—the undergrowth should be cleared at least once in the first 10 years. Effective management, in the early years after clearing, is important if the yield is to be maintained and timber stocks are to be maximized.

Since 2000, information coming from satellite imagery has allowed the detection of illegal cutting (now quite rare) and of poor management practice (lack of immediate re-planting and lack of pre-commercial thinning). Through the use of clear-cut maps, *i.e.*, maps showing where forest has been cleared for harvest, the SFA can check whether this clearing was allowed under law and can take action where and when appropriate.

However, most importantly, the forest owners know that the SFA can monitor their land—this has improved compliance with the law. As a consequence of the availability of imagery, the area of forest cleared "illegally" has fallen from around 10 percent of harvested forest each year (in 1998) to less than 0.5 percent (according to a 2003 study carried out internally by the SFA).

The gathering and use of the imagery and the clear-cut maps cost very little (64K euros) while the benefits are quite large. The core benefits are related to the compliance costs savings and the long term value increase as a result of higher timber production and enhanced quality.

In addition to that, as the clear-cut maps produced by the SFA are made available as open data, other additional positive externalities accrue in the form of more social-economic values (wild life preservation, forest diversity protection).

All together, EARSC estimates that the use of satellite imagery brings a total direct economic benefit to Sweden of between 16.1 million and 21.6 million per annum.

www.earsc.org/

thegreenland.eu/

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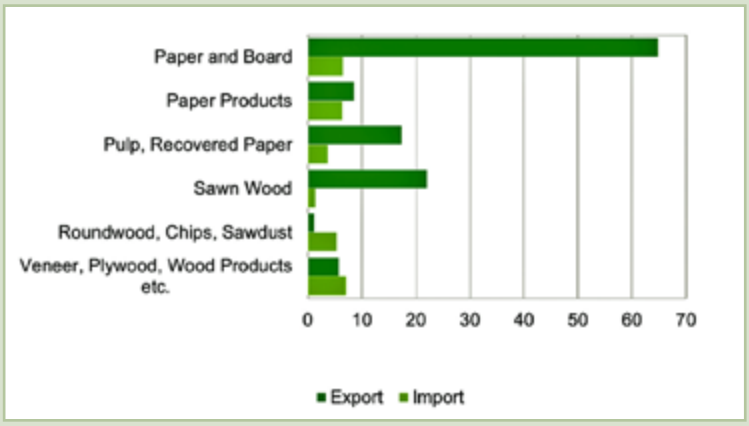

Exports and Imports of Forest Industry products 2013 (billion SEK).

Rising To The Needs Of The LATAM Market: An Elara Focus

By Carlos Sánchez, Customer Experience Specialist, Elara Comunicaciones

When thinking about connectivity in Latin America (LATAM), the belief is that this region of the world is a complicated market.

On the one hand, satellite connectivity represents a solid business opportunity, given the topography of LATAM countries. There is often difficulty in accessing some of the more remote towns which are far away from Mexico's urban areas and where terrestrial connectivity is unknown. On the other hand, satellite connectivity as an alternative communications solution is too expensive for many would-be users.

Nevertheless, since 2004, Elara Comunicaciones has been delivering satellite connectivity and a reliable customer experience for the LATAM market. This has enabled the Mexican company to meet with great success and over a relatively short period of time.

Since 3012, Elara's teleport has been ranked in the Top Teleport Operators ranking of the World Teleport Association (WTA); the company works with eight satellites that provide and guarantee communication services for clients, with an availability of 99.8 percent.

With more than 6,000 VSATs in operation, Elara builds tailor-made solutions for the company's demanding clientele in 11 LATAM countries, in addition to Mexico: Guatemala, Honduras, El Salvador, Costa Rica, Panama, Ecuador, Peru, Colombia, Venezuela, Chile and Argentina. The company pursues a variety of markets in these countries, all having different requirements and user requested features.

Either for an oil well on the Chilean cost; delivering data, voice and video in Columbia; or reducing the digital divide for users in the Mexican mountains, Elara keeps people well connected.

