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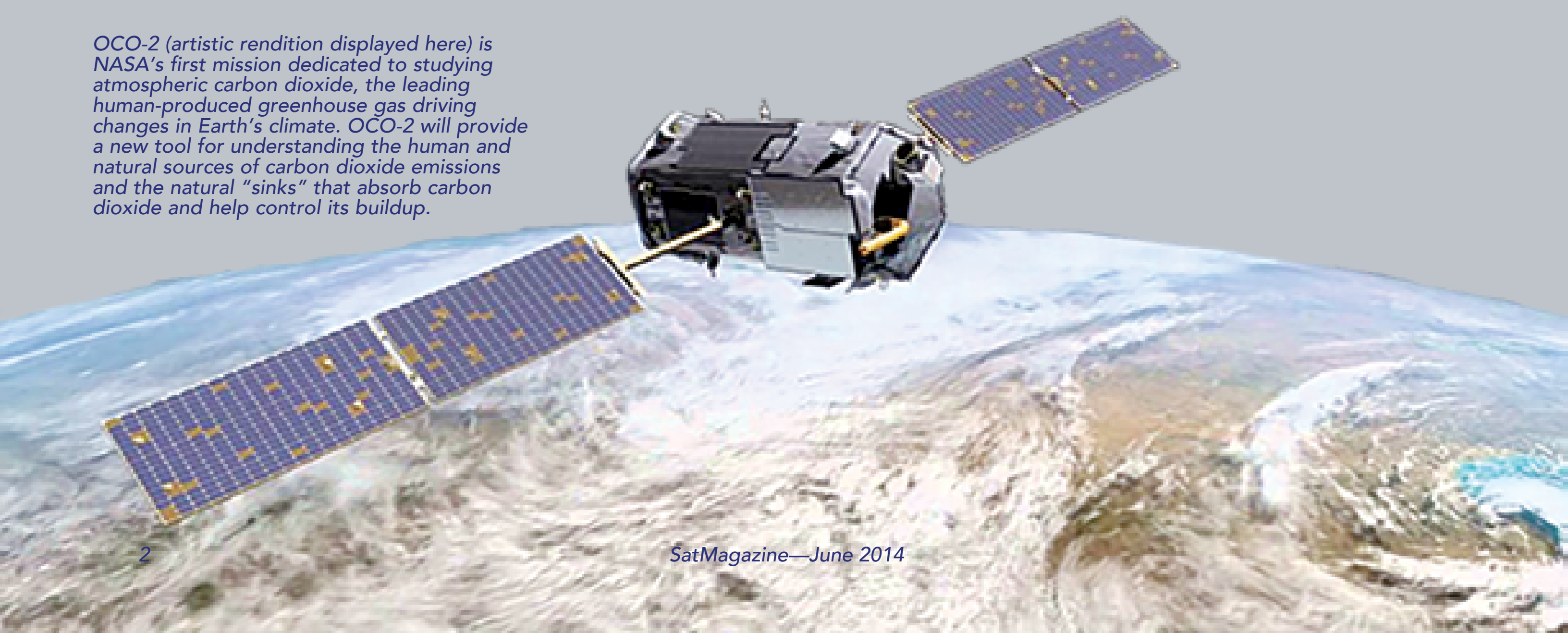

OCO-2 (artistic rendition displayed here) is NASA's first mission dedicated to studying atmospheric carbon dioxide, the leading human-produced greenhouse gas driving changes in Earth's climate. OCO-2 will provide a new tool for understanding the human and natural sources of carbon dioxide emissions and the natural "sinks" that absorb carbon dioxide and help control its buildup.

Features

Launch-O-Rama

The Soyuz-2.1b lifts off on July 8, 2014.

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Launch-O-Rama: A Flight Of Four (O3b Networks)

O3b Network's additional four satellites for their constellation were successfully launched from the European Space Center in French Guiana. Arianespace launched the satellites into a circular orbit at an altitude of 8062km.

These satellites are the latest addition to the company's Medium Earth Orbit (MEO) constellation, which aims to increase broadband connectivity to the underserved populations around the world.

O3b Networks Limited is a global satellite service provider that continues to build a nexgen satellite network for telecommunications operators, Internet service providers, enterprise and government customers in emerging markets. The O3b system will combine the global reach of satellite with the speed of a fiber-optic network providing billions of consumers and businesses in nearly 180 countries around the world, with low-cost, high-speed, low latency Internet and mobile connectivity.

O3b Networks' investors include SES, Google, Liberty Global, HSBC Principal Investments, Northbridge Venture Partners, Allen & Company, Development Bank of Southern Africa, Sofina, Satya Capital and Luxempart. O3b Networks is headquartered in St. Helier, Jersey, Channel Islands.

O3b, a reference to the "Other 3 billion" people on Earth who do not have broadband access, will complete its initial constellation with this launch, heralding the introduction of O3b's services on a global basis.

The second Arianespace Soyuz mission for O3b Networks deployed four spacecraft to complete this customer's basic satellite network. Photo is courtesy of Arianespace.

The company, founded in 2007, is already providing services following the launch of its first four satellites in 2013—the O3b system combines the global reach of satellite with the speed of a fiber-optic network, removing the impact that satellite delay has traditionally had on the quality of satellite connections.

Steve Collar, the CEO of O3b said, “When we first envisioned delivering high-speed connections to the underserved populations around the world over a state-of-the-art satellite network, we knew this was a project that could dramatically improve people’s lives. The response that we have had from our customers so far has been emphatic. They tell us that what we are bringing to the market is game-changing and this launch will enable us to provide that same game-changing service globally.”

The launch success—which had a total payload lift performance of more than 3,200kg.—continues the partnership between Arianespace and O3b Networks and builds upon the on-target Soyuz mission that orbited O3b’s initial four spacecraft in June 2013.

Soyuz is the medium-lift member of Arianespace’s launcher family operated from French Guiana, joined by the heavy-lift Ariane 5 and lightweight Vega. This recent mission delivered O3b Networks’ satellites during a flight lasting 2 hours and 22 minutes—which included multiple burns of the Fregat upper stage, with the four passengers released in two phases from a dispenser system.

The latest O3b Networks connectivity satellites are equipped with Ka-band transponders. Along with the four spacecraft launched last year, they form the network framework to provide billions of consumers and businesses in nearly 180 countries with low-cost, high-speed, low-latency Internet and mobile connectivity. The O3b spacecraft were designed, integrated and tested by Thales Alenia Space.

With the presence of top officials in the mission control center for this latest launch, Stephan Israël also reaffirmed Arianespace’s commitment to continue delivering tailor-made launch solutions with O3b’s specific requirements.

Speaking after the satellites’ separation was confirmed, O3b Networks CEO Steve Collar thanked all those involved with the mission success—and gave a special acknowledgement to the Arianespace and Thales Alenia Space leadership in attendance. “The relationship that we have is a unique one— it’s one of partnership, one of cooperation, one of openness and one of friendship,” he added.

With the Soyuz, Ariane 5 and Vega launchers fully operational at the Spaceport in French Guiana, Arianespace is the only launch services company capable of delivering any payload into any orbit—from the smallest spacecraft to the largest geostationary satellites, as well as satellite clusters for constellations and cargo missions to the International Space Station.

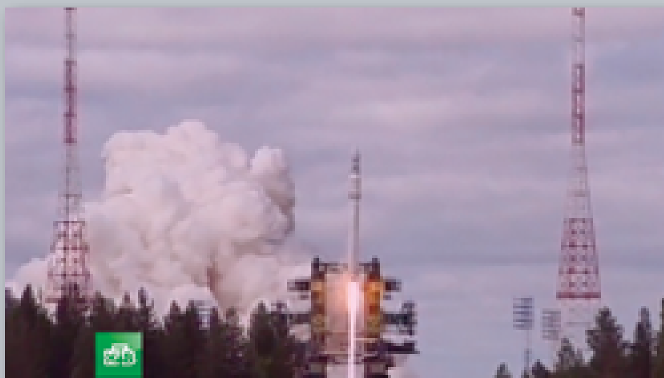
This Soyuz success marked the medium-lift vehicle’s eighth flight from the Spaceport since its 2011 introduction at French Guiana, as well as the fifth Arianespace mission from this equatorial launch site in 2014—for which a total of 12 flights are planned with Soyuz, Ariane 5 and Vega during the year.

The O3b Networks infosite is located at ***http://www.o3bnetworks.com/***
The Arianespace infosite is located at ***http://www.arianespace.com/***
The Thales Alenia infosite is located at ***http://www.thalesaleniaspace.com***

Launch photo is courtesy of Arianespace.

Launch-O-Rama: Delivering A Dummy

The Angara-1.2ML (Maiden Launch) integrated launch vehicle (ILV) was successfully launched by the Russian Ministry of Defense from the State Testing Cosmodrome (Plesetsk Cosmodrome) in the Archangelsk Region of Northern Russia on July 9, 2014.



The light-lift Angara-1.2ML with a mock payload on board lifted off from the Angara multi-purpose launch pad and delivered a dummy satellite to the designated landing site at the Kura range in the far eastern Kamchatka Peninsula, 5,700km away from the launch pad.

The ILV mission proceeded over the Russian territory along a ballistic trajectory in accordance with the planned timeline. Following the liftoff and the subsequent separation of Stage 1, the payload fairing was jettisoned during the Stage 2 powered flight. Stage 1 and the fairing were released into a planned targeted area in the southern part of the Barents Sea. After 21 minutes and 28 seconds, Stage 2 and the firmly attached mass/dimensional payload simulator reached the planned targeted area.

Building the Angara launch system is a task of particular national importance. When the Angara launch system becomes operational, Russia will be in a position to launch all types of satellites from its own territory, gaining guaranteed independent access to outer space.

The Angara-1.2ML ILV comprises two stages that are based on Common Core Boosters (URM-1 and URM-2), a payload mockup with a mass of 1.43MT, and a payload fairing. The propulsion system runs on ecologically clean components of oxygen and kerosene. The lift off mass of Angara-1.2ML ILV is approximately 171 Metric Tons. The Angara Launch Vehicle family includes a range of light-, medium-, and heavy-lift launch vehicles based on generic modules. The Angara family will have the capacity to launch virtually the entire range of would-be payloads to orbits of the entire range of altitudes and inclinations including geostationary orbits, affording true independence to domestic space programs.

To see the video of the Angara 1.2 ML launch, please go to **http://www.ntv.ru/novosti/1117456/**

Launch-O-Rama: TechDemoSat-1 On Orbit

Surrey Satellite Technology Ltd (SSTL) has successfully launched their TechDemoSat-1, an in-orbit technology demonstration mission designed and implemented for innovative UK spacecraft equipment and software.

Liftoff of TechDemoSat-1 aboard a Soyuz-2 launch vehicle. Photo is courtesy of SSTL.

The spacecraft was launched into 635km sun-synchronous orbit on board a Soyuz-2 launch vehicle with a Fregat upper stage from the Baikonur Cosmodrome in Kazakhstan at 15:58:28 UTC on July 8th, 2014. Following confirmation of separation from the launch vehicle, the ground station at the Satellite Applications Catapult Operations Centre at Harwell established contact with TechDemoSat-1 on its first pass and commissioning of the platform was initiated, undertaken by the Operations team from SSTL. TechDemoSat-1 is the first satellite to be operated from the company's new facility at Harwell.

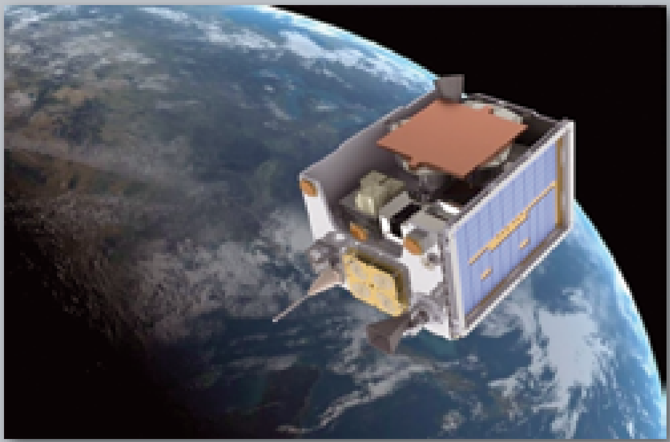
The TechDemoSat-1 satellite being lifted by crane toward the Fregat upper stage. Photo courtesy of SSTL.

TechDemoSat-1 being integrated onto the Fregat upper stage along with all of the additional satellites on this launch. Photo is courtesy of SSTL.

TechDemoSat-1 is based on the SSTL-150 platform and is part-funded by a grant from the UK's Technology Strategy Board, and SEEDA (South East England Development Agency). The spacecraft carries eight separate payloads from UK academia and industry, providing valuable in-orbit validation for new technologies. The payloads flying on TechDemoSat-1 are:

- *MuREM, a flexible miniature radiation and effects monitor from Surrey Space Centre*
- *ChaPS, a prototype compact instrument to detect electrons and ions from the Mullard Space Science Laboratory*
- *HMRM, a lightweight, ultra-compact radiation monitor designed to measure total radiation dose, particle flux rate and identify electrons, protons and ions from Rutherford Appleton Laboratory and Imperial College*
- *LUCID, a device to measure characterization of the energy, type, intensity and directionality of high energy particles from the Langton Star Centre*
- *Compact Modular Sounder system, a modular infrared remote sensing radiometer unit from Oxford University's Planetary Group and Rutherford Appleton Laboratory*
- *De-orbit sail from Cranfield University*
- *Cubesat ADCS, a 3-axes attitude determination and control subsystem from SSBV*
- *Sea State Payload, a device using an enhanced GPS receiver from SSTL and components from a Synthetic Aperture Radar from Airbus Defence and Space to monitor reflected signals to determine ocean roughness*

Commissioning of the payloads on board the satellite will be performed by SSTL via its own Mission Control Centre in Guildford, before handing over day-to-day operation of the payloads back to the Catapult. SSTL will continue to manage spacecraft level monitoring and operations for TechDemoSat-1 in Guildford.



Artistic rendition of TechDemoSat-1 on orbit over Earth. Image courtesy of SSTL.

Universities and Science Minister David Willetts said, "The successful launch of TechDemoSat-1 has given UK space companies a unique opportunity to test their cutting-edge technologies in orbit. These innovators can now show investors and potential customers how their products perform in the harsh environment of space. TechDemoSat-1 is also the first satellite to be controlled by the Satellite Applications Catapult. This was established by the Government to harness the success of the UK space sector and its world-leading companies like SSTL."

Luis Gomes, Director of Earth Exploration and Science at SSTL, said, "The successful launch of the TechDemoSat-1 satellite marks the end of an exciting spacecraft build challenge for SSTL, with no less than eight payloads and more than 25 of our own engineering developments on-board. We can now look forward to the mission phase, where data is returned from the satellite in orbit and we, alongside our payload providers, can prove new concepts in space."

Iain Gray, Chief Executive of the Technology Strategy Board, said, "The TechDemoSat-1 project is an excellent example of how our space program is supporting business innovation in new applications using satellite data and space-based systems. This significant project is the first in-orbit satellite project directly funded by the Technology Strategy Board. It allows us to provide UK businesses with an in orbit demonstration platform to test several new satellite-based products and services - a fantastic way to support innovation in the space sector and help businesses take advantage of the growing space market."

The SSTL infosite may be reached at http://www.sstl.co.uk/

Launch-O-Rama: Student Developed LUCIDity Aboard TechDemoSat-1

A cosmic ray detector designed by sixth form students from the UK blasted off into orbit overnight aboard Surrey Satellite Technology Ltd.'s TechDemoSat-1.

Surrey Satellite Technology's TechDemoSat-1.

Hundreds of schools across the United Kingdom will play a hands-on role analyzing vital 'space weather' data sent back to Earth by TechDemoSat-1, a UK-built satellite that started its journey into space overnight. TechDemoSat-1 is equipped with LUCID (Langton Ultimate Cosmic Ray Intensity Detector), a student-designed instrument which will collect information about the types, intensity and direction of cosmic rays that bombard satellites stationed around 635km above Earth, data crucial to ensuring that telecoms and other low-orbit satellites can withstand such radiation and function effectively.

Funded by the Science and Technology Facilities Council (STFC) the data from the project will be posted on the CERN@school (http://thelangtonstarcentre.org/) website where students across the country will be able to access it, scrutinize it and input their findings. These findings will then be made available to space experts around the world. Over 200 UK schools are expected to take up this unique opportunity to play a key part in serious science of global importance.

LUCID is the brainchild of sixth-form students at Simon Langton Grammar School in Canterbury, Kent and has taken seven years to go from original concept to final lift-off. Pupils at the schools taking part in the project will be able to help sift the enormous volume of data produced by LUCID and pinpoint key features, trends and patterns. The aim is to fire them with enthusiasm for science and provide them with a launch pad for future careers in physics, engineering and other disciplines. The project is part of the CERN@school initiative. Supported by STFC and hosted at the Langton, CERN@school aims to assist the teaching of particle physics in the classroom by giving students the opportunity to analyze data from ground-based and space-based detectors.

The data obtained from LUCID is of interest to the Space Weather community and NASA.

Photo courtesy of Langton Space Center.

STFC is also involved in other aspects of the TechDemoSat-1 mission including:

- *Co-funding with the UK Space Agency on the establishment and operation of the UKube-1 ground segment. (planning and commanding) for the complex payload on UKube-1, and the running of the Ground Station at STFC's Chilbolton Observatory which is now communicating with the satellite*
- *STFC also sponsored an extended knowledge transfer partnership over 4 years between the University of Strathclyde and Clyde Space Ltd. for the development of the UKube-1 platform for all of the instruments*

STFC RAL Space provided a novel electronics module to control the Compact Modular Sounder (CMS) instrument in a joint build with researchers from Oxford University.

The CMS uses infrared technology to create thermal maps of the surface of a Near Earth Asteroid. This will tell us about the rockiness of its surface, for example, where is a good place to land a robotic spacecraft, and how heating from the Sun and cooling in space can 'push' the asteroid around changing its orbit. While orbiting Earth, the mission will also take the opportunity to map surface temperature, including oceans, and the temperature structure of the atmosphere, with the view to compare this data with that from other Earth-observing instruments.

Professor Richard Holdaway, STFC's Director of RAL Space, said, "If the UK is to compete successfully in the global economy, we need a new generation of bright, motivated young scientists to step forward and keep driving research and industry to new heights. Participating in a real-life space mission with clear, comprehensible benefits is the perfect way of highlighting to young people the value, fascination and sense of achievement that a career in science and technology can

13m Ku-Band Antenna in Rio de Janeiro, Brazil.
Picture - V. Ruta

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The LUCID team with Professor Larry Pinsky, NASA dosimetry expert, Dr. Tom Whyntie from the STFC, and SSTL's David Cooke and Sahand Ghanoun

deliver." Langton pupils came up with the idea for the LUCID detector following a trip in 2007 to CERN (the European Organization for Nuclear Research, home of the Large Hadron Collider). Having seen Timepix microchips developed there for particle physics, medical and other uses, they had a real 'eureka!' moment—realizing that the chips might be adapted to analyze charged particles in the 'solar wind' that streams from the Sun and sometimes disrupts satellite operations.

After entering the idea into a competition run by Surrey Satellite Technology Limited (SSTL) and the UK Space Agency, they worked with SSTL to develop it further with additional input from scientists worldwide. SSTL subsequently selected LUCID for inclusion as a payload on its TechDemoSat-1 satellite. Developed and built with support from the Technology Strategy Board and the South East England Development Agency (SEEDA), the satellite is providing low-cost flight opportunities for innovative commercial and research payloads developed by the UK space sector.

The launch of TechDemoSat-1 took place at Baikonur Cosmodrome in Kazakhstan, using a Russian Soyuz-2 rocket. LUCID will now undergo a month of in-flight testing prior to producing 'live' data over the course of a mission expected to last three years—a perfect illustration of how technology devised for the world's largest science experiments at CERN can be adapted to meet a range of real-world needs beyond the realm of particle physics.

Dr. Jonathan Eastwood, Lecturer in Space and Atmospheric Physics at Imperial College and an STFC Advanced Fellow, said, "LUCID isn't just an educational experiment. Its research-quality data will be of direct interest to the wider science community, allowing students to engage in real research, studying the basic physics of how space weather works."

The original six people in the LUCID team are now all doing research or working having finished their degrees. The current LUCID leader Matt Harrison said, "We are organized to process the data when it comes down to school. We have two full days of data collection in an eight day cycle, so we should see a huge number of frames where particles are detected by LUCID. We will be excited to be analyzing results and sharing this new data with the Space Weather community and with NASA."

At the Surrey Satellite Technology Ltd. (SSTL) blog, the company presented a conversation they had with LUCID's project manager and Year 12 student, Matt Harrison, and the school.

SSTL asked Matt, *what will LUCID enable us to do*?

Harrison answered, "Traditional particle detectors (such as Geiger counters) just click when they detect radiation. Using Timepix silicon pixel detectors, LUCID is able to act a bit like a digital camera in that it lets us take a three-dimensional picture of the particles passing through it at any one time. This will allow us to have a very detailed look at the Low Earth Orbit (LEO) environment; to an extent we believe no one has done before.

We also intend to investigate phenomena such as the South Atlantic Anomaly (a region in space where the Van-Allen Belts bend inwards), which is infamous for causing damage to satellites, look at the composition of Coronal Mass Ejections (CMEs) and cosmic rays and perhaps even determine the source of extra-galactic cosmic rays."

SSTL: *Where did the idea for LUCID come from?*

"Our students decided to enter a competition, the brainchild of SSTL's Dr. Stuart Eves, to get an experiment sent into space. On a trip to CERN, students visited the laboratories of the Medipix collaboration and it occurred to them that the Timepix detector chips that they had seen there could measure cosmic radiation in a very precise way.