Even with the recent oil and gas market downturn, Elara has found rich opportunities. Maurice Soreque, CCO of Elara, said recently, "*The exchange rate, low price per barrel in*

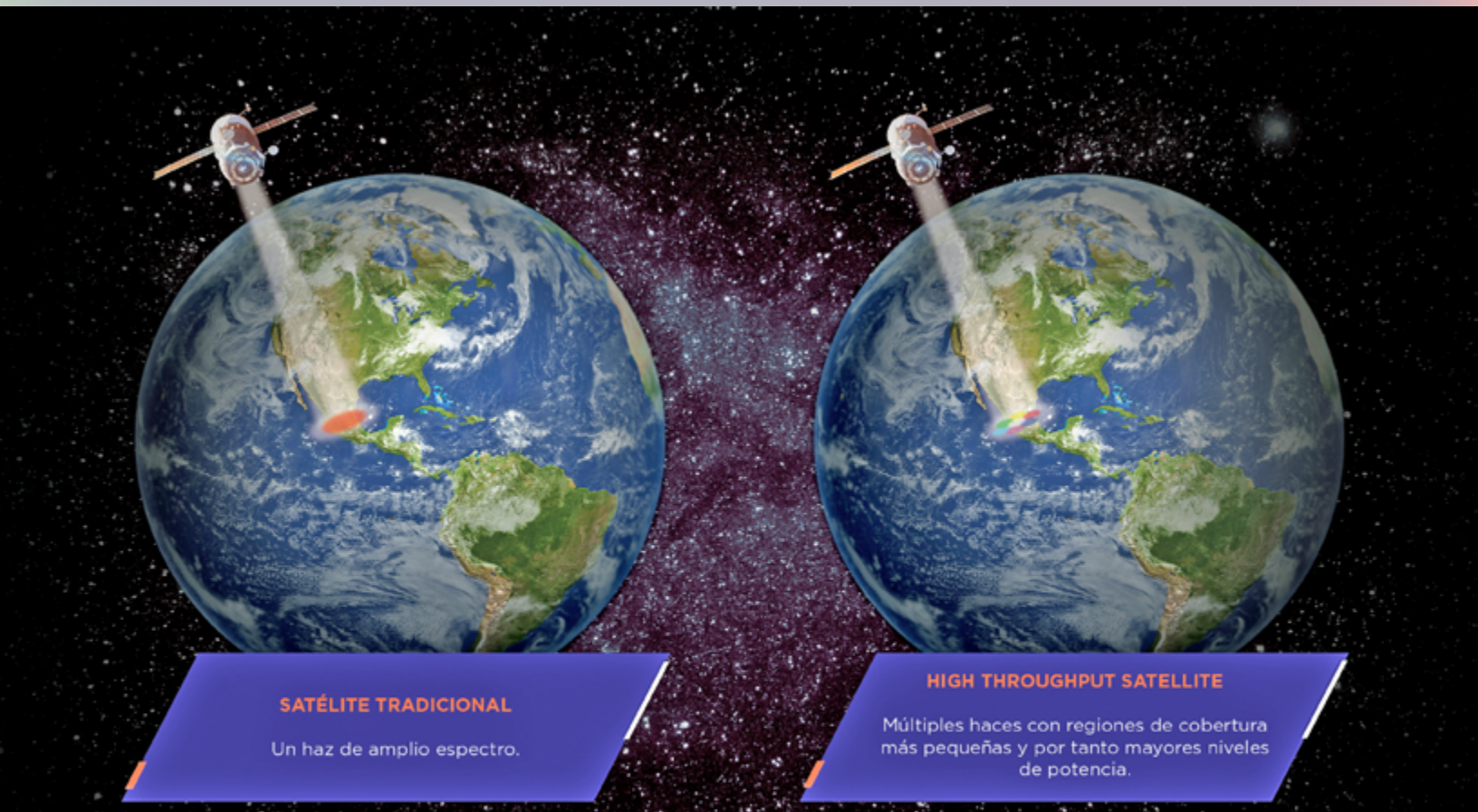

Photo of Elara Communications personnel at the company's teleport in Mexico.

the Oil & Gas industry, and the reduction in budget for government projects in Mexico have made Elara focus on being a more innovative and creative company. We continue providing tailor-made solutions, but we also integrate more and new services to offer. Customer Service is our main focus, what we do is to offer an integrated solution to our customers, not only satellite connectivity."