Medipix were very happy for us to enter an experiment based on their technology because—surprisingly—the Timepix detectors had not yet been considered for use in space. Unfortunately, as the equipment was not space qualified, the projected costs came in above the budget limits of the competition. As a result, we didn't win—but we were told that if we could raise a further £60,000 in funding we could still fly. Thanks to the tremendous efforts of Dr. Becky Parker, Director of the Langton Star Centre, we quickly raised this money and SSTL agreed that we could go ahead with making LUCID a reality."

SSTL: *What have the pupils at Simon Langton Grammar School (and other UK schools) been working on?*

"Currently the students are gearing up to receive and analyze data from the LUCID payload: running particle simulations on software packages produced by CERN, reading up on the LEO environment, and writing the software to process and interpret the LUCID data.

The LUCID experiment is part of a wider project called CERN@school, a program that aims to bring the excitement of CERN into the classroom, and encourage the future generation of scientists. CERN@school covers the effort to get individual Timepix chips into schools for educational and research purposes. We've started a number of different activities, the most recent of which is Radiation Around You (RAY)—a project to build up a radiation map of South East England. We're into the final of the Rolls-Royce Science Prize with the RAY pilot program, so watch this space!"

SSTL: *Would the project have been possible without TechDemoSat-1?*

"Absolutely not! TechDemoSat-1 is perfect for testing out the LUCID experiment. While NASA recently put a few Timepix chips on the International Space Station, they have never been in open space and so we'll all be very interested to see what we can measure. It will also be immensely useful to collaborate with the other cosmic ray payloads on TechDemoSat-1 to independently verify each other's measurements—something that runs at the heart of good scientific practice. We're incredibly grateful to SSTL, for providing this fantastic opportunity for school students around the country to get the first look at scientific data from a cutting-edge space-based particle physics experiment. We can't wait for the launch!"

Dr. Becky Parker, who leads the LUCID project for the school, said, "I'd like to thank Dr. Tom Whyntie, the STFC Researcher on the LUCID project, who is the key person responsible for getting the data in a format that can be accessible to other schools on the web, and David Cooke of SSTL has been a truly phenomenal engineer on LUCID—he has worked so very hard to make LUCID work and be brilliant—it is his triumph as much as ours."

The dedicated LUCID infosite is accessible via ***http://www.thelangtonstarcentre.org/lucid/***

Launch-O-Rama: NASA's OCO-2

A United Launch Alliance Delta II 7320-10 launch vehicle delivered the Orbiting Carbon Observatory (OCO-2) satellite to a 370-nmi (686km) near-circular orbit on July 2, 2014. Liftoff occurred from Space Launch Complex 2W at Vandenberg Air Force Base, California.

OCO-2 is NASA's first spacecraft dedicated to studying atmospheric carbon dioxide (CO_2), the most significant human-produced greenhouse gas and the principal, human-produced driver of climate change.

OCO-2 will collect space-based global measurements of atmospheric CO_2 with the precision, resolution, and coverage needed to provide the first complete picture of the regional-scale geographic distribution and seasonal variations of human and natural sources of carbon dioxide emissions and their sinks—the reservoirs that pull carbon dioxide out of the atmosphere and store it.

The OCO-2 mission provides a key new measurement that can be combined with other ground and aircraft measurements and satellite data to answer important questions about the processes that regulate atmospheric CO2 and its role in the carbon cycle and climate.

The Orbiting Carbon Observatory is managed by NASA's Jet Propulsion Laboratory (JPL), Pasadena, California, for NASA's Science Mission Directorate, Washington, D.C.

Orbital Sciences Corporation, Dulles, Virginia, built the spacecraft and provides mission operations under JPL leadership.

NASA's Launch Services Program at NASA's Kennedy Space Center in Florida is responsible for launch management.

The Launch Vehicle

Payload Fairing (PLF)
The PLF is a composite bisector (two-piece shell), 10 feet in diameter fairing. The PLF encapsulates the spacecraft to protect it from the launch environment on ascent. The vehicle's height, with the 10 feet PLF, is approximately 128 feet.

Delta II Second Stage
The Delta II Second Stage propellant tanks are constructed of corrosion-resistant stainless steel. The Delta II second stage is a hypergolic- (Aerozine 50 and Nitrogen Tetroxide) fueled vehicle. It uses a single AJ10-118K engine producing 9,850 pounds of thrust. The propellant tanks are insulated with Dacron/Mylar blankets.

The second stage's miniskirt/guidance section provides the load path for the payload to the booster as well as the structural support for the second–stage propellant tanks, the PLF, mountings for vehicle electronics, and the structural and electronic interfaces with the spacecraft. The second-stage, other than the mini-skirt, is nested inside the interstage adapter.

Booster
The Delta II booster is eight feet in diameter and approximately 87 feet in length. The booster's fuel and oxidizer tanks are structurally rigid and constructed of stiffened isogrid aluminum barrels and spun-formed aluminum domes. The booster structure is completed by the centerbody that joins the fuel and oxidizer tanks and the LO2 skirt, which joins the tank structure to the engine section.


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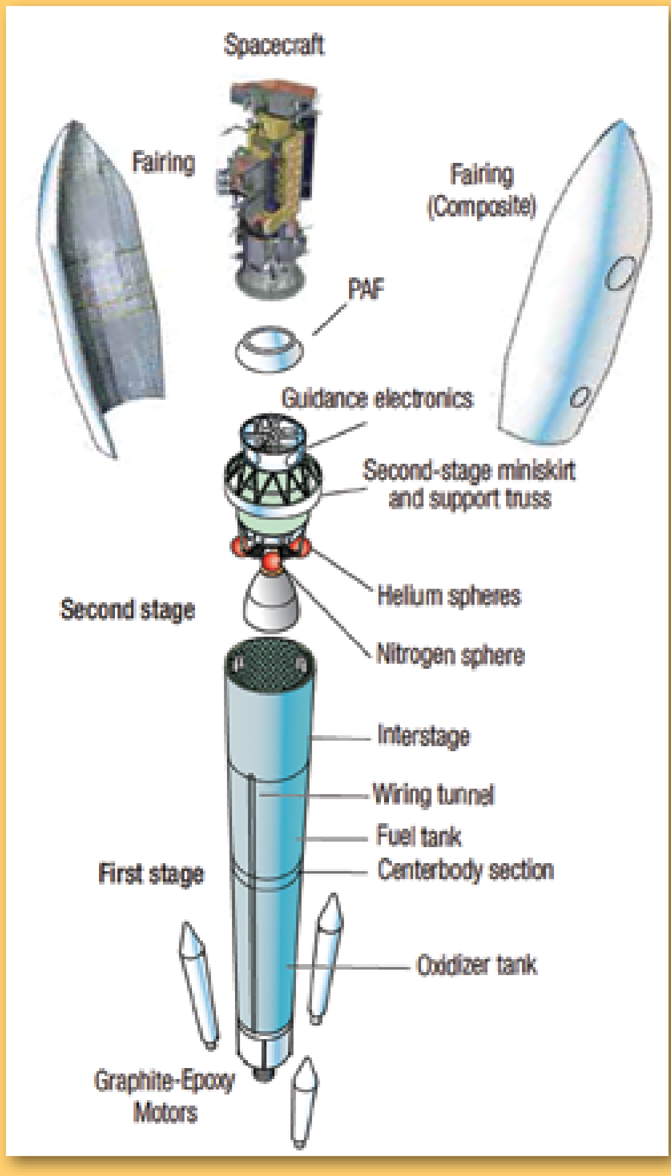


Delta II booster propulsion is provided by the RS-27A engine. The RS-27A burns RP-1 (Rocket Propellant-1 or highly purified kerosene) and liquid oxygen, and delivers 200,000 pounds of thrust at sea level.

The Delta II booster is controlled by the second-stage avionics system, which provides guidance, flight control, and vehicle sequencing functions during the booster and second-stage phases of flight.

Solid Rocket Motors (SRM)
The Delta II 7320-10 launch vehicle uses three SRMs, approximately 40 inches in diameter and 42 feet in length. The SRMs are constructed of a graphite-epoxy composite with the throttle profile designed into the propellant grain. The SRMs are jettisoned by structural thrusters following a 63-second burn.

The Delta II is part of a launch vehicle family that first entered service in 1989 and has recorded well over 140 successful launches to date. The Delta II has also been selected to place a number of other Earth-orbiting satellites into orbit, including SMAP (Soil Moisture Active Passive) mission and ICESat-2.

Delta rockets have been carrying NASA spacecraft aloft since the 1960s. You can share the excitement that was at the live countdown via NASA TV or the web.

The Satellite

The Orbiting Carbon Observatory-2 (OCO-2) satellite is designed to make the first space-based measurements of atmospheric carbon dioxide (CO_2).

Looking at the satellite's history, the initial Orbiting Carbon Observatory (OCO) was a NASA Earth System Science Pathfinder Project (ESSP) mission designed to make precise, time-dependent global measurements of atmospheric CO_2 from an Earth orbiting satellite. Unfortunately, on February 24, 2009, due to a launch vehicle payload fairing anomaly, OCO failed to reach

orbit. However, in December of 2009, the Congressional Conference committee directed NASA to allocate no less than $50M for the 2010 fiscal year (FY10) for the initial costs associated with an OCO replacement. Released on February 1st, 2010, the President's Budget provided adequate funding to support the launch of an OCO re-flight mission (now known as OCO-2).

The OCO-2 mission underwent critical design review (CDR) in August 2010 and key design point-C (KDP-C) in September 2010. On October 2010, it began the implementation phase.

On July 16, 2012, NASA announced that it had awarded launch services contracts for three United Launch Alliance Delta 2 rockets. A little over five years after the OCO launch failure, OCO-2 manifest stated the launch, from Vandenberg Air Force Base would take place No Earlier Than (NET) Tuesday, July 1, 2014, which was successful. Originally flown on a Taurus XL, OCO-2 is now flying on a Boeing Delta II 7320-10C. The Delta II is one of the most successful launch vehicles ever flown with well over 100 successful launches.

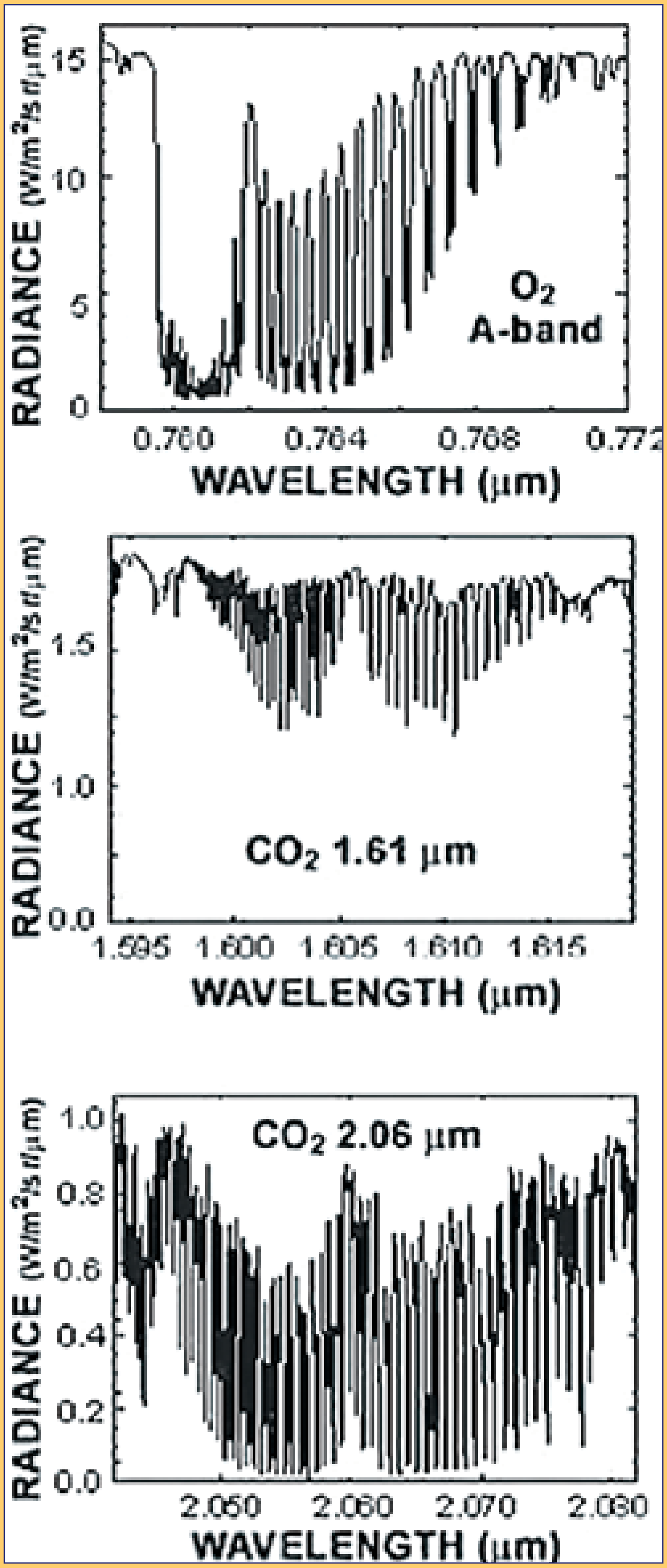
The Mission

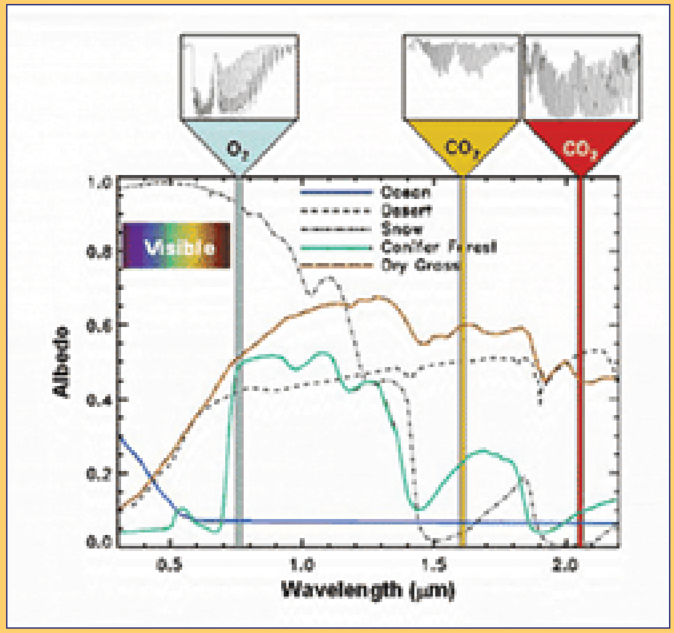
OCO-2 was built based on the original Orbiting Carbon Observatory mission to minimize cost, schedule and performance impacts. OCO-2 is designed to have a nominal mission time frame of at least two years, but the spacecraft could continue to fly well beyond its prime mission. OCO-2's primary science objective is still to substantially increase the understanding of how carbon dioxide sources and sinks are geographically distributed on regional scales and how their efficiency changes over time.

OCO-2 will not be measuring CO_2 directly; but actually, the intensity of the sunlight reflected from the presence of CO_2 in a column of air. This measurement is unique like a fingerprint, and can be used for identification. The OCO-2 instrument will use a diffraction grating (like the back of a compact disk) to separate the incoming sunlight into a spectrum of multiple component colors.

The instrument measures the intensity of three relatively small wavelength bands (Weak CO_2, Strong CO_2 and Oxygen O_2) from the spectrum, each specific to one of the three spectrometers. The absorption levels will indicate the presence of the different gases. By simultaneously measuring the gases over the same location and over time, OCO-2 will be able to track the changes over the surface over time.

The OCO-2 spectrometers will measure sunlight reflected off the Earth's surface. The sunlight's rays entering the spectrometers will pass through the atmosphere twice—once as they travel from the Sun to the Earth, and then again as they bounce off from the Earth's surface to the OCO-2 instrument. Carbon dioxide and molecular oxygen molecules in the atmosphere absorb light energy at very specific colors, or wavelengths.





This diagram displays the spectral reflectance of common Earth surfaces at the wavelength of the three OCO-2 channels.

The OCO-2 instrument uses diffraction grating to separate the inbound light energy into a spectrum of multiple component colors. The reflection gratings used in the OCO-2 spectrometers will consist of a very regularly-spaced series of grooves that lie on a very flat surface.

The characteristic spectral pattern for CO_2 can alternate from transparent to opaque over very small variations in wavelength. The OCO-2 instrument must be able to detect these dramatic changes, and specify the wavelengths where these variations take place. So, the grooves in the instrument diffraction grating will be very finely tuned to spread the light spectrum into a large number of very narrow wavelength bands or colors. In fact, the OCO-2 instrument design incorporates 17,500 different colors, to cover the entire wavelength range that can be seen by the human eye. A digital camera covers the same wavelength range using just three colors.

OCO-2 measurements must be very accurate. To eliminate energy from other sources that would generate measurement errors, the light detectors for each camera must remain very cold. To ensure that the detectors remain sufficiently cold, the OCO-2 instrument design will include a cryocooler, which is a refrigeration device. The cryocooler keeps the detector temperature at or near -120 degrees C (-184 degrees F).

The principal science objective of the OCO-2 mission is to retrieve a global geographic distribution of CO_2 sources and sinks. The OCO-2 mission will not, however, directly measure CO_2 sources and sinks. Instead, sophisticated computer-based data assimilation models that use column averaged dry air CO_2 mole fraction (Xco_2) data will infer the location of these sources and sinks.

To obtain the representative values of Xco_2, or the amount of CO_2 in the measured space, the OCO-2 instrument will measure at a given location, the intensity of reflected sunlight off the Earth's surface at specific wavelengths. Gas molecules in the atmosphere absorb the sunlight at specific wavelengths. So when light passes through the Earth's atmosphere, the gases that are present leave a distinguishing fingerprint that can be captured.

The OCO-2 spectrometers, working like cameras, will detect these molecular fingerprints. Then the absorption levels shown in these spectra, like a captured image, will tell us how many molecules were in the region where the instrument measured. The OCO-2 measurement approach will concentrate on gathering data near the Earth's surface, where almost all of the CO_2 sources and sinks are located.

One of the challenges to get to these sources and sinks, is that the light detected by the instrument must penetrate through all of the atmosphere. If you can picture the image of Earth from Space, that image will always include white swirls over the land and ocean. The presence of clouds and optically thick aerosols or uneven terrain such as mountains can block the light, and create an incomplete measurement of the complete atmospheric column. To reduce any uncertainties, the OCO-2 instrument will acquire a large number of densely-spaced samples.
Each sample will cover an area of about 3 km^2 when the instrument is looking straight down (nadir), along the spacecraft's ground track. The OCO-2 instrument can gather as many as 72,000 soundings on the sunlit side of any orbit. With measurement footprints of this size and density, the OCO-2 instrument will get an adequate number of high quality soundings, even in those regions where clouds, aerosols and topographic variations are present.

OCO-2 mission designers selected three specific Near Infrared (NIR) wavelength bands, O_2 (Oxygen) A-band Weak CO_2, and Strong CO_2. The OCO-2 instrument will measure intensity over all three of these bands at the same location on the Earth's surface simultaneously. Each of the three selected wavelength bands provides specific information to measurement accuracy. The weak CO_2 band wavelength, in the vicinity of 1.61 μm, is most sensitive to the CO_2 concentration near the surface. Since other atmospheric gases do not absorb significant energy within this spectral range, the 1.61 μm band measurements are relatively clear and unambiguous.

To make sure that we have an accurate derivation of Xco_2, we also do a comparative absorption measurement of a second atmospheric gas, O_2. The concentration of molecular oxygen O_2 is constant,

well known, and uniformly distributed throughout the atmosphere. Therefore, O_2 is the best candidate for reference measurements. The O2 A-band wavelength channel, in the vicinity of 0.76 μm, will provide the required absorption spectra. The O2 A-band spectra indicate the presence of clouds and optically thick aerosols that preclude full column measurements of CO_2. Observations from this band will be used to infer the total atmospheric pressure, as well as to measure of solar light path length as it passes through the atmosphere.

Last, but not least, the strong CO_2 wavelength channel, in the vicinity of 2.06 μm, will provide a second and totally independent measure of the CO_2 abundance. The 2.06 μm band spectra are very sensitive to the presence of aerosols.

The ability to detect and mitigate aerosol presence enhances the accuracy of Xco_2. The 2.06 μm band measurements are also sensitive to variations in atmospheric pressure and humidity along the optical path. These variations in pressure and humidity have a known impact on Xco_2.

OCO-2 will fly in a polar, sun-synchronous orbit, providing global coverage with a 16-day repeat cycle. On each orbit, the Observatory path will cross the equator at approximately 1:35 p.m. local time. Acquisition at this time of day is ideal for spectroscopic observations of CO_2 that use reflected sunlight as the high sun maximizes the measurement signal-to-noise ratio. Furthermore, since Xco2 measurements tend to be near their daily average value at this time of day, the Observatory data will be highly representative of the region where they were acquired.

Coordination of the orbit with the A-train facilitates carbon cycle science by integrating OCO-2 observations with those of other instruments that fly aboard the Aqua (***http://aqua.nasa.gov/***) and Aura (***http://aura.gsfc.nasa.gov/index.html***) spacecraft. Among these measurements are the temperature, humidity, and CO_2 retrievals from Atmospheric Infrared Sounder (AIRS—***http://www-airs.jpl.nasa.gov/***), the cloud, aerosol and ocean color observations as well as carbon source and sink measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS—***http://modis.gsfc.nasa.gov/***), and the CH4 and CO retrievals from Tropospheric Emission Spectrometer (TES—***http://tes.jpl.nasa.gov/***).

To enhance the quality and to verify the validity of mission data, OCO-2 will collect science observations in Nadir, Glint, and Target Modes.

In Nadir Mode, the satellite points the instrument to the local nadir, so that data can be collected along the ground track just below the spacecraft. Science observations will be collected at all latitudes where the solar zenith angle is less than 85 degrees. Nadir Mode provides the highest spatial resolution on the surface and is expected to return more usable soundings in regions that are partially cloudy or have significant surface topography. Nadir observations may not provide adequate signal to noise over dark ocean surfaces.

In Glint Mode, the spacecraft points the instrument toward the bright "glint" spot, where solar radiation is specularly reflected from the surface. At high latitudes over the ocean, observations of the bright glint spot provide up to 100 times as much signal as measurements collected while looking straight downward at the ocean surface. Thus, the use of glint measurements significantly improves the signal to noise ratio over the dark ocean.

Glint soundings will be collected at all latitudes where the local solar zenith angle is less than 75 degrees. The OCO-2 mission plans to alternate between Nadir and Glint Modes over sequential 16-day global ground track repeat cycles so that the entire Earth is mapped in each mode on, roughly, monthly time scales.

In Target Mode, the Observatory will lock its view onto a specific surface location, and will retain that view while flying overhead. A target track pass can last for up to nine minutes. Over that time period, the Observatory can acquire as many as 12,960 samples at local zenith angles that vary between 0 degrees and 85 degrees.

The mission plans to conduct regular Target track passes over each of the OCO-2 calibration sites where the ground-based solar-looking Fourier Transform Spectrometers are located. Comparison of space-based and ground-based measures provides a means to identify and correct systematic and random errors in the OCO-2 Xco2 data products.

OCO-2 Specs

- ***Orbit**: 705 km/98.2 degrees Inclination*
- ***Power**: 521 W orbit average*
- ***Launch Mass**: 447 kg (985 lbs)*
- ***Solar Arrays**: 813 W EOL, single axis articulated arrays*
- ***Stabilization**: 3-axis, zero momentum, nadir and target pointing*
- ***Design life**: 24 months*

*Editor's note: Our thanks to United Launch Alliance (**www.ulalaunch.com**), Orbital Sciences Corporation (**http://www.orbital.com/**) and NASA's Jet Propulsion Laboratory (**http://www.jpl.nasa.gov/**) for their assistance, copy and the imagery used in this article.*

Launch-O-Rama: Flinging Six Into Orbit + Deeper Looks...

A Russian Soyuz-2.1b launch vehicle, coupled with a Fregat upper stage and carrying a Meteor-M meteorological satellite and additional secondary payload smallsats, was successfully launched on July 8th at 15:58 GMT from the Baikonur space center in Kazakhstan, according to Roscosmos.

The primary payload is the ***Meteor M2***, one of four Russian meteorological satellites the country hopes to orbit no later than 2015. In a sun synchronous orbit, at an altitude of 835 kilometers, this satellite has a life expectancy of five years.

Artistic rendition of Russia's Meteor M2 satellite.

A Russian Meteor-M No. 2 primary satellite and secondary payloads lift off on July 8, 2014, aboard a Soyuz-2.1b launch vehicle. Photo is courtesy of Roscosmos.

The 2,778-kilogram Meteor-M No. 2-1 satellite is designed to track global weather, the ozone layer as well as the ocean surface temperature and ice conditions to facilitate shipping in polar regions and to monitor radiation environment in the near-Earth space. The payload package onboard Meteor-M No. 2 includes:

- *Multi-channel imaging scanner, MSU-MR*
- *Multi-channel imaging complex, KMSS*
- *Ultra-high frequency temperature and humidity radiometer, MTVZA-GYa*
- *Infrared Fourier spectrometer, IKFS-2*
- *Radar complex, BRLK Severyanin*
- *Heliophysics instrument complex, GGAK-M*
- *Radio relay complex, BRK SSPD*

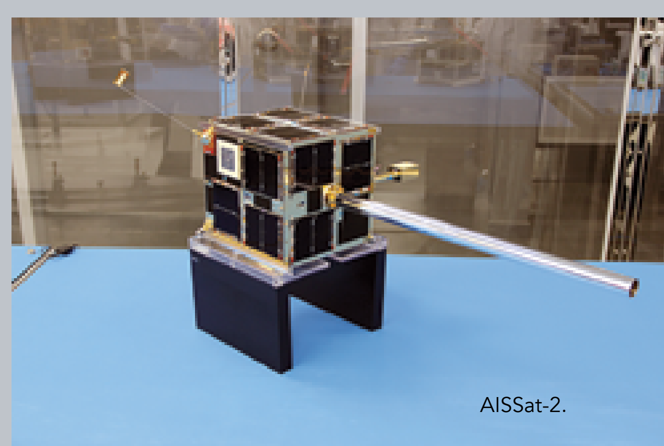
The satellite was designed to operate in orbit for five years. It will become the second spacecraft in the Meteor-3M network, complementing the Meteor-M No. 1 satellite, which was launched on Sept. 17, 2009. In addition, the Russian space program funds the development of the two similar Meteor-M No. 2-1 and 2-2 satellites, as well as the Meteor-M No. 3 satellite, which is custom-designed to carry a phased-array radar for high resolution observations of the ocean surface.

All spacecraft in the series were developed by the Moscow-based VNIIEM corporation based on its Resurs-UKP platform. At the start of 2014, the launch of the follow-on Meteor-M No. 2-1 satellite was scheduled for 2015.

The secondary payloads, in alphabetical order, are:

AISSat-2

The AISSat-2 satellite, funded by the Norwegian Space Centre with support from the Norwegian Defence Research Establishment, is



AISSat-2.

identical to *AISSat-1* and incorporates all the improvements made to AISSat-1 following its launch.

Given the great success of AISSat-1, the development of AISSat-2 implies that SFL's nanosatellite solution has become ideal for operational monitoring and tracking of ships in Norwegian territorial waters.

While AISSat-1 was intended to be a demonstration mission, the impact of its quick success and reliable performance was an almost immediate paradigm shift. Norway quickly promoted AISSat-1 to operational status and the nanosatellite approach was adopted for Norway's operational AIS constellation.

AISSat-2 will increase coverage, shorten revisit times, and provide natural redundancy for space-based AIS observation under direct control by Norway.

The Soyuz-12.1B rocket carried the satellite to orbit after lifting off at 15:58 UTC. After separating the primary payload, the Meteor-M #2 satellite, the Fregat upper stage maneuvered to a lower 643km altitude orbit and dropped off AISSat-2 along with other secondary payloads.

At approximately 19:26 UTC, the first pass over Norway's ground stations in Svalbard resulted in successful contact with AISSat-2, confirming that all systems were healthy.

Early data collection from the AIS receiver was also initiated and messages from ships were successfully received. Due to the past success of AISSat-1, commissioning of the AISSat-2 satellite is expected to proceed at an accelerated rate.

Alex Beattie, SFL's project manager for AISSat-2, was in Oslo for first contact with AISSat-2. Working together with the operations team at SFL in Toronto, the satellite is poised to become one of the most quickly commissioned satellites developed by SFL in recent history.

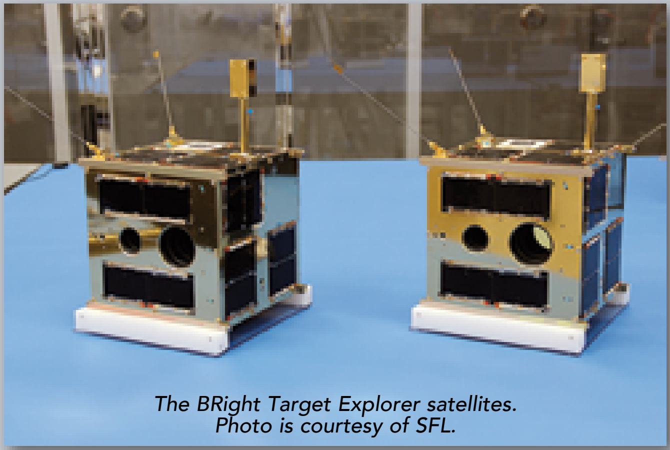
AISSat-2 is Norway's second satellite in orbit and represents a great accomplishment for the country and its people. The satellite will work in tandem with AISSat-1 to provide greater coverage over Norwegian territorial waters. In fact, shortly after AISSat-2's first pass, AISSat-1 was contacted as part of its routine operations. "Some new company for AISSat-1 in orbit!" said Alex Beattie.

The University of Toronto Institute for Aerospace Studies' The Space Flight Laboratory (SFL) mission is to lower the entry barrier to space for companies, research institutions, government, and end users in order to enable more productive use of space for the next generation. SFL believes in offering the lowest cost possible to achieve objectives in space while adhering to approaches known to result in high quality and high reliability.

Additional, Recent UTIAS SFL Successes

SFL's goal is to apply the microspace philosophy to a wide range of mission objectives, thereby expanding the possible applications that are within reach of organizations with limited budgets. Simply put, SFL's business is to challenge the current state-of-the-art in space technology performance while achieving remarkably low cost without sacrificing quality or introducing risk.

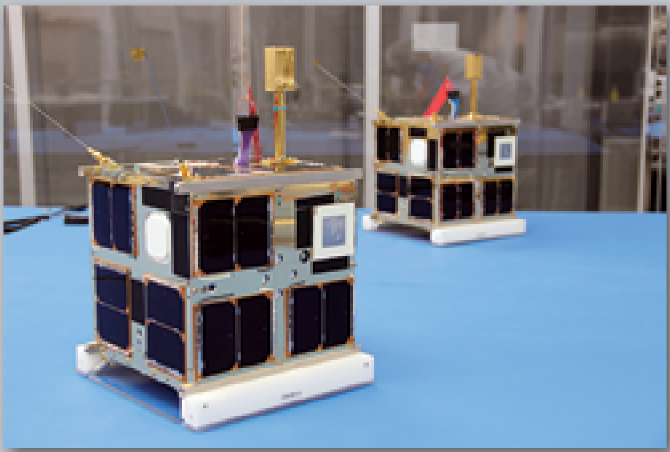
In an age where significant advances have been made in data processing and information technology, SFL strives to leverage the latest advances in commercial technologies to provide performance advantage in space for tomorrow's space-based data users.



The BRight Target Explorer satellites. Photo is courtesy of SFL.

In a little more than two weeks, the Space Flight Laboratory has launched five satellites. Two satellites are Canadian ***BRIght Target Explorer*** (***BRITE***) satellites for studying luminous stars from orbit (launched on June 19, 2014, on a Dnepr rocket from Yasny, Russia).

Two additional satellites are the ***CanX-4*** and ***CanX-5*** formation flying satellites (launched on June 30, 2014, on PSLV-C23 from Sriharikota, India). Then came the aforementioned AISSat-2 onboard the Soyuz-2.1B. With the exception of one of the two BRITE satellites, all satellites have been contacted and confirmed healthy—the BRITE-Montreal satellite is believed not to have separated from its Dnepr launch vehicle.



CanX-4 + CanX-5 cubesats. Photo courtesy of SFL.

The four satellites have also been making swift progress in commissioning. After only eight days on orbit, BRITE-Toronto entered fine pointing with accuracy and stability better than one arcminute (12 arcsec RMS), and, since then, has been managing regular observations of Centaurus and Cygnus.

BRITE-Toronto joins three other successful BRITE satellites already operating in orbit, all based on SFL satellite technology. Also, in just over a week's time, the CanX-4 and CanX-5 satellites have been largely commissioned, including their on-board propulsion systems, and will soon execute a drift recovery maneuver as a prelude to their tandem formation flying demonstrations. AISSat-2 was contacted during its first pass over Svalbard, within hours of launch. During its first pass, which only lasted about 10 minutes, several on-board systems were commissioned quickly, thanks to prior experience with AISSat-1. Also during its first pass, AISSat-2 detected many ships, confirming the operation of its main mission payload.

"Today is a great day for SFL," said Dr. Robert E. Zee, Director of SFL, "Not only have we demonstrated the versatility of SFL's small satellite technology, which offers high performance in a miniature package at ultra-low cost, but we have demonstrated the robustness and grittiness of SFL's XPOD dispenser, which continues to be a reliable workhorse for nanosatellite separations from many different launch vehicles."

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SFL's XPOD dispenser has successfully ejected 22 satellites to date from the Cosmos-3M, PSLV, Dnepr, and Soyuz 2-1B rockets.

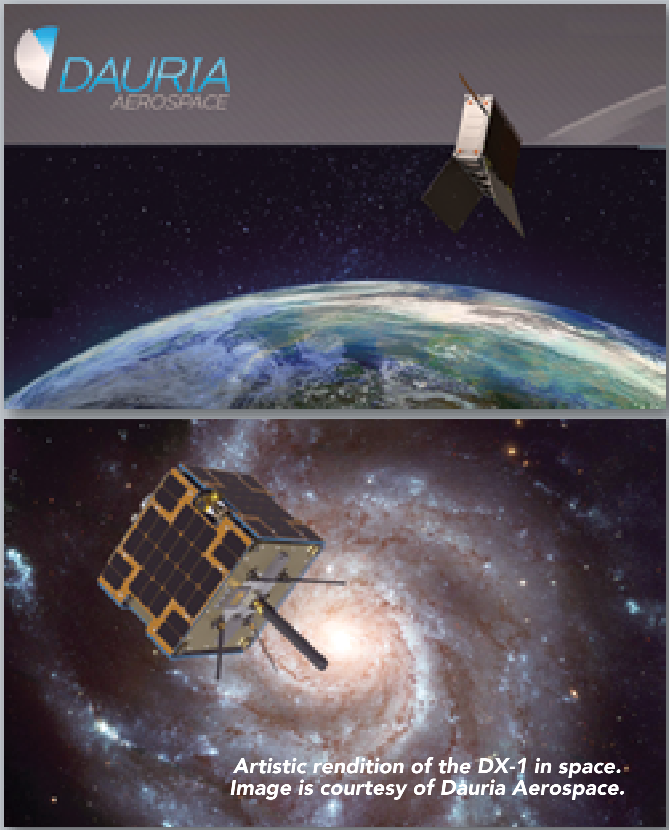
"Although we are a bit saddened about the lack of separation of BRITE-Montreal, we have seen no evidence to suggest that there was anything amiss with the XPOD responsible for its ejection. We continue to ask the launch agency, Kosmotras, for a detailed telemetry report to help us to understand what happened," said Zee. "There is a small chance that the XPOD will still deploy BRITE-Montreal, as the cord that holds the clamping mechanism together may degrade in the space environment over time. SFL will continue to send commands when the Dnepr upper stage is overhead, in case the XPOD deploys BRITE-Montreal. We never give up hope."

With four new satellites working just fine in orbit, SFL now boasts 11 operational satellites that they have either developed in house or played a major role in developing. With more satellites to be launched and under construction, SFL remains Canada's most prolific satellite builder and exporter of complete satellite missions.

For further information regarding UTIAS SFL, please visit
http://utias-sfl.net/

DX-1

DX-1, from Dauria Aerospace, will track navigation on waterways throughout North America, Northern Europe, as well as Russia. This smallsat carries an AIS payload on a proprietary platform that was completely designed and built by the company and takes advantage of the ongoing growth in the remote sensing industry.



Artistic rendition of the DX-1 in space. Image is courtesy of Dauria Aerospace.

DX-1 joins the company's Perseus constellation and is the first and only moderate resolution Earth Observation (EO) satellite constellation that delivers monitoring services. A proprietary, low-cost approach offers imagery at an affordable price, making the data widely accessible.

AMSAT UK (Radio Amateur Satellites) is requesting assistance from all radio amateurs who are interested in receiving signals from this spacecraft. The organization invites all to participate in the "catching" of the satellite immediately after the launch.

Based on the parameters of the DX-1's orbit, the satellite's separation from the upper stage occurred over Eastern Europe and the spacecraft returned above Russia after only a few hours from its "travels" over the Far East. The AMSAT UK MCC in Moscow held the first session the day after the launch.

Beacon satellite broadcasts in amateur radio frequency—everyone was be able to "hear" DX-1 before the organization itself. AMSAT UK needed to clarify and confirm the satellite's orbit performance. Those who assist as "lucky hunters" from around the world will be receiving souvenirs.

The parameters of the radio beacon mode:

- *Carrier frequency: 438.225 MHz [it is understood there is a 145 MHz command uplink]*
- *The protocol used: AX.25*
- *Call Sign source: DSC001*
- *Call Sign Receiver: Dauria*
- *Size TMI frame within AX.25 packet: 55 bytes*
- *Speed: 9600 bit / s*
- *Modulation GFSK*

Source: **http://habrahabr.ru/company/dauria/blog/228669/**

The Google English Version is located at **http://tinyurl.com/pdueyt2**

The satellite will also be using the following frequencies:

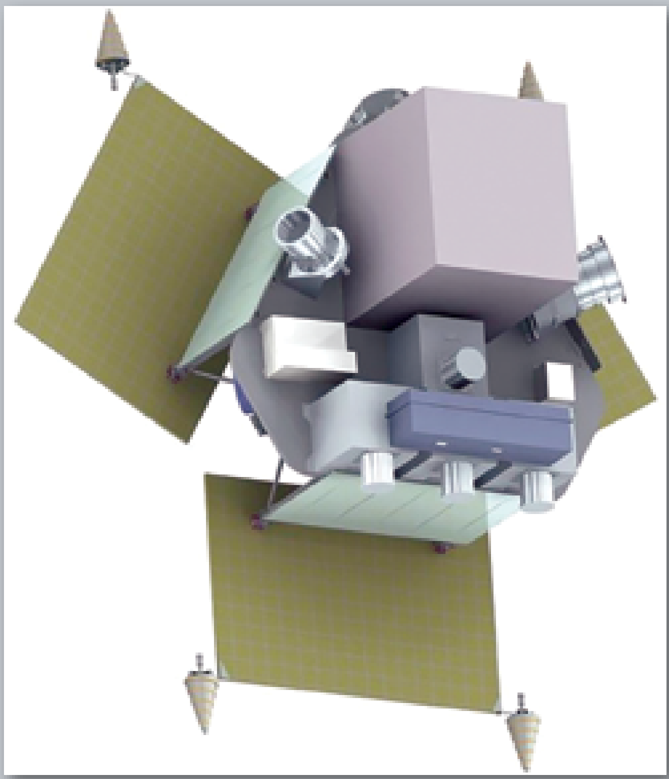
- *162.0125-162.0375 MHz Uplink – AIS ship tracking receiver*
- *2269.5-2270.5 MHz Downlink – Data*

AMSAT-UK is an information service that offers a first class magazine in *OSCAR News* (free to members at least every three months), and provides technical data and advice on all aspects of amateur satellite communications. Orbital data and general assistance to all radio amateurs wishing to enter this specialized part of the hobby is still available at minimal cost.

For further information regarding AMSAT UK, please visit
http://amsat-uk.org/

Relek (MKA-PN 2)

The ***MKA-PN 2*** satellite, also known as ***Relek*** for its scientific payload, is a smallsat dedicated to the study of energetic particles in the near-Earth space environment, including the Van Allen Belts. The last Russian satellite to study charged particles flew in 2001. Scientists wanted the continued flow of data regarding particle distribution around Earth for geophysical research and space weather monitoring.



Artistic illustration of the MKA-PN 2 (Relek) satellite. Image is courtesy of Lomonosov Moscow State University.

Additionally, part of the Relek mission is dedicated to the participation of young scientists to allow them to gather valuable experience in the operation of a scientific satellite mission.

The Relek satellite weighs under 250kg. and is based on the Karat satellite bus manufactured by NPO Lavochkin. The spacecraft features three deployable, fixed solar panels that deliver a peak power of 100W for distribution to the satellite's subsystems and batteries. Attitude determination is accomplished with star trackers, a magnetometer and sun sensors, as well as via an inertial measurement system. Reaction wheels are used for attitude control.

A hydrazine monopropellant propulsion system consisting of several thrusters and two spherical propellant tanks is used for orbital maneuvers and attitude control. Optionally, a hydrazine system could be substituted by an electric propulsion system. However, which form is being used for Relek is not known as of this writing. Overall, the satellite achieves a pointing accuracy of 0.004 degrees per second.

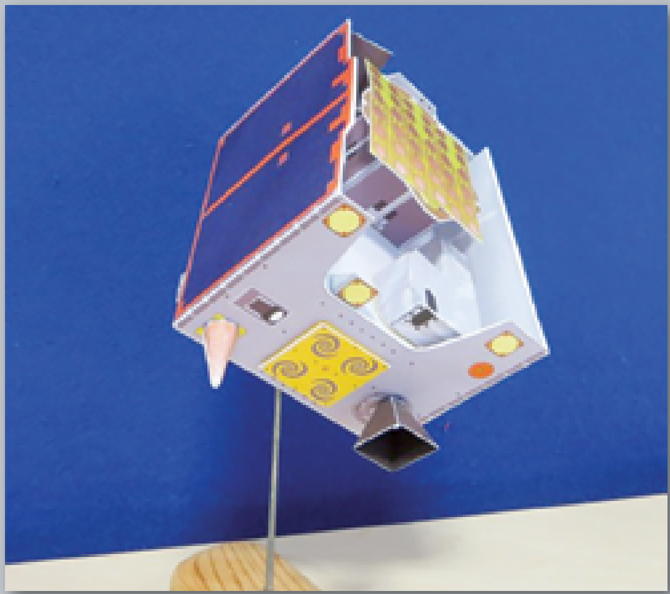
The communications system uses S-band for command uplink and telemetry downlink, while high-volume science data from the payload is stored in an 8GB memory for downlink via an X-band terminal. The Relek payload generates around 500MB of data per day.

The goal of the Relek payload is the detailed study of cosmic ray and magnetospheric energetic particles and their interactions with Earth's upper atmosphere. Also, transient luminous events are studied by the satellite. The satellite will provide data for research into acceleration and precipitation of charged particles in Earth's radiation belts, the interactions of high-energy particles with the ionosphere and atmosphere, and the connections of particle interactions with transient phenomena. To meet these objectives, the Relek payload will simultaneously observe electron and proton flux as well as electromagnetic waves and the low-frequency range which contribute to particle acceleration.