Elara has also identified the need to offer greater bandwidths to customers, as well as the need to implement High Throughput Satellites (HTS), both key necessities for the continued development of the telecom industry in LATAM.

Elara is a company that is not afraid to change, accepting challenging tasks to ensure better results, which in turn drives increased profitability, results in loss reduction, and brings best connectivity solutions to happy customers.

Elara has won several awards and honors. The international firm Deloitte has twice recognized Elara for being in the front line of Continuous Improvement Strategies and Best Practices. The firm has also been awarded with the ISO 9001:2008 by the International Organization for Standardization for business management excellence, efficiency with the handling of assets and the ability to oversee internal strengths and external agents.

The United Nations has included Elara in the United Nations Global Compact as the company has demonstrated responsible business practices in the areas of human rights, labor, environment and anti-corruption schemes.

In July of 2015, Northgate Capital showed interest in Elara and decided to partner with the firm as a financial ally to continue the pattern of strong growth. This financial strength, along with a highly qualified staff and satisfied customers, reveal that Elara is a best choice when LATAM satellite connectivity solutions are required.

www.elara.com.mx/

Carlos Sánchez is Customer Experience Specialist for Elara Comunicaciones, based in Mexico City, and he works with the firm's Marketing department. He holds a B.A. in International Affairs by Universidad Nacional Autónoma de México and is also certified in Corporate Communication and Corporate Meeting Planning. Carlos has worked within Mexico and several foreign countries. The author may be reached at ***carlos.sanchez@elara.com.mx****.*

The Final Battle To End Polio: A Better Satellite World Perspective

By Robert Bell, Executive Director, SSPI and WTA

In 1988, a meeting of the World Health Assembly set a mind-boggling goal: to eradicate the ancient scourge of polio.

At the time the goal was set, the polio virus was endemic in 125 countries and about 350,000 people, mostly children, were paralyzed by polio each year.

This was an audacious goal; however, 24 years later, the number of polio cases worldwide had fallen by more than 99 percent, saving more than 10 million children from paralysis.

How To End A Plague

The near-eradication of polio required big public investment in vaccine. Polio is highly infectious, and entire villages and districts had to be vaccinated to stop the chain of transmission.

Stamping polio out meant recruiting and training hundreds of thousands of vaccinators and sending them into the field with millions of doses of vaccine, which had to be kept cold in foam-plastic boxes. The goal was to vaccinate every child in the country several times, with a month or so between each round.

This was an unprecedented effort that allowed India to declare itself polio-free in February of 2012. India was long considered one of the most unlikely places to eradicate polio because of that nation's high population density, high rates of migration, poor sanitation, and low rates of route immunization. Data-driven planning, well-trained and motivated staff, rigorous monitoring and political will at all levels, that made the difference.

As did satellite technology... according to Bill Gates, whose Gates Foundation is funding the battle against polio in nations around the world, satellite imagery and mobile phones equipped with GPS are instrumental in the fight.

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India is now sharing their best practices with Nigeria, Afghanistan and Pakistan—countries where polio remains endemic—and the Nigerian experience reveals just how technology can help a person-to-person effort achieve national scale.

Satellite Maps & Cell Phones

Mr. Gates outlined the basics in a 2012 interview with author Rick Smolan.

"*The Environmental Systems Research Institute (ESRI) creates these incredibly detailed satellite maps for governments*," he said. "*They found that there were villages in Nigeria, which has the highest rate of polio resurgence in the world, that have never shown up on any map. No one in the government knew they were there. ESRI can recognize the shape of huts and pathways. They updated the satellite maps and handed out 10,000 GPS-enabled cell phones to polio workers. They could see where the workers were in real-time, and make sure they got to each of the houses.*"

Satellite technologies feed into many steps in the process. Space-based imaging is used to update geographical information systems (GIS) that generate maps for the field workers.

Using GIS as a tool, supervisors plan how to deploy their teams in order to cover every village and settlement. Each morning, the teams receive their GPS-equipped phones and start their visits. In the villages, with the help of local guides, they visit health facilities, schools, markets and mosques, where they vaccinate both children and adults.

At the end of the day, the phones are collected for charging, which lets supervisors download their tracking data and match that information to the GIS system. The results are tracks showing where every vaccinator has been, as well as updated map coordinates for important buildings. Every few days, the teams receive summaries of missed or partially-covered settlements that need a return visit.