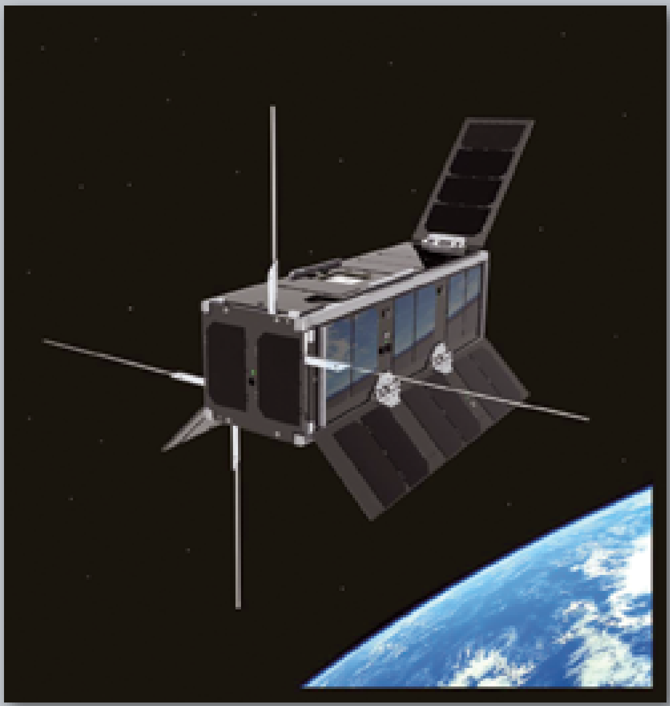
SkySat-2, the next smallsat iteration from SkyBox Imaging, will be primarily focused on Earth imaging and will offer resolutions of up to 3.3 feet (one meter). This smallsat is the second of the company's planned constellation of 24 satellites.

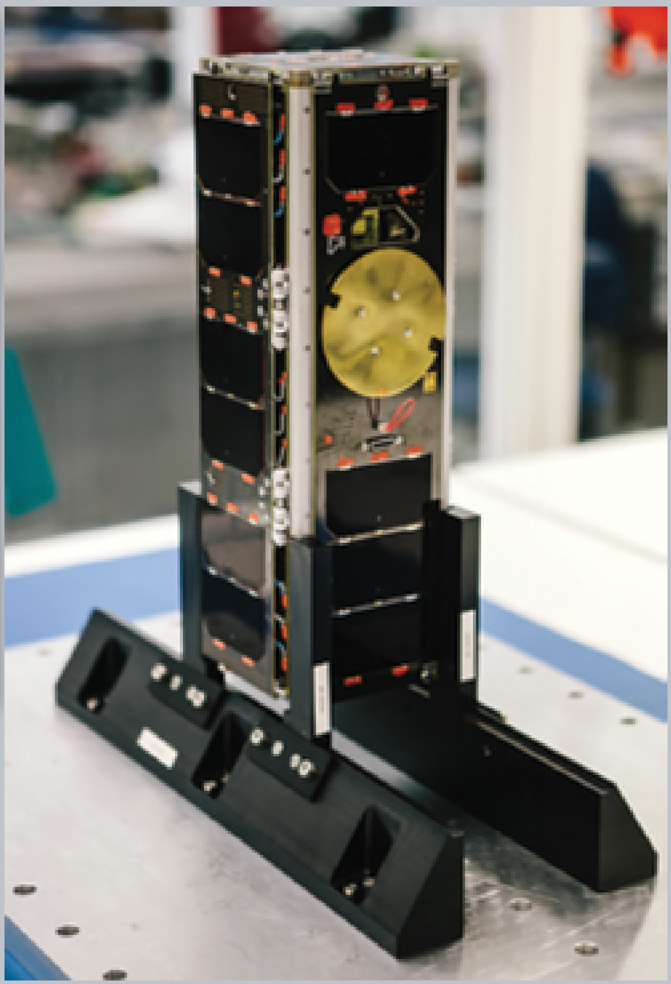
TechDemoSat-1

TechDemoSat-1 (TDS-1), from Surrey Satellite Technology Limited (SSTL), is, basically, an on orbit test facility for a variety of payloads and software applications developed in the United Kingdom. There are eight payloads aboard TDS-1, which include a new form of battery charge regulator; new cell designs on two of the smallsat's solar panels; a computer system that will enable the remote control of various software experiments; and a self-destruction technology that uses a sail to force the craft out of orbit to burn up in the Earth's atmosphere.



A scale model of TechDemoSat-1. Photo courtesy of SSTL.





See the complete story starting on Page 10 in this issue of SatMagazine.

UKube-1

Scotland's first space satellite has been launched into orbit — ***UKube-1***, designed and manufactured by Clyde Space in Glasgow, was one of the secondary payloads rocketed into space aboard the Russian Soyuz-2 launch vehicle.

There was a great deal of cheering at the Glasgow HQ of Clyde Space as the launch unfolded before them. The UKube-1 nanosatellite is about the size of a shoe box and is described by Clyde Space as being one of the most advanced of its kind, featuring GPS devices aimed at measuring plasmaspheric space weather, as well as a camera that will take images of the Earth and test the effects of radiation on space hardware. UKube-1 will orbit at 635 kilometers above Earth, and has an expected life span of five years, although its primary mission is expected to be completed within one year."

Clyde Space chief executive Craig Clark said it is a very proud moment for the team. "I am delighted that the launch went so smoothly and the UKube-1 mission is underway. It is fantastic that a spacecraft designed, built and tested in Scotland by a Scottish company has been so successful and I'd like to thank everyone who backed us and contributed to this amazing project."

Andrew Strain, vice-president of engineering at Clyde Space, recently returned from Baikonur where he supervised the integration of UKube-1 on to the rocket. He said, "UKube-1 shipped out six months ago so our first task was to make sure everything was still healthy. The beauty of the CubeSat is that at the launch site we were able to set up the test kit and do all the checkouts within a few hours, confirming we were good to go. Once that was done all that remained was to bolt the satellite to the launcher and wait for the launch."

Ukube-1, part of the UK's national collaborative CubeSat program, will test several new technologies in space. The payloads flying on UKube-1 were selected following a competition administered by the UK Space Agency to find the most innovative and creative payloads in the UK for a CubeSat. The competition received more than 20 payload submissions, several of which are also being considered for future missions.
Payloads on UKube-1 include:

- *TOPCAT, from the University of Bath, is the first GPS device aimed at measuring plasmaspheric space weather*
- *The CMOS Image Demonstrator by the Open University is a camera that will take images of the earth and test the effect of radiation on space hardware using a new generation of image sensor*
- *Astrium's "Janus" Experiment to demonstrate the feasibility of using cosmic radiation to improve the security of communications satellites and to flight test lower cost electronic systems*
- *AMSAT's FUNcube-2, an outreach payload allowing school children of primary and secondary age to interact with the spacecraft*

RAL Space is the primary operator for UKube and has established a UHF/VHF ground station, which commands the satellite A 2.4m S-band antenna will be used to provide data downlink for UKube. These two systems will be able to support amateur satellites within the international community.

Also onboard the Clyde Space satellite is an advanced On-Board Computer (OBC) from Steepest Ascent in Glasgow, Scotland, and an S-band Transmitter from Cape Peninsula University of Technology. UKube-1 is essentially a technology demonstration mission and most of the payloads on UKube-1 are already being used on other CubeSat missions around the world.

Clyde Space took on the role as "platform prime" for the build and development of UKube-1 and it was the company's responsibility to deliver the complete mission for the UK Space Agency, from concept to delivery to the launch site. The majority of the design and system integration took place at the company's high-tech facility in the West of Scotland Science Park. UKube-1 consists of a combination of standard off the shelf subsystems from Clyde Space' CubeSat Lab, modifications to standard subsystems and new products. The company provided an interface emulator to all payload teams at the start of the program. This allowed the rapid parallel development of subsystems —payloads that could be developed and tested without the need to interface to the spacecraft platform. Both the payload and the platform could, therefore, be developed simultaneously. This will be beneficial for other missions in future and the product is currently for sale in the Clyde Space cubesat shop.

On-Board software was developed for UKube-1 in collaboration with Bright Ascension. The software was designed for the command and data handling needs of the next generation of highly capable cubesats and is also available to purchase for use on other spacecraft and can be easily supplemented with new components and payloads when necessary to suit various mission configurations.

The deployable solar panels have more features than ever before, as they were built to support the large amount of power required for a multi-payload mission, with the company able to improve and test a more integrated solar panel that would supply power and interface sensors and actuators to the ADCS. This included the use of sun detectors and sun sensors as well as embedded magnetorquers. Additionally, the solar panels accommodated S-band patch antenna and a GPS antenna.

Supporting the power delivery from the new deployable solar panels required an updated EPS. The design was extended to enable it to handle the increased power from the panels and to deliver more power to the payloads and subsystems. Modularity of the system was improved by increasing the number of arrays that can be interfaced. The isolation switch was re-configured to reduce the risk of high currents being carried in physical switches which has, in turn, reduced the magnetic impact of the system (e.g., the resultant magnetic force from currents running through harnessing). Also increased was the number of regulated power buses to accommodate the needs of all the payloads.

The S-Band transmitter used on UKube-1 offers the highest data rate for downlink of any others on the market at the moment and was developed in collaboration with CPUT and FSATI and is increasingly important as cubesats become more complex.

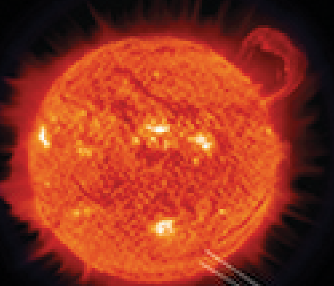
Craig Clark added, "UKube-1 has been years in the making, with a great deal of hard work from our fantastic Clyde Space team. As anyone in the business will tell you, there's nothing easy about designing a spacecraft, especially one as complex as UKube-1, so the achievement is a testament to the capability and application of the team here. It has also been a dream for me, to be responsible for producing Scotland's first satellite. I'm very proud of UKube-1. But we're not stopping there. This is the first of many, and by that I mean hundreds of satellites of this size to be produced in Glasgow in the coming years."

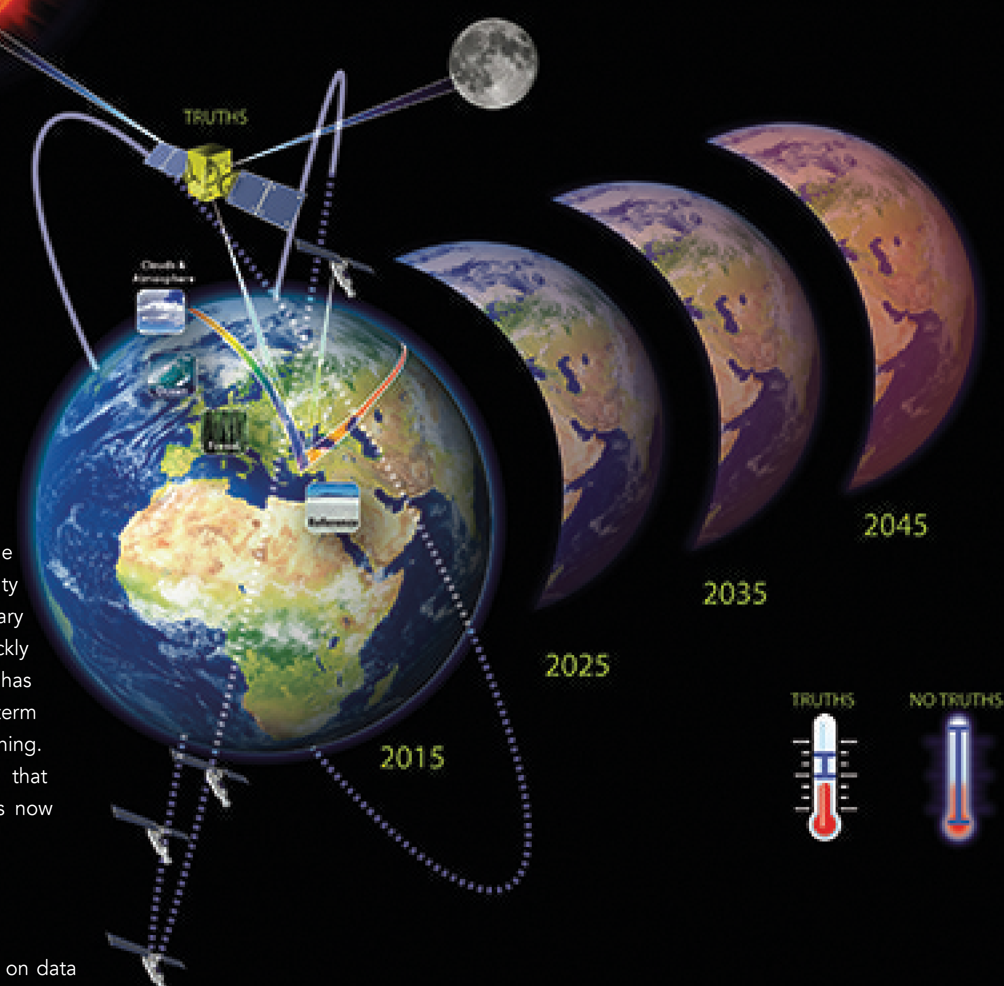
The Clyde Space infosite is located at ***http://www.clyde-space.com/***

The TRUTHS About Climate Change

By Dr. Nigel Fox, the National Physical Laboratory, UK

The Earth's climate is undoubtedly changing, but the rate of change and the implications are unclear. The reason is that measuring climate parameters is a tough job.





Measurements taken by satellites must contend with huge numbers of variables while their precise instruments get knocked about in space. The resulting margin of uncertainty means predictions can vary wildly about how quickly temperatures will rise. This has serious implications for long term political and economic planning. A long proposed project that could meet this challenge is now gaining momentum.

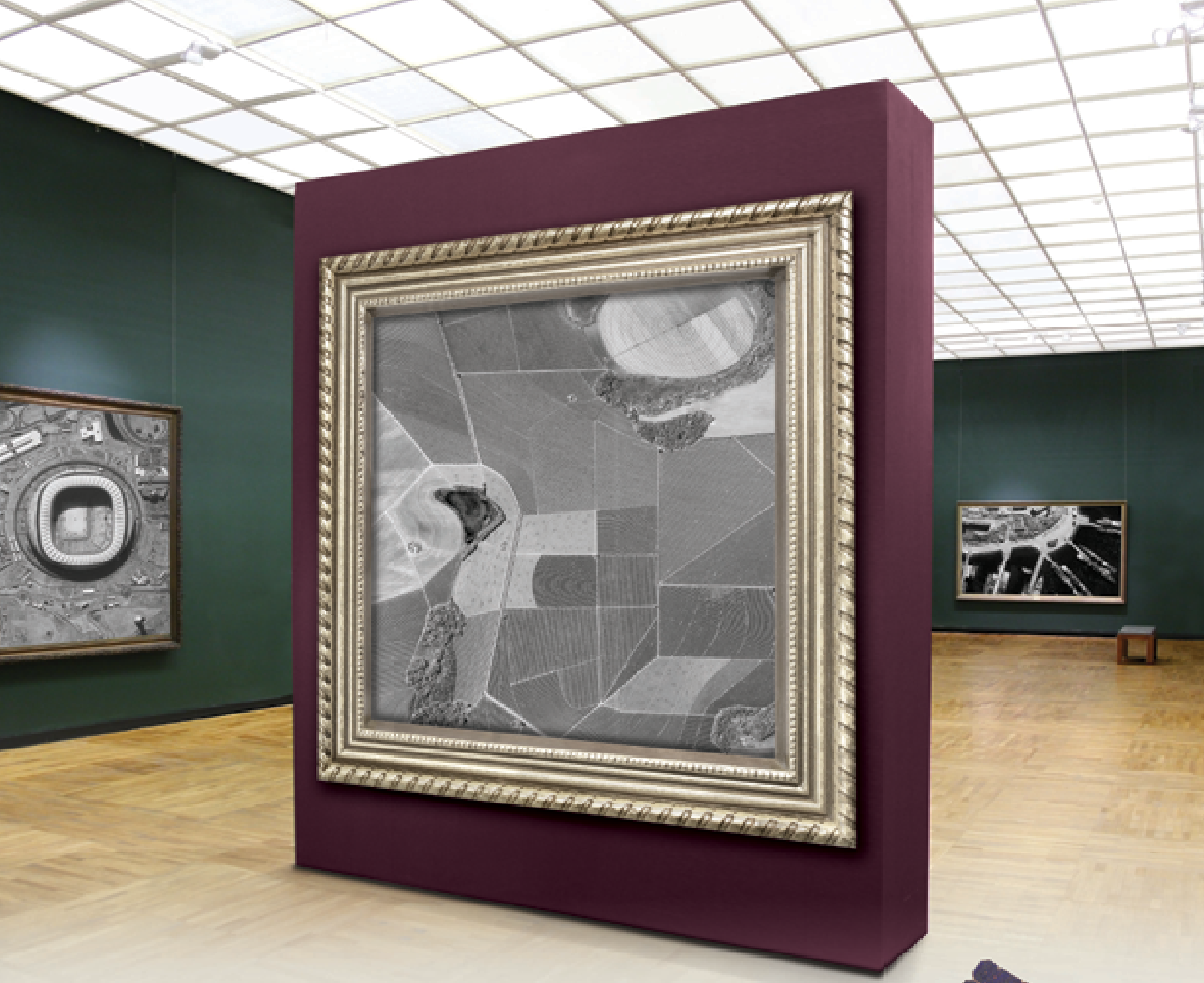
The Challenge Of Earth Observation

Climate forecast models rely on data acquired through a range of complex measurements. Most of the important measurements—such as ice cover, cloud cover, sea levels and temperature, chlorophyll (oceans and land) and the radiation balance (incoming to outgoing energy)—must be taken by satellites. To constrain and test the models, they must be made over long timescales.

Our reliance on satellite measurements presents two major problems.

First, we have to detect small changes in the levels of radiation or reflection from a background fluctuating as a result of natural variability. This requires measurements to be made on decadal timescales—beyond the life of any one satellite mission. Such, therefore, demands high accuracy as well as high confidence that measurements will be made in a consistent manner.

Secondly, although the space industry adheres to high levels of quality assurance during manufacture, satellites (particularly optical ones) usually lose their calibration during the launch, and this drifts further over time. Similar ground based instruments would be regularly calibrated, traceable to a primary standard to ensure confidence in the measurements. This is much harder to accomplish in space.



The result is varying model forecasts. Estimates of global temperature increases by 2100, range from ~2–10 degrees Celcius. Which of these is correct is important for making major decisions about mitigating and adapting to climate change.

Nowhere are we measuring with uncertainties that are close to what we need in order to understand climate change and allow us to constrain and test the models. Our current best measurement capabilities would require more than 30 years before we have any possibility of identifying which model is most likely to be correct in its forecast of potentially devastating impacts. That may be too late.

More Accurate Measurement

The proposed solution is a mission that will launch a satellite into orbit with the ability to make very high accuracy measurements (a factor ten improvement) and also to calibrate and upgrade the performance of other Earth Observation (EO) satellites in space.

The National Physical Laboratory has long been working on such a mission, called TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio-Studies). A team in the US, led by NASA, have also proposed a similar complementary mission called CLARREO (The Climate Absolute Radiance and Refractivity Observatory).

The novelty of TRUTHS lies in its on-board calibration system. The instruments on the TRUTHS satellite will be calibrated directly against an on-board primary standard—an instrument called a CSAR (Cryogenic Solar Absolute Radiometer). This compares the heating effect of optical radiation with that of electrical power—transferring all the difficulties associated with existing space based optical measurements (drift, contamination, and so on) to more stable electrical SI units. In effect, this mimics the traceability chain carried out on the ground.

Such will provide its own comprehensive and climate critical data sets as well as facilitate an upgrade in performance of much of the world's EO systems as a whole, both satellite and ground data sets. By performing reference calibrations of other in-flight sensors through near simultaneous observations of the same target, it can transfer its calibration accuracy to them.

The unprecedented accuracy allows benchmark measurements to be made of key climate indicators such as the amount of cloud, albedo (Earth's reflectance) or solar radiation at a level that allows trends to be detected in a third of the time required compared with current instruments.

Accurately identifying trends—for example, a 0.2 percent increase in high cloud cover per decade—requires approximately 30 years using current measurements, which limits our climate models. TRUTHS would reduce this timeframe to 12 years. This means that 12 years from launch, we would have a very clear picture of the impact of climate change. Background noise from natural variability makes measurements less than 12 years unreliable, even with greater accuracy. TRUTHS represents the best climate monitoring we can ever achieve.

The Commercial Opportunity

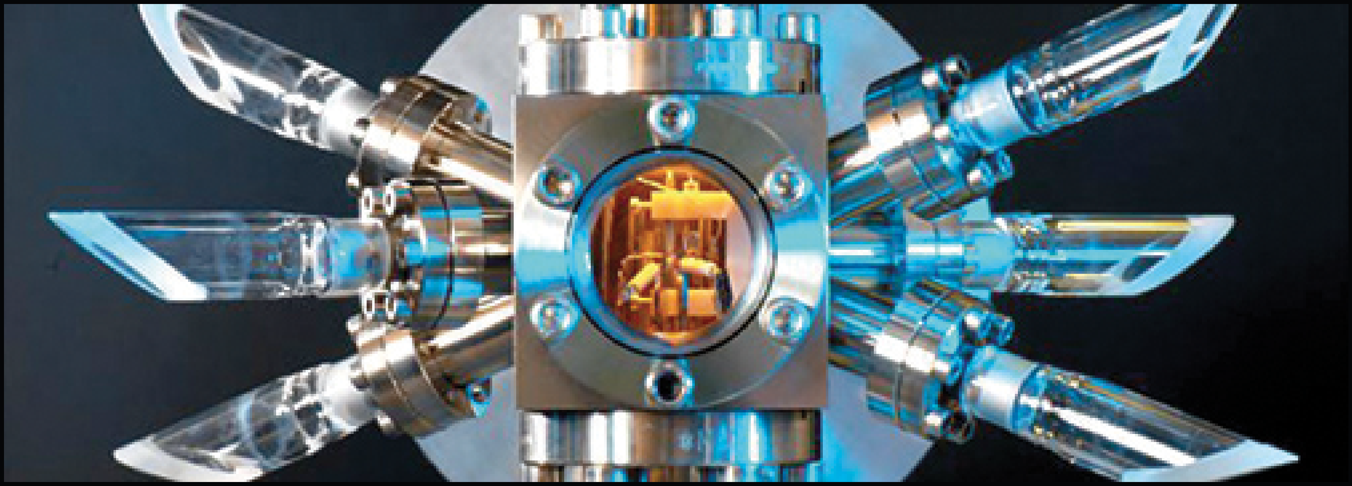
TRUTHS measurements will aid our understanding of climate change as well as facilitate the establishment and growth of commercial climate and environmental services. TRUTHS data will also enable improvements in our knowledge of climate and environmental processes, such as aerosols, land cover change, pollution and the sequestration of carbon in forests.