Winning The Final Prize

As impressive as this effort has been, the battle is not yet won. The 2012 World Health Assembly declared that the complete eradication of polio was "*an emergency for global public health.*" That is because the disease is making a comeback in nations where civil unrest and war are making it impossible for vaccination programs to function.

This is a battle worth fighting—in addition to the relief of human suffering, experts believe that eradicating polio will generate US$40 to $50 billion in benefits, with most of that money going to low-income countries. Winning that prize is a cause to which the satellite business is proud to contribute.

"*The Final Battle to End Polio*" is part of SSPI's **Better Satellite World** campaign, which educates end-users, policymakers and the next generation on the indispensable contributions of satellite to our world.

More stories and videos are available at
www.bettersatelliteworld.com.

www.sspi.org/

Sources

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Growing An Organic Workforce: A Space Foundation Perspective

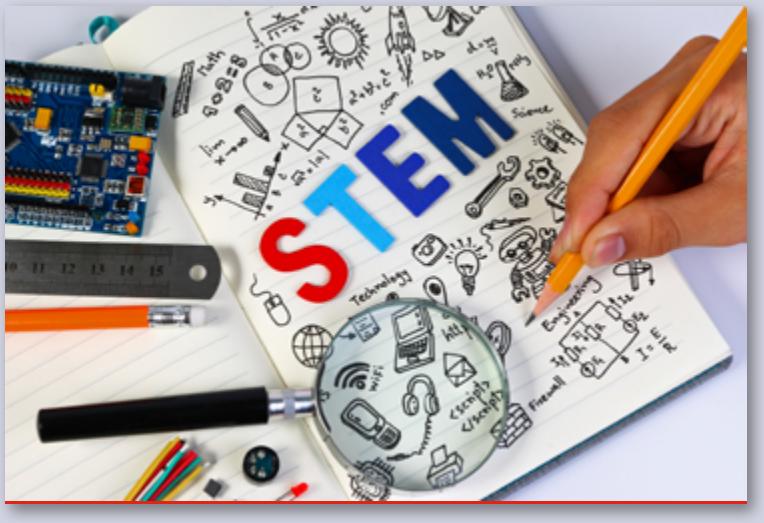
By Bryan DeBates, Vice President—Education, Space Foundation

The United States is in trouble—according to the May 2016 jobs report (*CNN Money*), there were 5.8 million job openings that month that went unfulfilled. This is an indication that employers can't find enough qualified individuals to fill those openings.

Let's take a closer look at what impacts our industry. The President's Council of Advisors on Science and Technology reports that the U.S. will produce one million fewer STEM professionals over the next decade than will be required if the graduation rates keep to the status quo. STEM occupations are projected to continue to grow, but unfortunately, our education system isn't producing enough graduates. Why is that? Ironically, that question has been asked for more than two decades.

At a hearing before the Committee on Science, Space, and Technology (U.S. Space Program Benefits, 1992), Congressman Sensenbrenner of Wisconsin expressed his views on: (a) the cuts in the NASA budget, (b) student science and mathematics test scores, and (c) the importance of students choosing a career in science. He warned, "*The space program is one of the things that does that [excite students]. And if we should neglect the space program, we are going to see fewer and fewer students go into math and science, and we are going to pay the price for that, maybe not next year, but in the decades ahead.*"

He proved to be prophetic. Student assessment scores in science and mathematics have not improved as desired over the past three decades (*Gonzales et al., 2000*). As a result of the low scores and a low interest in science and mathematics, there has been a shortage of qualified professionals in the engineering related fields that has reached crisis proportions (The President's Commission, 2002).



The members of the National Commission on Mathematics and Science Teaching (2000) warned: The goals and action strategies we suggest may be seen by some as too great a reach, by some as not bold enough. We are convinced, however, that if they are ignored, our children and our nation will soon pay the high price that always accompanies apathy.

In addition, at the 2003 National Space Education Workshop, Pelton, Johnson, and Flournoy (2004) reported that the attendees met and discussed the plight of science education in the U.S. in order to analyze and discuss new initiatives as well as glean suggestions from several entities involved in science education in the United States.

Notable participants included the (a) Air Force Institute of Technology, (b) American Institute of Aeronautics and Astronautics, (c) General Dynamics, (d) Massachusetts Institute of Technology, (e) National Space Society, (f) Office of Management and Budget, (g) The White House, and (h) the Space Foundation.

Their conclusions were based on the concerns addressed at the workshop, and they aligned with President Bush's new space initiative. Among the concerns, the attendees recognized the failure of public education in the U.S. to provide students the necessary knowledge to be successful in science and technology.

They also noted the lack of quality and appeal of science and technology instruction in public schools. This problem has resulted in a breakdown in the intellectual and industrial capacity of the U.S. which is a threat to national security and capability to continue as a world leader. This problem has turned students away from choosing careers in science.

They concluded that teachers needed to be trained better to incorporate space into their curriculum to make science more attractive to students. To that end, the Space Foundation embarked on a journey to create Space Across the Curriculum teacher professional development courses that infused space into the curriculum to create excitement in students' learning. While thousands of teachers have been trained and tens of thousands of students have been impacted, it is just a drop in the bucket of the overall problem. Teacher training alone isn't the solution.

What about engaging student programs? There have been amazing student programs that have sprung up around the country over the last couple of decades.

However, in an Aviation Week survey from 2013 which gathered information from aerospace companies, 9.6 percent of employees in aerospace and defense were eligible for retirement. That number was projected to increase to 18.5 percent in 2017.

The problem is that those companies will be unable to fill those openings with qualified talent. Twenty-two percent of respondents to the Aviation Week survey said that the shortage of scientists and design engineers was the most significant factor affecting their organization's ability to expand operations or deliver to customers, and 35 percent said that a highly skilled workforce will be the most important element to their organization's success over the next three to five years. Engaging student programs isn't enough. Student programs and teacher training haven't solved the problem.

So, *what is the solution*?

At the Space Foundation, we feel that it is going to take more than just engaging programs for students and teacher professional development to start making a difference. What is the missing factor?

The key factor that has been overlooked is a community that understands the importance of STEM education and that strongly supports STEM education in its schools. A community must understand the critical role that space plays in their daily lives. Only then, will we make an impact. Only then, will we start to make a difference.

How do we start making that difference? At the local level we must:

- *Develop a PreK-20 STEM pipeline*
- *Grow an organic work force*
- *Strengthen economic development*

First, we need to start developing a PreK-20 STEM pipeline in communities through engaging programs and activities for students. When that pipeline is established, we will be able to start growing an organic workforce which is educated locally and stays in that community. When that organic workforce has taken root, the economic development of a community will start to strengthen. When that happens, communities will begin to support STEM education programs in their schools.

The Space Foundation has, this past year, created a program that is the instigator of this change. Called ***Space in the Community***, SITC for short, we have combined 25 years of Space Foundation education programs into one encompassing outreach program. In following the Space Foundation's mission—to advance space-related endeavors to inspire, enable, and propel humanity—this is what SITC looks like:

- *Inspire students through Audience with an Astronaut™ school assemblies and hands-on activities*
- *Enable teachers through Space Across the Curriculum professional development*
- *Propel communities through events that are designed to educate them on the importance of space and supporting STEM programs*

In addition, an enduring relationship is created between the Space Foundation and the target community through our International Teacher Liaison program. Through this program, educators have access to other master teachers from around the world that are also passionate about STEM. They will be able to share ideas with each other, as well as, get curriculum support from Space Foundation education specialists.

During our first SITC programs held in Erie and Colorado Springs, Colorado, we reached more than 7,000 students, teachers and community members. In Tulsa, Oklahoma, we impacted more than 7,000 students, teachers and community members.

During these two events we noticed excited students and teachers as well as community members who finally saw the light. Here is how the sponsor, Tulsa Flight Night, of our Tulsa Space in the Community explained the importance of our program there:

"Kids can't be what they can't see, so the Space Foundation's Space in the Community program allows them to see a NASA astronaut, firsthand! This program makes it easy to create enthusiasm for space exploration, with assemblies and hands-on activities for area elementary, middle- and high-school students," said Bailey Siegfried, Vice President Global Marketing, NORDAM. "The astronaut and Space Foundation educators work together to provide ready-to-launch educational materials, promotional content and more. We have found Space in the Community to be great help as we strive to develop a STEM-literate local workforce for the future."