This will find wide applications in forest, land and water monitoring projects, with significantly higher performance than any other planned mission. One of the barriers to this market's growth is customer confidence in the results and long-term reliability of service, an issue TRUTHS will resolve.

Furthermore, an economic study has also highlighted that the improvements from such a mission could result in an economic saving to the world economy of $5 to $30 trillion, by switching to informed mitigation and adaptation strategies.

The History + Future

The TRUTHS proposal (and its U.S. sister CLARREO) has been around for some time and has received international interest from governments and space agencies. However, perhaps in part due to the mission's uniqueness, TRUTHS has struggled to secure funding. Recognizing the project's importance, the Centre for Earth Observation Instrumentation (CEOI) stepped in 2012 to fund a study to produce a lower cost version, while maintaining the key objectives as far as possible.



Thanks to a new approach and technological advances, the complexity of mission was reduced, all the while still providing the needed data accuracy. Happy with the new approach, CEOI has now provided additional funding to develop a detailed design of the instrument and assign costs.

The scope of this funding also includes a remit to look for partners from around world who can bring different elements to a bilateral mission, sharing the costs and benefits.

TRUTHS represents a huge opportunity, particularly for the UK where the project was born. This is a chance to showcase UK expertise in science, technology and engineering and would support UK ambitions to be a global leader in climate services.

The priority remains getting TRUTHS into orbit. Who finances, and benefits, from the mission is of secondary importance to realizing the purpose of providing the accurate climate models so desperately needed. There is active interest from other parties, particularly from the Chinese Government, who are looking at building a system using the TRUTHS concept as a blueprint.

As reports, such as those by the IPCC, make the potential consequences of climate change clear, politicians are taking the need to accurately understand climate change more seriously. TRUTHS now feels like it is gathering serious momentum.

With the correct support, the mission could be in orbit within three to five years, and we can finally move from what the impacts of climate change might be, to what the impacts will be.

For additional information regarding the NPL, please visit **http://www.npl.co.uk/**

About the author

Nigel Fox is the head of Earth Observation and Climate at NPL, and an NPL Fellow. He joined NPL from the University College London in 1981 with a BSc in Astronomy and Physics. Since that time, he been responsible for the establishment and dissemination of primary optical radiation measurement scales and, in particular, pioneered the development of techniques such as laser and cryogenic radiometry. These techniques led to an improvement of nearly two orders of magnitude in the accuracy of many radiometric measurements and have been widely adopted by the international metrology community, resulting in the award of a PhD.

More recently, Nigel has expanded his interests to include Earth Observation and associated climate change parameters, with a particular emphasis on satellite observations. This has led to further innovation in both pre-flight and post-launch calibration and validation techniques and has culminated in the design and leadership of a proposed satellite mission called TRUTHS. The novel mission concept provides fully SI traceable measurements from orbit at uncertainties a factor ten lower than any other, sufficient to make benchmark measurements suitable for the detection of decadal climate change.

Nigel has published more than 120 papers, chairs the Infrared Visible and Optical Sensors (IVOS) sub-group of the international Committee on Earth Observation Satellites (CEOS) and represents the international metrology community on relevant WMO committees.

Strategic Partnership Now In Place

The Universities of Strathclyde and Surrey have been identified as preferred partners to enter into a new strategic partnership with the Department for Business, Innovation and Skills (BIS) and the world-renowned National Physical Laboratory (NPL), a global center of excellence in measurement and materials science. This new partnership will help to provide future leadership of NPL.

University of Strathclyde Glasgow — University of Surrey

The new alliance will see the two universities and NPL collaborate to bring together their track record of working with business and industry and their complementary academic strengths.

Working with BIS and NPL, the successful bid will help to shape the scientific priorities of the UK. The establishment of a Graduate Institute, which will train up to 300 high-caliber PhD students, will provide a pipeline of skilled researchers. Working with the staff at NPL, the potential of the Laboratory will be grown through the creation of a series of regional hubs which will reflect local expertise and business needs.

An Historic Look @ The Mission To Planet Earth Program

By Jos Heyman, Senior Contributor

The Earth Observing System (EOS) was the principal element of NASA's Mission to Planet Earth (MTPE) program that can be traced back to the 1960s when the study of Earth was considered an appropriate effort for the international community.

EOS was conceived as a program to understand Earth systems via a broad range of environmental and Earth science measurements, all from the vantage point of space. The goal was to measure as many of the variables of interest to Earth scientists as was possible.

An observation period of 15 years was considered appropriate as that timeframe would include a complete sunspot cycle as well as several El Niño events and perhaps even the eruption of one or more major volcanoes.

Planning for the EOS missions started in the early 1980s and, at that time, NASA planned to make extensive use of satellites in Low Earth polar orbit, which would be serviced by Space Shuttle launches from Vandenberg Air Force Base (VAFB) in California in order to maintain and change instruments.

The connection with the Space Station ended after the Challenger accident when NASA terminated plans to launch the Space Shuttle into polar orbit, although the idea of large platforms remained.

This led to the EOS-A and EOS-B series spacecraft as well as payloads designed to be attached to the proposed Freedom Space Station. Some instruments were also earmarked for the proposed Japanese and European polar-orbiting satellites, then referred to as the Japanese Polar-Orbiting Platform (JPOP) and the European Polar-Orbiting Platform (EPOP).

The initial EOS, as devised in 1989, was to consist of two 15,000 kg. satellites that would have been launched by a Titan IV (with Solid Rocket Motor Upgrades (SRMU's) rocket, launched from VAFB.

EOS-A and –B would have carried a range of instruments. EOS-A1 was scheduled for a 1998 launch, while EOS-B1 was scheduled for launch in 2001.

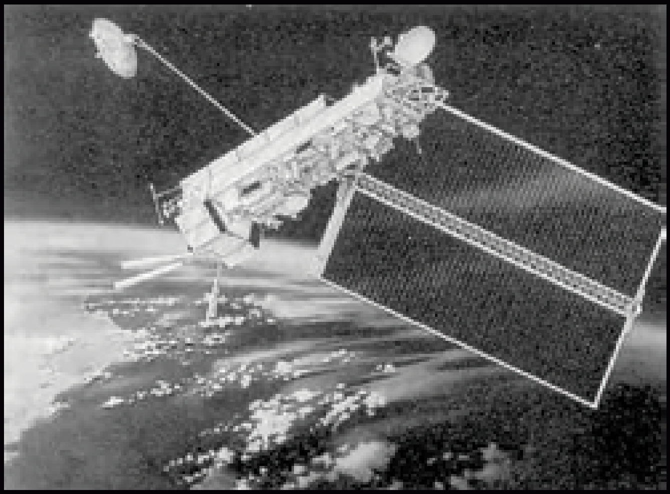
Similarly instrumented satellites, EOS-A2 and –A3, as well as EOS-B2 and –B3, were to be launched at two to three year intervals. With an operational life of five years for each satellite, this would have covered the desired 15- year mission timeframe.

Following an Announcement of Opportunity in 1988, 458 proposals for instruments were received from the scientific community. Eventually, NASA selected 29 instruments.

1992 Revision

In 1992 the original EOS plans were modified for three reasons:

- ***A new focus of EOS objectives towards the problem of global climate change***
- ***A move towards flying the instruments on multiple smaller platforms, rather than a series of large observatories***
- ***A reduction in budget from US$17 to US$11 billion through FY2000***



An early, artistic rendition of the first EOS platform that was planned for launch in 1998 to 1999 aboard a Titan 4 rocket. Image was produced by the GE Astro Space Division.

EOS Terra, launched on December 18, 1999, also known as Terra Earth.

By 1992 this evolved into a revised program consisting of:

- ***The EOS-AM series of three satellites were to be polar orbiting crossing the equator at 10.30 a.m. local time to characterize the radiation balance of terrestrial surfaces, clouds and aerosols. The satellites were to be built by Lockheed Martin and scheduled for launch in 1998, 2003 and 2008***

- ***The EOS-PM series of three satellites were to cross the equator at 1.30 p.m. local time to study clouds, precipitation and radiative balance, terrestrial snow and ice, sea surface temperatures as well as ocean productivity. The satellites were to be built by TRW and were to be launched in 2000, 2005 and 2010***

- ***The EOSChem series of three satellites were to be built by TRW to investigate atmospheric chemicals and their transformations as well as ocean surface stress. The planned launch dates were 2002, 2007 and 2012***

- ***EOSColor, a single satellite was to be launched in 1998 into a sun-synchronous polar orbit to study the biomass and the productivity of aerosols***

- ***EOSAero series of five satellites to be launched in 2000, 2003, 2006, 2009 and 2012 were scheduled to be launched into an orbit with an inclination of 57 degrees and would have studied atmospheric aerosols***

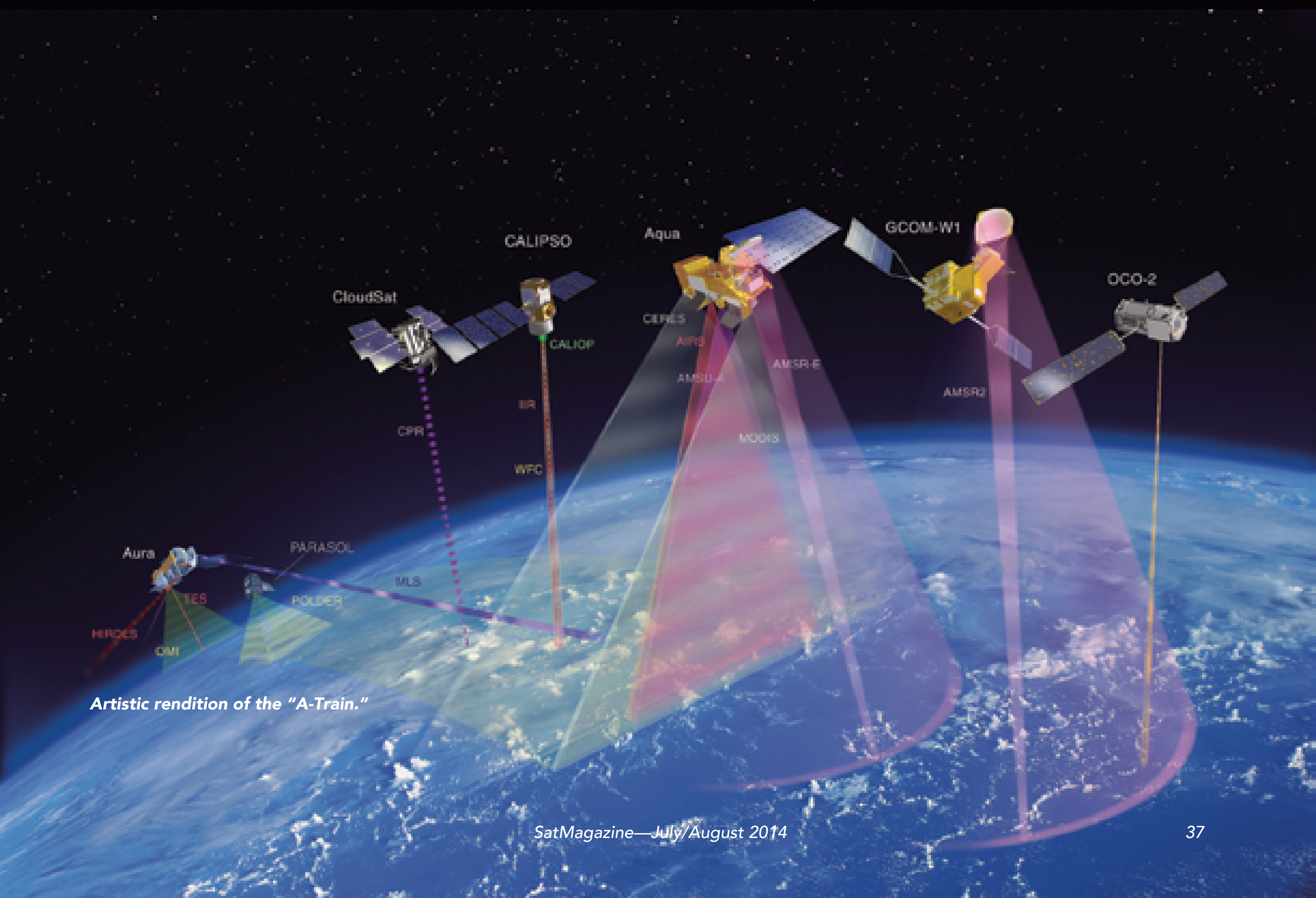
- ***EOSAltimetry series of three satellites to be launched in 2002, 2007 and 2012 were scheduled to be launched into a sun-synchronous polar orbit to study ocean circulation and ice sheet mass balance***

A number of the instruments planned for EOS-A and –B found their way to these satellites. Other instruments that were part of the original EOS plan were dropped, placed on other satellites, or simply replaced by newer instruments.

Gradually, plans were further modified and, by 1995, the program was reduced to three series of satellite missions, as well as several smaller missions and joint missions with other countries. Under the baseline plan, as many as 36 spacecraft would carry 80 instruments, of which NASA would provide 21 spacecraft and 65 instruments.

1998 Revision

Over the years, the budget was further reduced to US$8 billion—EOS began to rely more and more on the international partners. By June of 1998, NASA's EOS program consisted of just three satellites:



Artistic rendition of the "A-Train."

- ***EOS-AM-1, which was launched as Terra Earth on December 18, 1999***

- ***EOS-PM-1, which was launched as Aqua on May 4, 2002***

- ***EOSChem-1, which was launched as Aura on July 14, 2004***

Two of these three satellites are currently part of the A Train, a system that was to consist of six polar orbiting satellites that traveled in line mere minutes apart. Their overlapping science instruments give a comprehensive picture of Earth weather and climate.

The "A" in the A-Train is for "afternoon" as the lead satellite, Aqua, crosses the equator at the mean local time of approximately 1:30 p.m. The satellites are, in flight order:

- *Aqua, launched on May 4, 2002*
- *CloudSat, launched on April 28, 2006*
- *CALIPSO, a French satellite launched on April 28, 2006*
- *PARASOL, French satellite launched on December 18, 2004*
- *Aura, launched on July 14, 2004*
- *Glory, launched on March 4, 2011 which failed to gain orbit*

OCO, launched on February 24, 2009, was also to be part of the A Train but also failed to gain orbit.

The A Train

Other satellites that picked up EOS instruments included:

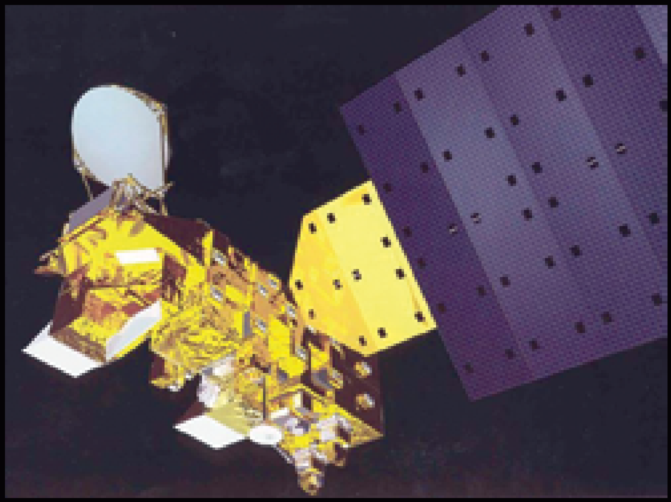
- ***TRMM, launched on November 27,1997***

- ***Rocsat-1, launched on January 27, 1999***

- ***Landsat-7, launched on April 15, 1999***

- ***Acrimsat, launched on December 21, 1999***

- ***EO-1, launched on November 21, 2000***



EOS PM1 / EOS Aqua, launched on May 4, 2002.

EOS-Autor (was known as EOS-Chem), launched on July 15, 2004.

- ***Meteor 3M-1, launched on December 10, 2001***

- ***Jason-1 and -2, launched on December 7, 2001 and June 29, 2008, respectively***

- ***Envisat, launched on March 1, 2002***

- ***ADEOS-2, launched on December 14, 2002***

- ***ICESAT, launched on January 13, 2003***

- ***SORCE, launched on January 25, 2003***

- ***MetOp-1, launched on October 19, 2006***

As indicated above, out of the 458 instrument proposals received in 1988, 29 were selected for further development as payloads on the EOS-A and –B satellites. As the program was modified, as outlined above, several of these instruments were carried forward and some were eventually launched, while others were completely dropped from the program.

The tables on the following pages provide an overview that is based on information that could be gathered from currently available sources.

About the author

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

Experiment	Original	1992	Actual
Active Cavity Radiometer Irradiance Monitor (ACRIM) to monitor the variability of total solar irradiance	EOS-A	EOS-Chem-1, -2, -3	Acrimsat
Atmospheric Infrared Sounder (AIRS) an infrared spectrometer to determine temperature and humidity vertical profiles	EOS-A	EOS-PM-1, -2, -3	Aqua
ALT/RA, an altimeter to measure ocean surface movements and ocean currents	EOS-B	EOS-ALT-1, -2, -3	Jason-1
Advanced Microwave Scanning Radiometer (AMSR) to determine rainfall rates and measure sea surface winds and temperatures	---	---	Aqua
Advanced Microwave Sounding Units (AMSU) to determine temperature profiles	EOS-A	EOS-PM-1, -2, -3, EOS-PM-1, 1, 2	Terra, Aqua
Advanced Spacebourne Thermal Emission and Reflection Radiometer (ASTER) to provide high resolution images of surface features	EOS-A	EOS-AM-1	Terra
Clouds and Earth Radiant Energy System (CERES) to measure the Earth radiation budget and atmospheric radiation from the top of the atmosphere	EOS-A	EOS-AM-1, -2, -3, EOS-PM-1, 2, 3	Terra, Aqua
COLOR, a ocean color instrument to provide measurements of the role of oceans in the global carbon cycle and ocean primary productivity.	---	EOS-Color	canceled ?
Doppler Orbitography and Radiopositioning Integrated (DORIS) to provide orbital positioning information	---	EOS-ALT-1, -2, -3	Jason -1, -2
Earth Observing Scanning Polarimeter (EOSP) to globally map radiance and linear polarization of reflected and scattered sunlight to obtain atmospheric aerosol content	EOS-A	EOS-AM-2, -3	canceled ?
Enhanced Thematic Mapper Plus (ETM+) to provide high spatial resolution images of the land surface, water, ice, and clouds	---	Landsat-7	Landsat-7
GPS Geoscience Instrument (GGI) to determine orbit location	EOS-A, EOS-B	EOS-ALT-1, -2, -3	canceled ?
Geoscience Laser Altimeter System (GLAS) to measure ice sheet topography, cloud heights, and aerosol vertical structure	---	EOS-ALT-1, -2, -3	ICESat
Geodynamics Laser Ranging System (GLRS) which measured the elevation of icesheets over a period of time	EOS-B	EOS-ALT-1, -2, -3	canceled ?
Geomagnetic Observing System (GOS) to perform particle physics research of the upper atmosphere	EOS-B	canceled	---
High Resolution Dynamics Limb Sounder (HIRDLS), an infrared limb-scanning radiometer designed to sound the upper troposphere, stratosphere, and mesosphere to determine the temperature and concentration of the elements of the atmosphere	EOS-A	EOS-Chem-1, -2, -3	Aura
High-Resolution Imaging Spectrometer (HIRIS) to detect important ground characteristics that cannot be detected by other multispectral remote sensing instruments such as absorption and reflectance characteristics of ground objects and the components of solid and liquid object	EOS-A	EOS-AM-2, -3	canceled
High-Resolution Microwave Spectrometer Sounder (HMISS), replaced by Multifrequency Imaging Microwave Radiometer (MIMR) to measure precipitation rate, cloud water, water vapor, sea surface roughness, sea surface temperature, ice, snow, and soil moisture	EOS-A	EOS-PM-1, -2, -3	canceled ?
Ionospheric Plasma and Electrodynamics Instrument (IPEI) to measure ion density, ion drift velocities in the cross-track directions, and ionospheric plasma parameters of major ion constituents	EOS A, EOS-B	canceled	Rocsat-1
Landsat Advanced Technology Instrument (LATI) to provide high spatial resolution images of the land surface, water, ice, and clouds	---	EOS-AM	Future Landsat
Laser Atmospheric Wind Sounder (LAWS), a doppler light detection and ranging instrument, which will use a laser to measure wind speed and direction in the lower atmosphere.	EOS-B	canceled	---

Experiment	Original	1992	Actual
Lightning Imaging Sensor (LIS) to measure the distribution and variability of lightning	EOS-B	TRMM	TRMM
Medium Resolution Imaging Spectrometer (MERIS) a programmable, medium-spectral resolution, imaging spectrometer operating in the solar reflective spectral range	---	---	Terra, Aqua, Envisat
Microwave Humidity Sounder (MHS) to provide atmospheric water vapor profile	EOS-A	EOS-PM	MetOp-1
Multi-angle Imaging Spectro-Radiometer (MISR) to measure the reflectance functions of the atmosphere, cloud and surface as well as small particles and vegetation properties	EOS-A	EOS-AM-1, -2, -3	Terra
Microwave Limb Sounder (MLS) to improve understanding of the chemistry of the lower stratosphere and upper troposphere, the chemistry of the middle and upper stratosphere, water in the upper troposphere and the effect of volcanoes on global change	EOS-B	EOS-Chem-1, -2, -3	Aura
Moderate Resolution Imaging Spectro-Radiometer-Nadir (MODIS-N) to measure biological and physical processes on land and ocean	EOS-A	EOS-AM-1, -2, -3; EOS-PM-1, 2,3	Terra, Aqua
Moderate Resolution Imaging Spectro-Radiometer-Tilt (MODIS-T) to measure biological and physical processes on land and ocean	EOS-A	canceled	---
Measurement of Pollution in the Troposphere (MOPITT) instrument to measure carbon monoxide and methane in the troposphere	EOS-A	EOS-AM-1, -2	Terra
Earth Observing Scanning Polarimeter (EOSP) to globally map radiance and linear polarization of reflected and scattered sunlight to obtain atmospheric aerosol content	EOS-A	EOS-AM-2, -3	canceled ?
Ozone Dynamic Ultraviolet Sounder (ODUS) to measure the total atmospheric column of ozone concentration	---	OEOS-Chem	GCOM A-1 canceled ?
Spectroscopy of the Atmosphere Using Far Infrared Emission (SAFIRE) for the investigation of aerosols and clouds properties	EOS-B	canceled	---
Stratospheric Aerosol and Gas Experiment (SAGE III) to provide profiles of aerosols, ozone, and trace gases in the mesosphere, stratosphere, and troposphere	EOS-B	EOS-AERO-1, -2, -3, -4, -5; EOS-CHEM-1, 2, 3	Meteor 3M-1
SeaWifs to gather information about ocean color and marine biological	---	EOS-Color	OrbView-2
SEAWINDS, to provide all weather measurements of ocean surface wind speed and direction	---	Adeos II	Adeos-2
Solar Stellar Irradiance Comparison Experiment (SOLSTICE) to provide long-term, accurate measurements of the Solar ultraviolet (UV) and far ultraviolet (FUV) radiation	EOS-B	EOS-Chem-1, -2, -3	SORCE
Solid-State Altimeter (SSALT) to map the topography of the sea surface and its impact on ocean circulation. Was also known as Poseidon.	---	EOS-ALT-1, -2, -3	Jason -1, -2
Scatterometer Six-stick Fan Beam (STIKSCAT) for all-weather measurements of near-surface wind velocity over the ocean using a fan beam design antennas, or, as an alternative instrument, Scatterometer Dual Pencil Beam (SCANSCAT) for all-weather measurements of near-surface wind velocity over the ocean using a pencil beam antenna	EOS-B	EOS-CHEM-1, -2, -3	canceled ?
Stratospheric Wind Infrared Limb Sounder (SWIRLS) to measure wind, temperature, and the abundance of O3 and N2O in the stratosphere from earth orbit	EOS-B	EOS-A-2, -3	Aura
Tropospheric Emission Spectrometer (TES), a high-resolution infrared-imaging Fourier transform spectrometer to further the understanding of long-term variations in the quantity, distribution, and mixing of minor gases in the troposphere, including sources, sinks, troposphere-stratosphere exchange, and the resulting effects on climate and the biosphere	EOS-B	EOS-A-2, -3	Aura
Topex/Poseidon Microwave Radiometer (TMR) to provide atmospheric water vapor data	---	EOS-ALT-1, -2, -3	Topex/Poseidon
X-ray Imaging Experiment (XIE) to perform particle physics research of the upper atmosphere	EOS-B	canceled	---

Space Is Going Commercial

By Yossi Avraham, Senior Product Marketing Manager, ORBIT

You've just landed in Paris, grabbed your rental car and are ready to drive to Provence for your long-awaited holiday. You enter the address of the bed-and-breakfast you reserved into the car's GPS and you're on your way. What could be simpler?

Fact is, GPS has come a long way since it was first developed by the U.S. Department of Defense at the height of the Cold War in the 1960's. Originally designed to track the location of submarines and launch ballistic missiles, this satellite-based navigational system has been miniaturized and today is considered a basic consumer item in cars, mobile devices and an ever-increasing array of commercial applications.

A similar transformation is also happening in the Earth Observation (EO) market. For decades, EO was dominated by military, government and space agencies. The first generation of Earth observation satellites, commonly referred to as "spy satellites," were deployed for intelligence operations. These satellites were subsequently used for civilian purposes such as environmental monitoring, meteorology and mapping.

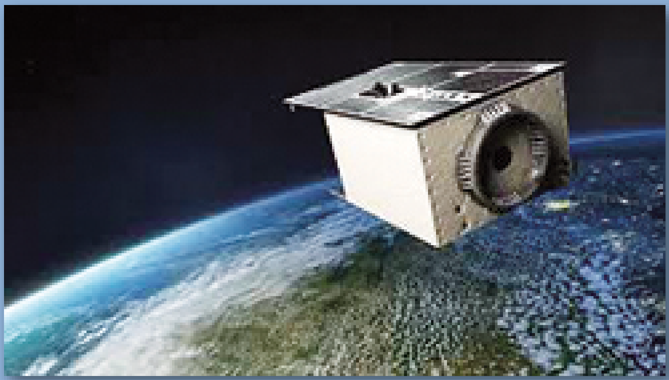
Now, with continuing advancements in hardware and the development of low-cost satellite technologies such as Cubesat, EO satellites have become available and affordable for commercial use.

In fact, these new technologies have spawned a brand new market segment of "space entrepreneurs." These companies are taking advantage of low-cost cube satellites (CubeSats) to provide Earth monitoring services at a fraction of the cost of legacy satellites.

With the average cost of constructing and launching a CubeSat in the range of $250,000, the business case for EO has become extremely compelling. This is evidenced by the establishment in recent years of dozens of start-ups, backed with venture capital dollars, focusing on the EO market.

As the entry barriers recede and business opportunities for EO services expand, more and more small companies are starting to offer data analysis and GIS services for commercial use. In fact, a full ecosystem is starting to develop around data and imagery from space—starting with the satellite owner, through the GIS expert responsible for analyzing the data and down to the end customer.

GPS: The most common commercial application using satellite navigation technology.



Artistic rendition of a CubeSat orbiting Earth.

Oil spills can be immediately detected by radar satellites

A Wide Range Of Commercial Applications

Use cases for EO are virtually endless. Take, for example, a farmer using data imagery to remotely monitor the health and yield of crops on a daily basis over huge tracts of land. Insurance companies, as well, are starting to understand the benefits of EO data for estimating the level of risk per territory and assessing the impact of natural disasters such as floods and earthquakes.

EO data is a key enabler when it comes to effective and efficient decision making, often translating into huge cost savings. Oil and gas companies use satellite imagery to monitor offshore oil spills and help coordinate cleanup efforts, which in the case of major spills, like that in the Gulf of Mexico in 2010, can cost billions of dollars. Data and imagery from space can be used to increase agricultural productivity, reduce risk to insurance companies and in some cases (such as disaster management) even save lives.

In many of these applications, the need for fresh, real-time data is crucial. Even in cases where an older image will suffice, there is no guarantee that stored data exists for the specific area of interest. In other words, on-demand access to the most up-to-date data and images is essential.

The Problem: Getting The Data When You Need It

At the end of the day, to benefit from the data and images collected by the satellite, service providers need to be able to download the data and analyze it in a timely manner. Moreover, as the number and types of satellites used to perform Earth observation continually increase, more ground stations are required for data transmission (taking into account that several satellites may be located above the same interest zone).

This has traditionally raised several problems for small and medium-sized providers of data services. First, they simply couldn't afford to purchase and operate their own ground station, with setup costs exceeding $1 million (excluding annual operational costs). This meant that smaller businesses had to rely on satellite owners or third party middlemen to download the raw data for them. These data download service providers did not give businesses the flexibility and availability they needed to support on-demand data downloads and often gave priority to defenses forces and other "high profile" customers.

Allowing Smaller Businesses To Control Their Data

ORBIT, a leading provider of highly accurate tracking systems, offers an innovative solution that removes these obstacles from the expert whose business depends on the data. At a fraction of the cost of a legacy ground station, ORBIT's new Gaia-100 family of ground stations enables real-time data capturing from LEO or MEO satellites without reliance on third parties and without delays. The Gaia series downloads real-time data online, so data experts and researchers can access and analyze the information they need, when their end customers need it.

Gaia-100 also helps CubeSat and smallsat owners boost their business. These new players have yet to establish a ground station network, and their business model to a large extent depends on how their end customers download the data. Requiring affordability without compromising on data quality, this growing segment of service providers is actively looking for new and creative solutions.

Gaia-100 is easy to install and supports a range of antenna sizes from 2.4 to 4.5 meters. Compact, relatively lightweight and operating under a radome, Gaia can be installed on a building roof, eliminating the need for an open field which was a common constraint faced by many businesses in urban areas.

For more information about the Gaia-100, please visit
http://www.orbit-cs.com

About the author

Yossi Avraham is an expert in the Earth observation and remote sensing domain and currently serves as a Senior Product Marketing Manager at ORBIT.

Executive Spotlight: Awaes Jaswal, CEO, ViewSat

Mr. Jaswal founded ViewSat in 2006 and has built ViewSat's customer base to more than 170 channels which are supported by a dedicated satellite and fiber network. ViewSat recently received an award in the Best Satellite Services category at the Digital Studio Awards and the company has been recognized for rapid growth and targeted industry expansion.

Awaes holds a BSc in Business Management and Accounting and an MSc in Banking and International Finance. His initial work as a reseller highlighted an underserved market in Africa, which led to the establishment of the View Africa Network that provides direct satellite distribution services.

Awaes spearheaded the growth of the business from start-up to global player, as well as the transition from a sales to a service-driven proposition. To achieve this, he oversaw the build of a standalone facility in the UK, offering services directly to ViewSat's customer base.

Awaes has overseen the diversification of ViewSat's product portfolio through a number of strategic partnerships and a successful rebranding project to position ViewSat at the forefront of the industry.

SatMagazine (SM)

Mr. Jaswal, how did you become interested in the satellite distribution industry?

Awaes Jaswal

Family connections introduced me to the satellite industry, and an underserved market was quickly identified in Sub-Saharan Africa. At ViewSat, we saw a massive opportunity to provide turnkey broadcast services to new entrants to this market and to prospective African broadcasters.

Due to previous activity in the market, we were able to offer our customers expertise in channel establishment and distribution. This insight into the broadcast landscape in Sub-Saharan Africa meant we were well positioned to offer our customers a personalized service that was based on an understanding of their technical needs. In addition, ViewSat is built around the ethos of collaborative relationships with customers, and the company specializes in providing guidance during the set-up process. Our aim was to introduce cost-effective broadcast distribution solution around the African continent.

SM

ViewSat was established to provide satellite distribution services to Sub-Saharan Africa. How do you think the satellite industry has grown and what does this mean for your African audiences?

Awaes Jaswal

Even now, satellite penetration in Sub-Saharan Africa is relatively low in comparison to the North America market. However, predicted growth is considerable in the region over the next five years as the distribution industry in Sub-Saharan Africa continues to flourish. This emerging market needs to be supported with distribution specialists and there is a growing requirement for satellite as opposed to terrestrial coverage to ensure ease of distribution, content quality and the scope of area coverage.

ViewSat customers are becoming increasingly aware of new distribution services and, with the advent of the DTT (Digital Terrestrial Television) in Africa, they are looking for additional multimedia applications such as OTT (Over the Top) delivery of content. Video distribution is also widely predicted to increase.

Satellite distribution supports this DTT transition in Africa and it also enables our customers to reach beyond the areas that are not served by the technology. Satellite broadcasting taps into an additional audience in the region's most remote areas.

SM

ViewSat recently spearheaded a successful expansion strategy into North America, having built a strong presence in the MENA region and Sub-Saharan Africa—what was your aim in the move and how was this achieved? What are your long-term goals for your North American operations?

Awaes Jaswal

The sales strategy into North America was designed to open up additional audiences for our customers, many of whom were already successfully distributing their content in the MENA (Middle East, North African) region, Europe, Asia and Sub-Saharan Africa. Our research revealed that there is a high proportion of ethnic audiences in North America who are looking to access quality international religious or entertainment programming.

We are supporting our new capacity for this region with a multi-platform strategy, using relevant events, editorial and online visibility to support our clients. We currently have 12 customers broadcasting their content to this new market, with great success.

Prior to additional investment in North America, we'll review our current product portfolio and look to introduce services for premium clients in the region. After this, we may consider opening a standalone facility in the region, based on supporting our growing customer base there.

ViewSat's broadcast control center.

SM

ViewSat is growing its teleport facilities in the UK, can you tell us more about the project and its value?

Awaes Jaswal

As we continue to expand our business and service portfolio, we are continually looking to strengthen our product offering as well as grow our 24/7 support team to offer our customers a more joined-up service. We have exciting plans to open a 20,000 square foot facility about 13 miles from Heathrow Airport in the UK and to grow our sales and support teams in this new location. We are in the favorable position of having outgrown our current facility and plan to accommodate a greater client number with our new location.

SM

What other services does ViewSat offer the European market?

Awaes Jaswal

We offer our entire service portfolio to European customers, who benefit from the same turnkey services as our channels in Africa, the Middle East and North America.

SM

What, in your opinion, are the new technologies on the horizon for content distribution? How does ViewSat plan to harness them for its customers?

Awaes Jaswal

ViewSat continually invests in new technology to suit the changing distribution needs of our clients. Most recently, we have reviewed different types of content distribution, such as OTT services. In addition, we are considering additional, cost-effective methods to deliver content to our customers, including via the Internet using ARQ technology.

Although not a new technology, we are experiencing an uptake in HDTV services, with audiences considering 4K content as well as multi-platform delivery. We will introduce relevant technology to support UHDTV (4K) services for our customers from our new facility.

SM

Given the intense interest in OTT and other forms of content delivery, such as IPTV and a variety of additional broadband schemes, how can satellite broadcasters become more involved within these environments?

Awaes Jaswal

At ViewSat, we believe that the ethos should be placed on integration with new services rather than one technology replacing another. As greater numbers of our existing customers look for multi-screen delivery, it makes sense for us to take on additional services to complement their existing distribution, meaning all distribution services can be covered in a single place.

Traditional satellite distribution is still a sought-after service in many regions around the world. ViewSat aims to provide a fully scalable solution based on individual requirements for new and established services.

SM

What markets across the globe are particularly attractive to ViewSat? And why?

Awaes Jaswal

The MENA (Middle East, North Africa) region still holds a great attraction for satellite distribution providers, as the exponential growth reported in the last five years looks set to continue throughout 2014 and beyond.

Following on from the relaxation of important media laws and political changes, such as the Arab Spring, there has been an exponential growth in the requirement of satellite services.

ViewSat looks to support the growing number of services and channels across the MENA region and sees an exciting opportunity for further growth.

SM

When you look back upon your career, what project—or projects—bring a true sense of satisfaction to you?

Awaes Jaswal

The completion of the upgrade to our company's Guildford facility from a 60 channel capacity to 200+ in 2012 was a real achievement. The upgrade allowed us to support our customers from initial channel set-up to final transmission, all in a single location. As we have now outgrown this site and look to accommodate greater numbers in our new facility, this sense of achievement is infused throughout ViewSat.

For further information regarding ViewSat, please visit:
http://www.viewsat.eu/

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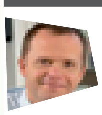

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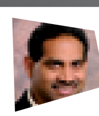

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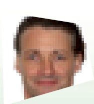

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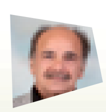

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The Changing Face Of Teleports

Teleports play an essential role within the satellite communications supply chain. Providing and managing services delivered, teleports are a satellite gateway with a variety of designs and network configurations.

Constantly evolving, teleports are becoming a bigger part of the telecommunications ecosystem to support a vast array of technologies, including Internet backbone access, server collocation and video-streaming. While satellite technology for the most part has not changed exponentially, platforms and technologies utilized by teleports are making innovative advancements, processing more data at faster speeds as the world's insatiable bandwidth appetite continues to grow; ultimately reorganizing the satellite industry.

Technology Drivers

The explosion of user demand for "anywhere, anytime" connectivity has driven satellite operators to build bigger satellites with increased capacity. Smart devices and data heavy applications such as video, the emergence of OTT television and advancements across DTH and UHDTV, as well as the increasing demand for commercial mobility requirements, have seen data levels soar. In fact, the research and analysis firm, NSR, projects that total industry revenues from leased C-, Ku- and Ka-band transponders—as well as the wholesale equivalent revenues from leased HTS and MEO-HTS capacity—is projected to top US$18.8 billion in the coming ten years. That's up from US$11.2 billion in 2012, demonstrating the ever-increasing demand for more and more connectivity.

Subsequently, the push for more capacity in the sky is driving change on the ground. This has resulted in more complex networks, as operators aim to meet user expectations which have been standardized by their day-to-day 'at home experience'.

As NewSat's chief technology officer, David Ball reinforced at the recent Australasia Satellite Forum, "one of the biggest success stories in innovation is on the ground. There have been tremendous

Pictured above: NewSat's Perth Teleport

achievements and advancements in that technology, becoming friendlier for the consumer. Previously, it had been difficult and complicated for customers to access satellite. New advancements make it efficient, affordable, and easy to use for customers."

Complexity Brings Risks + Rewards

The World Teleport Association (WTA) highlighted the evolution of the teleport segment, as well as the challenges and opportunities that come from complex networks in their recent report, *The Risks and Rewards of Delivering Complex Network Services*, defined as a network involving multiple inbound and outbound transmission paths, multiple media, data processing and management and ongoing network management systems, complex networks are now providing the solution to help meet customer expectations.

As highlighted by the report, essential technological advancements have assisted the role of teleports in the delivery of complex networks. Antenna manufacturers are developing products that enable multiple frequencies to be received such as Ultra High Frequency (UHF) through Ka-band while modem manufacturers have continually worked with DVB standards to increase throughput for many years, as well with higher-order modulation and adaptive coding and modulation to increase the transfer speed and mitigate weather conditions.

Further, the improvement of modems from processing 30-60Mbps to 100-200Mbps have increased networks' capabilities. Carrier-in-Carrier techniques now provide bandwidth savings. These are important technological advancements for teleports and enables them to deliver better service to their customers.

Teleport To Satellite Operator

Traditionally, teleports have been independently owned and operated, with satellite operators occasionally acquiring teleports to provide vertical services to end-users. One company that is presenting themselves differently is Australian based, NewSat. A key provider of commercial satellite services today, NewSat is currently making the transition from a teleport operator to that of a satellite operator with their Jabiru Satellite Program*.

NewSat's David Ball also said, "While the advancements made in the sky have been essential, the innovations on the ground have also been highly significant and have allowed NewSat to deliver the high quality services the company's customers have come to expect."

"Moving from a teleport operator to a satellite operator creates a unique position for us in the market. As a teleport operator, we have extensive knowledge of the teleport technology that has made our services more efficient and cost effective for our customers. Additionally, NewSat has the expertise to engage in the specific customer support required of a leading satellite operator."

The Future Of Teleports

As the WTA points out, a future where the ability to manage complex network services—and do it effectively, efficiently and with superb customer service—may well be a matter of survival for service providers both big and small, in every market that teleports serve.

While the future remains unpredictable, there is one trend that will continue moving forward: Consumers and organizations want more data "anywhere, anytime."

**NewSat will launch their first satellite, Jabiru-1 on an Ariane-5 ECA in 2015. Jabiru-1 is currently being constructed by Lockheed Martin. The satellite completed Critical Design Review in March of 2014.*

NewSat's Adelaide Teleport.

Full Steam Ahead For EO Differentiation

By Stéphane Gounari, Senior Analyst, NSR Ireland

Google's acquisition of SkyBox Imaging and the recent softening of the U.S.'s shutter-control regulations down to 25cm are two faces of the same coin. As more commercial companies provide sub-meter imagery, competition focuses on cost, thereby bringing profit margins down. To escape this low-profit scenario, Earth Observation (EO) companies need to differentiate themselves and create their own niche.

As NSR indicated in an October 2013 article, shutter-control regulations were softened for the benefit of DigitalGlobe in June 2014. The latter was seeing its commercial revenues increasingly threatened by competitors, launching satellites with increasingly lower resolutions thus transforming DigitalGlobe niche into a low-profit market. This move from U.S. regulation authorities creates a new segment solely addressable by DigitalGlobe thanks to its unique differentiation aspect (spatial resolution), which will mechanically allow for higher profit margins.

At the same time, Google's acquisition of SkyBox Imaging emphasizes another differentiation aspect: high-frequency revisit. The Skybox constellation has only one differentiation aspect: re-image the same area very quickly, a unique capability that Google will be able to monetize.

Beyond selling imagery (with good margins), Google will combine it with other data and propose a unique set of Information Products. Google's success is based on data; it has a unique know-how as well as tremendous tools to manage data and extract information. Skybox constellation's unique capabilities will be well leveraged by Google.

Both differentiation aspects will create new end-markets and new applications for EO-based Information Products. Most Defense & Intelligence organizations, as well as some large Public Authorities, already have access to imagery with resolution below 50cm.

SkyBox's imagery is, however, truly unique and may end-up being of use to both types of organizations. However, revenues from Defense and Intelligence and Public Authorities verticals will not grow at a fast pace, as both tend to internalize their processing and Information Products, limiting revenues generated by an uptake of imagery procurement.

Commercial verticals, and especially Energy & Natural Resources (Oil & Gas, Mining), Services

and Industrial should fully benefit from lower resolution and higher frequency revisit. As most of their Processing and Information Products is procured in the market, this uptake will boost revenues down the value-chain. As a result, commercial verticals will represent an increasing share of revenues.