Only when we combine programs for students, teacher professional development, and events and programs that foster community involvement and support, will we see an impact and pull ourselves out of this dark place.

For more information on how you can bring the Space Foundation's Space in the Community program to your community, please contact Bryan DeBates, Vice President-Education, ***BDeBates@SpaceFoundation.org***.

www.spacefoundation.org

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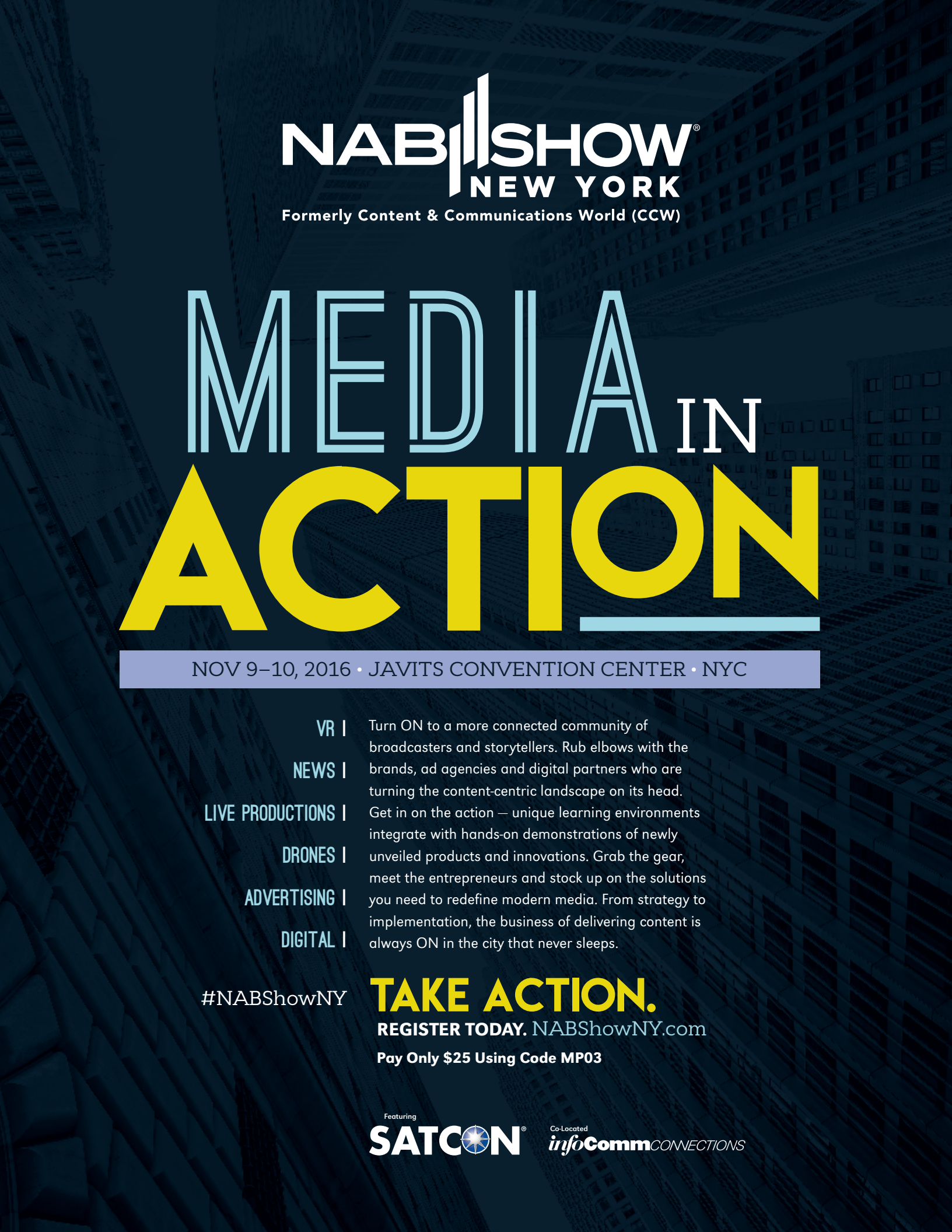
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