Shutter-control regulations have become less burdensome as UAVs are not impacted and continue to offer better resolution. However, regulations are now mainly a tool for authorities to support their local contender. As such, the softening of the shutter-control regulations (and not their disappearance) to a level tailored for DigitalGlobe operational capabilities can be seen as a step to repeat the same strategy in a few years.

Keeping the shutter-control at 25cm forbids other players from proposing an even higher resolution, that DigitalGlobe does not currently propose, making it less interesting to invest into a 25cm resolution imaging capability (direct competition with DigitalGlobe, no niche) thus slowing down the inevitable catch-up from competitors. When they do catch-up, one could expect that DigitalGlobe will have an operational capacity with a lower resolution (to provide imagery to the U.S. government), and it will likely be the only one with such a capacity.

This strategy is possible thanks to the attitude of most regulation authorities. Adapting instead of taking initiative, they turn their national champions into followers focused on catching-up, and not on innovating to differentiate.

Differentiation is now more than ever necessary for commercial companies if they want to generate large profits. DigitalGlobe and SkyBox chose different strategies, but they illustrate the same trend: after years spent catching-up, EO Optical satellite operators now propose increasingly similar products.

The time has come for a new phase of innovation: the differentiation engine must now be at full steam.

About the author

Mr. Gounari is NSR's subject matter expert on Satellite-based Earth Observation, Satellite Manufacturing and Launch Services markets. In addition to authoring reports in his areas of focus, Mr. Gounari is involved in a wide range of strategic consulting projects, several related to communications satellite markets. Prior to joining NSR in 2010, Mr. Gounari acquired experience in business development through his experience at Ad Astra Rocket Company (Space Propulsion start-up). While at Ad Astra Rocket Company, he focused on identifying and assessing potential new markets for the VASIMR engine.

Thuraya — Not Your Father's Satellite Company

By Randy Roberts, Vice President of Innovation, Thuraya

The rise of "*Bring Your Own Device*" (BYOD) over the past few years has significantly transformed the world of mobile telecommunications. Whether it is a business executive accessing the office networks while on the move, or an offshore crew member using a smartphone and tablet to communicate, today's connected consumers demand the flexibility of using their personal devices.

Increasingly, these trends are no longer unique to the mobile, terrestrial sector—today they wish for access to more data applications with seamless transition between networks, and that includes satellite. At the same time, the success of companies such as Apple and Samsung has led to heightened consumer expectations for the satellite industry to innovate and create new, game-changing products.

Consider the growing consumer influence on how satellite products and services are being designed, developed and delivered. Consumer perceptions of satellite equipment have evolved radically to the point where hefty satellite handsets no longer fit the bill. End-users now expect satellite phones to come in a sleek form factor, with enhanced functions and data capabilities that allow them to access social media and popular apps with ease.

While staying ahead of the latest mobility trends can be a challenge, the opportunities for the satellite industry to embrace the new realities of BYOD are simply too compelling to ignore. The following consumer-oriented developments serve as strategic guideposts for satellite operators to rethink and transform their business:

Delivering solutions that address consumer demands across networks

We are seeing the emergence of new products and exciting application development that are bringing the industry another step closer to the seamless integration between terrestrial and satellite communications.

From the satellite perspective, this means taking a closer look at how consumer behavior is impacting the way mobile devices are being used—and being able to deliver the products and network coverage to keep pace with evolving consumer demands. Satellite operators also need to take into consideration whether the products they develop can support popular consumer handset platforms, such as the iPhone or Samsung Galaxy.

The introduction of new, consumer-oriented form factors such as the Thuraya SatSleeve—which provide access to satellite connectivity with greater ease and convenience—clearly reflects this trend. Satellite end-users no longer have to carry a dedicated satellite handset everywhere, and they are now able to access data applications via their personal device of their choice, even when operating outside of GSM coverage.

The convergence between the satellite and terrestrial mobile sectors is fast becoming the norm, and is already considered to be business-as-usual for Thuraya. With more than 360 roaming agreements with mobile network operators around the world, end-users are able to use Thuraya devices just as effectively over the Thuraya satellite network or on GSM networks.

Broadening distribution beyond traditional satellite sales channels

As the lines between terrestrial and satellite continue to blur, another strategic differentiator for satellite operators can be achieved through deepened collaboration with service partners in the mobile terrestrial space.

In order to succeed in the consumer sector, there is added impetus for satellite operators to adopt a business model and product development cycles that are on par with mobile operators. We foresee a growing trend for satellite devices to be sold through mobile operators or be commercially available directly at retail stores alongside consumer phones—in a slick form factor and user interface that are virtually identical to that of a consumer mobile handset.

Establishing an ecosystem dedicated to fostering innovative platforms

The increased consumer orientation also means that the satellite industry, as a whole, needs to develop new, competitive products, and get them to market faster.

Traditionally, satellite operators do not consider the applications that ride on top of their networks as being part of their core business focus. However, this way of thinking is rapidly being challenged. To meet the requirements of the consumer market, satellite operators are starting to place more focus on supporting partner ecosystems to foster new innovation streams.

As part of our efforts to establish an entire ecosystem that will respond quickly to market trends, Thuraya is delivering new tools and network capabilities that enable developers to accelerate the pace of product development.

An example is the recently launched Thuraya VIPturbo Module, which serves as the engine for developing new broadband terminals that ride on the Thuraya network. We believe the Thuraya VIPturbo Module holds great potential for empowering partners to develop innovative products that address the latest BYOD demands.

By focusing on addressing emerging consumer demands and the latest technology shifts, Thuraya is building the next generation of agile, market-focused satellite solutions.

This is not your father's satellite company.

For further information regarding Thuraya, please visit http://www.thuraya.com/

About the author

Randy Roberts is responsible for driving product and solution innovation strategy. Based in Dubai, Randy leads the product development, product management and solutions engineering teams. He is also responsible for managing the business intelligence team to drive continuous development and enhancement of Thuraya's product lifecycle management process.

Careers: The Age Factor—Are You Too "Old?"

By Bert Sadtler, Senior Contributor

Are you old? While such an inquiry may certainly not be appropriate in our modern society, this is definitely a relevant question in today's workplace. Upon further consideration, is "old" as relevant as it has been in past years?

None of us are getting any younger. As one ages, the internal voice naturally asks, "Can I still do my job? Can I do my job well? Am I valuable to the marketplace?"

The marketplace today continues to change and requires that professionals practice agility and nimbleness. One of the obvious changes involves the length of employment. In past years, it was normal for employees to retire after 25 to 30 years with the same employer. However, these days, the average length of service is approximately three to five years.

The shift in length of employment has several impacts on "old" that include:

- *If the average length of employment is approximately three to five years, then employers are no longer hiring for lifelong employment.*
- *Therefore, potential employees could be any age, as long as they are qualified.*
- *Essentially, today's professionals are interviewing for the current as well as their next role while they are performing in their current job.*
- *Agility and nimbleness are required for today's professionals to position themselves to solve current business problems while having less concern about the 20 to 30 years of experience in the same role.*

In this changing marketplace, a candidate is viewed as someone who can solve the organization's business problems. This usually involves having passion, energy, desire, ability, and being a fit with the organization's culture. Interestingly, none of the qualifications above are tied directly to age. In fact, someone who can add demonstrated experience to the above qualifications would be more valued.

To examine the age question from another angle, who is *not* asking the age question? The folks who are *not* asking "Am I old?" are the men and women who run their own business or lead their companies in one way or another. They are heads down, problem solving and delivering

value. They don't have the time to ask "Are you old?"... and that question is simply not relevant to them.

To further highlight the shift in the hiring paradigm, employers are under significant competitive forces to deliver measurable results, efficiently. This urgency has eliminated many of the employees who "filled a seat" because their employer remembered the days when that individual once helped they company—back in the day.

Today's business places a high value on employees who can solve problems. Think of the answer to the "old" question in terms of a word used at the top of our discussion: "Relevant."

"Old" was relevant in previous years because, if your were older, it meant you were closer to receiving the gold watch on your way to retirement. If you were unemployed, and you were also "old," that was usually a bad combination.

Most hiring managers don't much care about a candidate's age these days. They know the person they hire has a statistical three to five years with them before moving on to another job. Hiring mangers want to bring into their firms the person who can solve their business problems. What is "relevant" has moved from "age" to "Agility," "Nimbleness" and "Problem Solving."

"Are you old" is becoming synonymous with "Are you nimble?" I recently heard a CEO say that "nimble" is the new "smart."

The mention of a shifting paradigm infers change and movement. With today's business being all about change, "old" is frequently replaced by "new" and "newer." If business is about change, and being agile is about being smart, then "old" must be about the need to be smarter.

For professionals seeking a job, if you are asking yourself, "Am I old?" you are focusing in on the wrong question. Look at your peers (by age) who are business leaders. They are not asking about age. The job market that you wish to enter, or re-enter, wants problem solvers—someone with more experience may be a better choice than a "younger" candidate.

The relevant questions for today's job seekers are:

- *What do I need to do to show I have passion?*
- *How can I be nimble and agile in solving business problems?*
- *Once I am in a new role, how do I remain relevant?*

Good hunting.

About the author + Boxwood Search

Bert Sadtler is the President of Boxwood Search and a Senior Contributor for SatMagazine—There is a ongoing battle for senior level talent. A great hire can make a long term positive impact and a failed hire can prove to be very expensive. How does a company recruit and hire the right talent? It is more than just networking within the community of friends and business associates. It requires focusing on results through a process oriented approach. We are committed to reaching a successful outcome. Our recruitment method has repeatedly proven to deliver very qualified senior talent.

Contact Bert at BertSadtler@BoxwoodSearch.com for more information.

Understanding Your Source-Sink Solutions For Satellite Power Testing

By Ed Brorein, Marketing Applications Engineer, Agilent Technologies

Satellites—those man-made objects that orbit the Earth—have a variety of different uses, from broadcast entertainment and telephone communication to weather prediction and navigation services.

While their uses may differ, all satellites share a key requirement—the need for power. Some satellites harvest their power from the sun via solar array or photovoltaic (PV) panels. However, because of the satellite's spin and potential for the solar panels to be shaded, that power source is not constant. To compensate, the solar power is often supplemented with batteries that can be charged and discharged to provide a consistent power source to the satellite payload.

The job of controlling the power flow from the solar array panels to the batteries, and distributing a constant stable power source to the rest of the satellite, falls to the Power Control and Distribution Unit (PCDU). The job of ensuring the PCDU and satellite batteries perform as expected falls to the test engineer, and that's no easy task.

While there are three primary options for addressing this challenge, each has its own shortcomings that make it less than ideal. Fortunately, technology advances are now bringing an alternate option to light and it promises to address all the key requirements for satellite power test.

Understanding The Test Requirements

When testing a satellite PCDU or performing satellite battery testing, there are a number of requirements that must be met—perhaps the most important of which is that the solution be able to source and sink (load) power. This is critical as both the satellite batteries and battery management electronics in the PCDU have bi-directional power flow test needs (*Figure 1*).

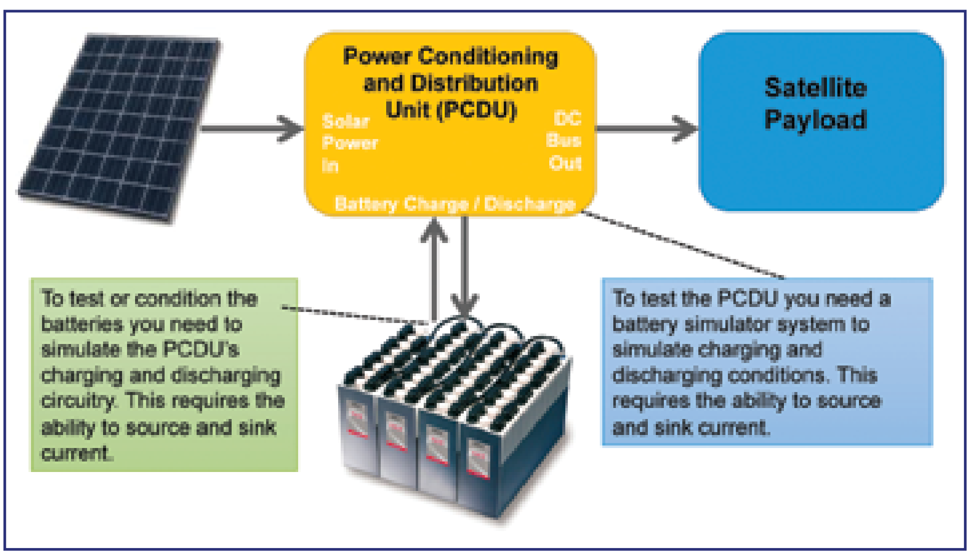


Figure 1.
Shown here is a simplified block diagram of the power flow of a satellite. The arrows going in both directions indicate the need for a solution that can source and sink power for testing.

For battery testing, for example, source power is needed to charge the batteries, while load power is needed to discharge the batteries. To test the PCDU, being able to simulate the charge and discharge of the batteries is critical.

Another requirement for a satellite power test, when testing or conditioning batteries, is for the solution to operate in voltage (CV) and current (CC) mode. For testing the PCDU, the solution should seamlessly transition between sourcing and sinking current without any disruptions or deadbands in the output. The ability for the solution to handle various load/Device-Under-Test (DUT) impedance conditions is also critical, as is the need for protection features, to limit settings and a fast reaction time to questionable test conditions. Protection, in particular, is critical for a number of reasons namely, because during satellite power test the batteries can explode and the DUT is typically very expensive and hard to replace. Having a source-sink solution that is able to tightly regulate its voltage and current, and react quickly to questionable test conditions helps minimize this risk.

Finally, the test solution must be able to deliver reasonable performance levels (*e.g.*, output noise levels and output level accuracy) to meet DUT test specifications, and be of a reasonable size and weight so that it can easily be integrated into a standard size test system.

Satellite Power Test Options

Three possible source-sink solution options for satellite power tests include a non-overlapping source-sink solution with deadband, an overlapping source-sink solution and an integrated source-sink solution. Each option has its pros and cons.

The non-overlapping source-sink solution with deadband combines a DC source and electronic load, as shown in *Figure 2 next page*. A diode may also be needed to prevent current from flowing into the DC source.

The solution provides a stable output, can handle dynamic load currents, and covers a wide power range. It operates primarily in CV mode, making it more suitable for PCDU testing. Its key disadvantage is that, due to the electronic load transitioning in and out of CV mode, it does not provide seamless, glitch-free operation. It is also quite complex, requiring the engineer to program and control

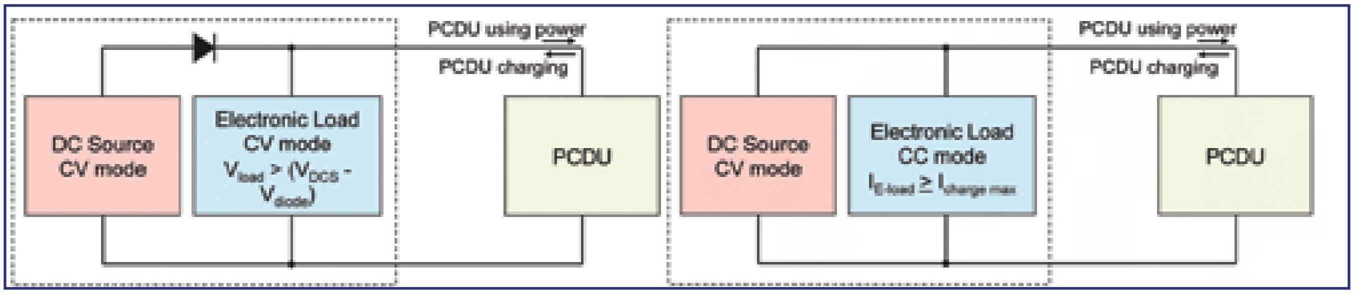


Figure 2.
The non-overlapping source-sink solution with deadband is shown on the left, while the overlapping source-sink solution is on the right; both are suitable for PCDU testing.

two instruments (the DC source and electronic load). Additionally, an external instrument such as a digital multimeter or shunt, is generally needed to ensure accurate, gap-free measurements.

Like the non-overlapping solution, the overlapping source-sink option uses an electronic load and a DC source; however, the DC source is a much higher power (higher current) and the electronic load is used in CC mode at a fixed level of at least the PCDU's maximum source (charge) current (*Figure 2*). Because of this, it does not have a deadband area and can maintain a constant voltage level when the DUT current transitions between sourcing and sinking.

While the solution does deliver a reasonably transient-free voltage response with no deadband, its size is a huge drawback. The DC source that's used has to be more than twice the DUT's power level, which results in a rather large power supply. Also, as the load is always dissipating power, it has a large energy usage footprint.

Making accurate current measurements is also challenging because the current is the difference of that between the electronic load and the DC source, meaning that the measurement uncertainty of each instrument must be combined. Moreover, to ensure the solution's stable and predictable operation, custom hardware may be needed. Although not depicted, battery testing requires a variation of the non-overlapping source-sink solution whereby the electronic load and DC source operate independently in constant current with voltage limits for limiting discharging and charging. Here, safety features are of primary concern and supplemental custom hardware is required over and above what protection features are built into standard electronic loads and DC sources.

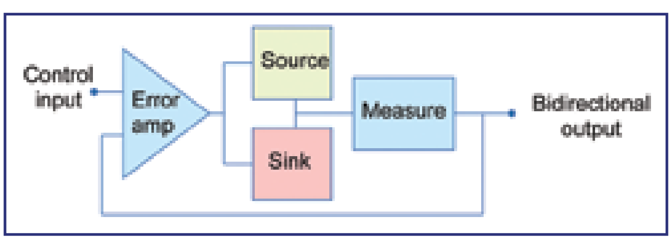


Figure 3.
Shown here is the configuration of a single instrument test solution with integrated sourcing and sinking.

The last option, the integrated source-sink solution, provides two-quadrant operation. This means that the power sourcing and sinking operation are control by a single regulation loop (*Figure 3 above*). As a result, it offers seamless operation when transitioning between sourcing and sinking, as well as consistent performance and operation whether sourcing or sinking power, all without the need to dissipate large amounts of power.

Another key advantage is that the solution, with appropriate voltage and current controls, can be used equally well for testing satellite batteries and PCDUs. A key disadvantage is simply that it's difficult to find an integrated source-sink solution that's within a satellite's power range (*i.e.*, kilowatt and greater power levels).

Linear DC power supplies offer an architecture that supports two-quadrant operation, but become too large at satellite power levels. The architecture of a switching DC power supply, on the other hand, provides a small test system footprint, but it doesn't easily support two-quadrant operation.

Overcoming The Disadvantages

Generally speaking, the most common approach for a satellite power test is to use separate instruments for sourcing and sinking, as is the case with the non-overlapping and overlapping source-sink solutions, because the instruments are readily available. The shortcomings of these solutions can be overcome by employing an integrated source-sink solution; however, the challenge here is to find a viable one. Fortunately, a number of new technologies are now making that search easier. The technologies include a bi-directional DC-to-DC converter, and a patented automatic down-programmer (ADP) and external dissipater (ED).

The DC-to-DC converter uses technologies including synchronous rectification to give it bi-directional power flow capabilities. Adding a bi-directional DC-to-DC converter capability to a switching power supply enables any stored energy at the output between the two conversion stages of the power supply to be discharged. The patented ADP allows down-programming to be performed on the DC bus. Essentially, it monitors and sinks current whenever the DC bus voltage begins to rise. The patented ED expands the bus monitoring and current sinking capabilities of the ADP, although unlike the ADP it is external to the power supply. With the ED in place, the power supply is able to achieve full source sink or two-quadrant operation.

When used together, these technologies enable the creation of an integrated source-sink solution, based off of a switching power supply architecture, which is controlled by a single regulation loop (*Figure 4 next page*). A prime example of one such solution is the Advanced

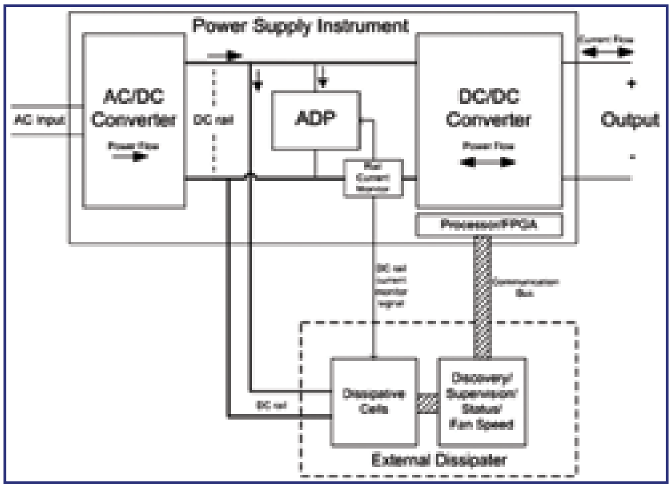


Figure 4.
Shown here is a block diagram of a switching power supply design with source-sink capability achieved through the use of a bi-directional DC-to-DC converter, ADP and ED.

Power System (APS) N6900 and N7900 family of system power supplies (*Figure 5*). These integrated source-sink solutions meet the solution requirements for satellite power test, while offering high precision and accuracy in an instrument-grade switching power supply architecture.

Using an integrated source-sink solution such as the APS offers a number of critical advantages over both the non-overlapping and overlapping source-sink solutions. To begin, whether sourcing or sinking current, the power supply uses a single regulation loop to control both. Consequently, the same specifications and performance are delivered regardless of whether the power supply is sinking or sourcing power. It also offers seamless glitch-free transitions between source and sink operation and does not waste large amounts of power.

There is also less hardware and software complexity since there is only one instrument to connect the DUT to and control via software. Additionally, no custom hardware is needed. Furthermore, since it's based off of a switching power supply architecture, the hardware size and weight is greatly reduced.

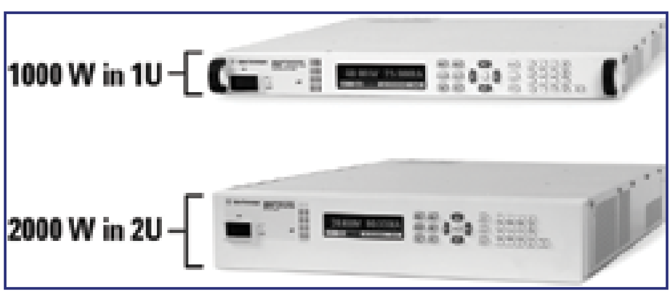


Figure 5.
Agilent Technologies' APS family of system power supplies comes in 1- and 2-kW power ranges, with the capability of being paralleled up to 10 kW. The family features two performance levels: the N6900 Series DC power supply, which is designed for ATE applications where high performance is critical, and the N7900 Series dynamic DC power supply, which is designed for ATE applications where high-speed dynamic sourcing and measurement is needed.

Solution Determination

While it's clear that a source-sink solution is needed to properly test satellite batteries and the PCDU, determining which solution to use is complicated by the fact that each has its own set of disadvantages. Today, the non-overlapping and overlapping options are most commonly employed, but the integrated source-sink solution offers a much more advantageous option; assuming one can be found.

That's where the development of a bi-directional DC-to-DC converter and patented ADP and ED technology have roles to play. These technologies have enabled the creation of an integrated source-sink solution in a switching power supply architecture. The solution meets all of the requirements for a satellite power solution, without any of the disadvantages of the other options—all of which is good news for any test engineer tasked with testing satellite batteries and PCDUs.

About the author

Ed Brorein is a marketing applications engineer with Agilent Technologies, helping customers using power products both in manufacturing and R&D. He joined Agilent (formerly Hewlett Packard) in 1979 and has worked as an R&D engineer, manufacturing engineer and marketing engineer in various roles. Over the years, Ed has been actively and deeply involved with the design, engineering and application of DC power products for testing of electronic devices and products. He received his BSEE from Villanova University in 1979 and an MSEE from the New Jersey Institute of Technology in 1987.

Agilent Technologies Becomes Keysight Technologies

On September 19, 2013, Agilent Technologies announced plans to separate into two publicly traded companies through a tax-free spinoff of its electronic measurement business.

The new company, Keysight Technologies, will began operating as a wholly owned subsidiary of Agilent on August 1, 2014 with a full separation anticipated in early November 2014. Keysight is expected to trade on the NYSE under the symbol KEYS.

Keysight is a global electronic measurement technology and market leader helping to transform its customers' measurement experience through innovation in wireless, modular, and software solutions.

Keysight provides; electronic measurement instruments and systems and related software; software design tools and services used in the design development, manufacture, installation, deployment and operation of electronic equipment.

Keysight—unlocking measurement insight.

Additional information is available at www.keysight.com.

Event: The NAB Shaping Of CCW+SATCON

The 2014 CCW+SATCON conference and expo, taking place November 12th through 13th in New York, is shaping up to be the most important fall event for the satellite industry in the US.

Following the purchase of the two co-located events by the National Association of Broadcasters (NAB) at the end of last year and a 22 percent increase in overall attendance, SATCON is attracting key players and conference sessions for the 13th consecutive year.

"We are excited about the positive response we have received from attendees, exhibitors, sponsors, advisory board members and industry partners to this year's show and the higher global visibility that SATCON and CCW will have as part of the NAB family of world-class trade shows and conferences," said SATCON Event Director and CCW+SATCON Sales Director, David Reynolds.

NAB is known throughout the broadcast, media and entertainment community for creating events offering high-impact experiences which they will now bring to CCW+SATCON, an event that already boasts a unique educational and high-touch networking opportunity as the East Coast's leading content and communications event.

Reynolds and the NAB conventions team are working closely with the SATCON advisory board to deliver: A full range of next-gen technology on the exhibit floor; cutting-edge sessions designed to expand knowledge and skills and provide actionable information; and valuable opportunities throughout the two-day event to exchange ideas and discover solutions not found anywhere else.

"This year's "*SATCON: Next-Gen Satellite Applications*" conference will deliver education for key segments in both the government and commercial markets. SATCON will feature industry thought leaders,

Photo of the Javits Convention Center at night.

policy makers, and business and technical experts speaking on many of the most critical topics shaping the future of the industry," added Reynolds. These topics include:

- *Multinational Military Satcom Challenges and Solutions*
- *Government Mobility Solutions*
- *Video for ISR Communications*
- *Hosted Payloads for Government*
- *Satellite for Emergency Response Communications*
- *HTS, Broadband and the Next Generation of Satellites*
- *Mobility Solutions for Aeronautical and Maritime*
- *Global Satellite Market Perspectives*
- *Satellite and the alternative technologies for distribution*
- *Satellite News Gathering - planning for live events*
- *Ultra HD's Potential Impact on the Satellite Operating Environment*

New for 2014, SATCON will offer a two-hour *MILSATCOM Acquisition Workshop* addressing the lessons learned from recent satellite acquisitions and how the deals were done.

The SATCON expo will feature the latest products and services from the major satellite operators and carriers, service and network providers, equipment manufacturers and integrators. Exhibiting companies will be showcasing everything from satellite antennas, down/up converters, modems, switches and test equipment to ENG/SNG, engineering services, IP Network Solutions, military satcom applications, mobile satcom, satellite services, distance learning solutions and everything in between.

All CCW+SATCON attendees will have access to both events' conference programs and exhibits, making it a well-rounded educational and networking experience for satellite communication professionals.

"An added value to SATCON attendees is the access to the CCW exhibits, conference sessions and vendor presentations, which will provide the latest information on content creation, management, distribution and delivery. If you are an end-user of satellite-enabled communications or an satellite industry executive, SATCON will provide you with a great opportunity to make personal contacts, network and gain valuable insights from the experts. Attendees will have networking receptions at the end of each day on the exhibitor floor and a special event for the Vision Awards winners on day one," said Reynolds.

Now in its third year, Satellite Markets and Research will be granting the *Vision Awards* at SATCON to deserving individuals, companies and products in the satellite industry in the following categories: *Visionary Executive of the Year*; *Most Promising Company of the Year;* and *Most Innovative Product or Service of the Year*. The winners of the 2014 Vision Awards will be awarded during a reception ceremony on November 12th from 6:00-7:00 pm. All SATCON attendees are invited to attend.

For more information on SATCON, please visit
http://www.satconexpo.com

To view the event schedule, please visit
http://www.ccwexpo.com/satcon/about/event-at-a-glance/

SATCOM For Railways

By Sunil Gupta, Senior Product Director, International Network Products Division, Hughes Network Systems

Rail travel has been an essential mode of transportation for centuries. Today, rail offers a distinct advantage over often congested air or automobile travel. Rail is a relaxing mode of travel that affords more leisure time which can be used for a myriad of purposes. Travelers today welcome that extra time to catch up on reading or emails at their leisure, surf the Web, or do other tasks that require high-speed Internet or Virtual Private Network (VPN) access. The foundation of all these activities is broadband connectivity.

As illustrated in *Figure 1 (on the next page)*, broadband data requirements for rail generally cover two broad areas—railway operations and passenger services:

- *Railway operations may include the exchange of critical data, including operational safety data such as maintenance systems status and emergency information, video monitoring using IP-based CCTV systems, telemetry data, and command and control systems known as Positive Train Control (PTC). This type of traffic is typically high priority.*

- *Passenger services include the data and voice connectivity that today's passengers expect. This type of Internet traffic includes activities like Web surfing, downloading videos and files, online gaming, and VoIP traffic. In addition to data services, linking of travelers' cellular phones via micro or picocells enables them to communicate even in areas where cellular towers do not exist.*

Forecasts show land mobile bandwidth utilization growing at a steady pace across both conventional Ku-band and High-Throughput Satellites (HTS), which are typically Ka-band *(Figure 2 on the next page*). Much of this growth will be on passenger rail transport, similar to the surge of airborne broadband.

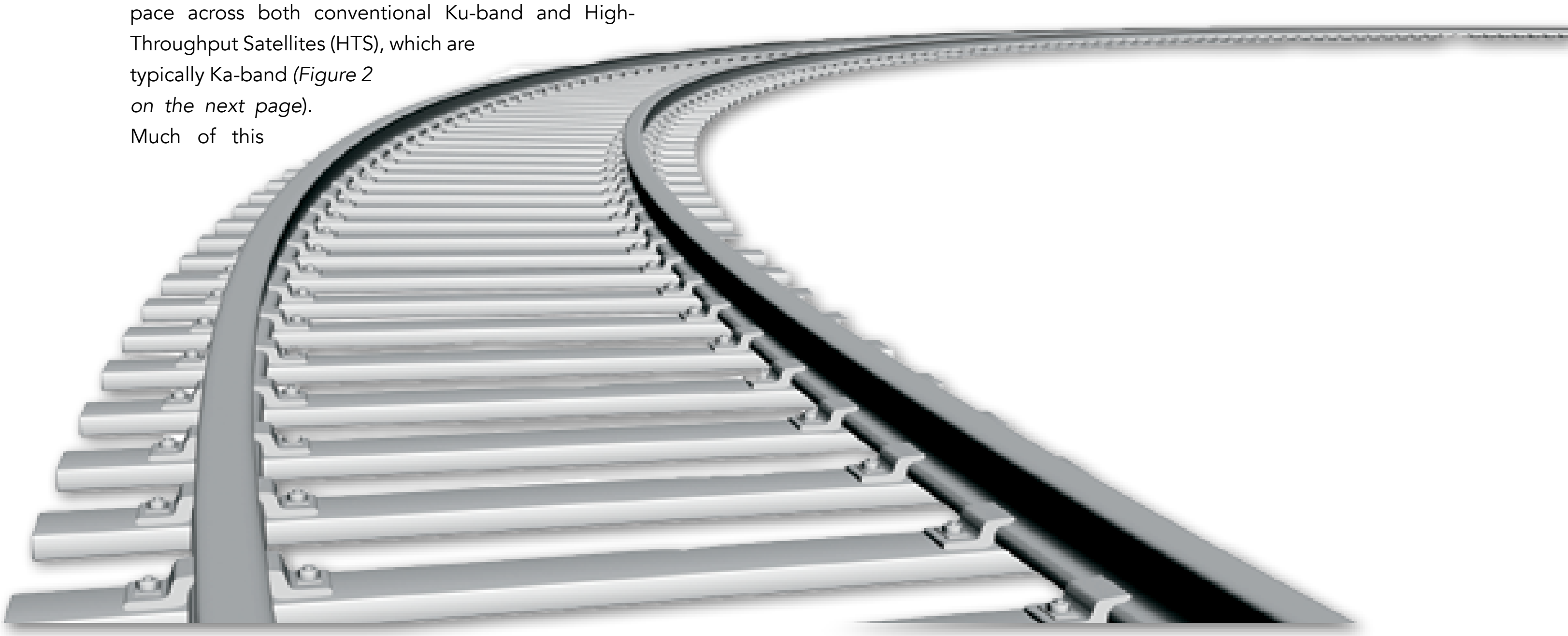
Similar to airborne broadband, the ideal networking technology for rail is via satellite. The use of cellular (3G/4G) services for backhaul is possible but is an incomplete option in the case of rail due to the high traffic requirements and typical gaps in terrestrial cellular coverage over the route of a long-haul train. A direct connection to cellular systems alone cannot meet the consistent quality expected by customers for the duration of a journey. Only satellite-based solutions can address these challenges in a comprehensive and cost-effective way, especially with the growing availability of less expensive Ka-band bandwidth.

The Unique Challenges Of Mobility

All mobility applications—airborne, maritime, and land-mobile alike—face similar challenges related to signal interference caused by physical line-of-sight (LoS) obstructions. But land-mobile is likely to face the most extreme and unpredictable obstructions (*Figure 3, two pages forward*).

The challenges unique to rail and ground-based vehicle mobility include:

- *Line-of-sight (LoS) blockage from buildings, trees, tunnels, and other structures*
- *Crossing of national and service provider boundaries*
- *Harsh physical environments, such as heat, vibration, and electro-magnetic interference*



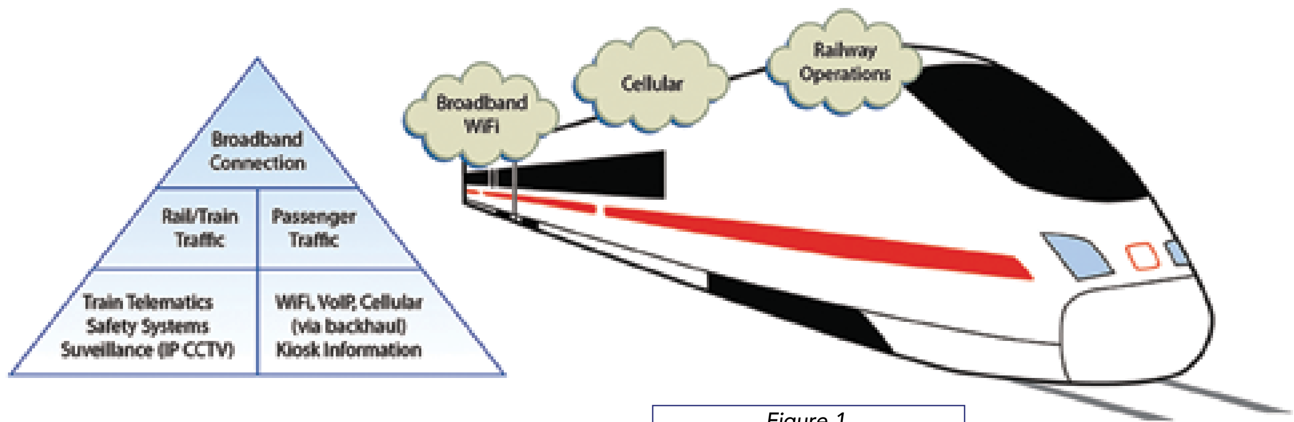


Figure 1.

Compounding these issues are additional challenges on high-speed trains:

- *Doppler shift*
- *Changes in signal levels due to movement within coverage beams*
- *Crossing satellite footprints and beams*
- *Limits in antenna size*

Synchronization

In a fixed satellite installation, the modem or router locks onto a synchronization signal received from the satellite. It's used to synthesize the transmit clock, which serves two purposes: it ensures the transmit center frequency is correct, and the burst timing is synchronized. In Time Division Multiple Access (TDMA) systems, this synchronization is crucial. Without it, bursts from different modems will not be aligned and can interfere with each other.

In rail mobility applications, the clear signal reception is not guaranteed due to the aforementioned obstructions. It requires that the regeneration of the clock for the transmission is derived from another source if interruptions occur for more than several seconds. In the case of short interruptions, typically less than 30 seconds, the modem's own internal clock can "free-wheel" or "fly-wheel" in order to bridge the gap. However, this free-wheeling is not sufficiently accurate over longer periods. In the absence of an external clock reference, the modem must turn off the transmitter in order to prevent problems with the transmissions of other terminals using the same in-route.

Challenges Of Position, Weather, Speed + Beam Switching

As a train moves across the footprint of the satellite beam, the receive signal level may vary, especially towards the edge of the beam. Changing atmospheric conditions may also cause receive and transmit signal degradation. To maintain a high-quality service, the satellite modem and hub must take these factors into account by dynamically

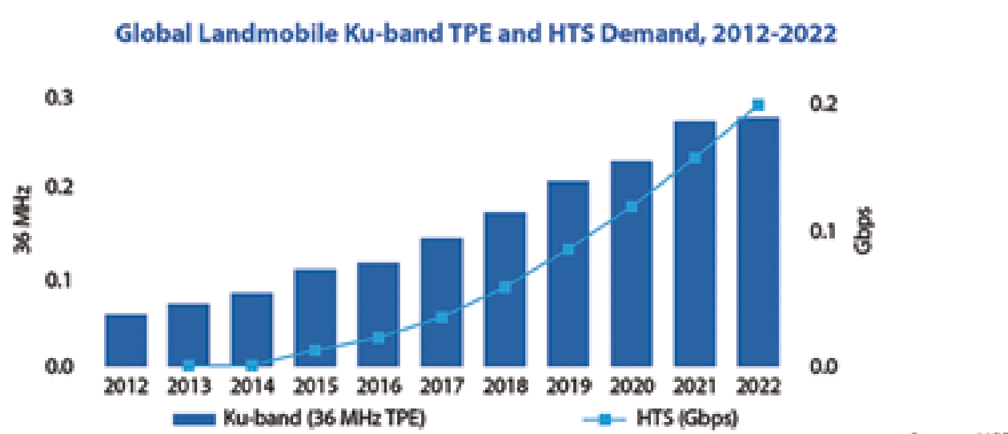


Figure 2.

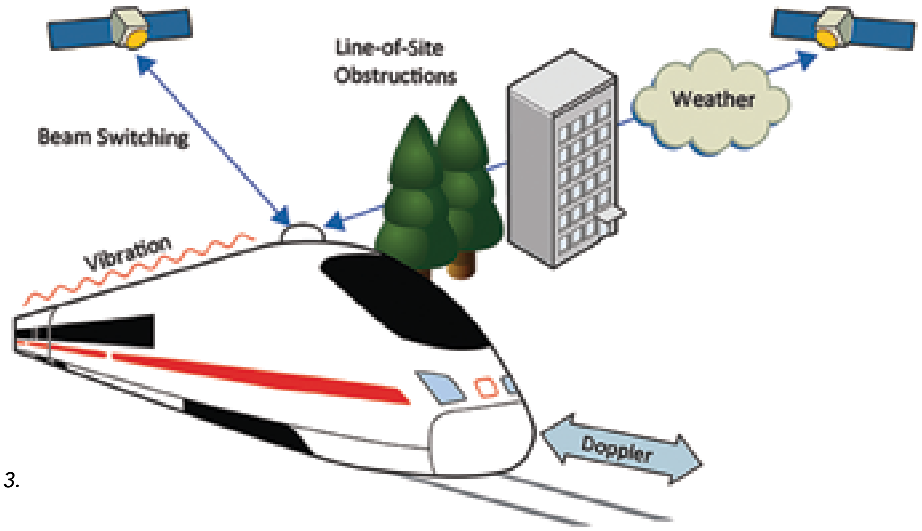


Figure 3.

changing the modulation and/or coding used, and by changing the transmit power in the satellite in-route direction.

Speed is another issue. The modem must also account for Doppler shifts in the signal. Doppler shifts cause changes in symbol timing, which has a worsening effect in the modem as modulation complexity increases. Therefore, it is crucial that the speed and direction of the train be known, so that algorithms can be applied to correct for the frequency shift.

In some cases, a train may cross from one satellite's coverage area to another. Or, as would be the case for the newer HTS satellites utilizing spot beams, trains move from one spot beam to another. In either scenario, the satellite system must be able to seamlessly hand off traffic from one beam to another.

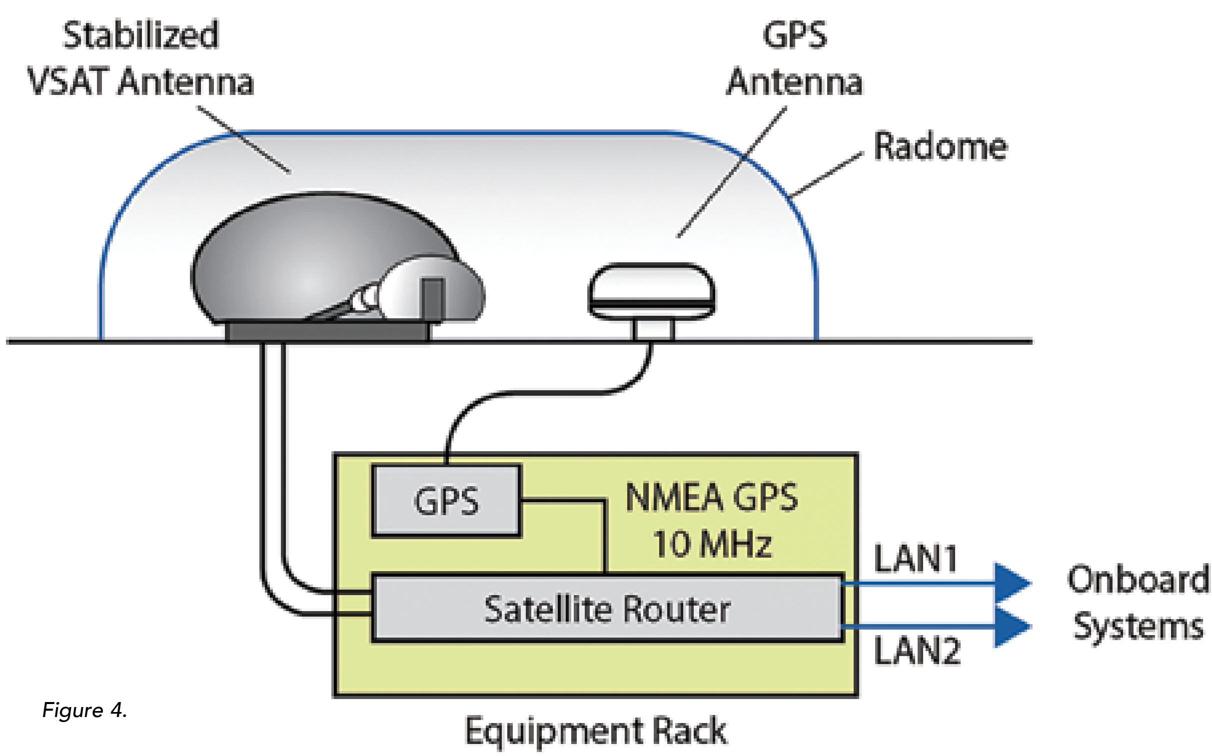


Figure 4.

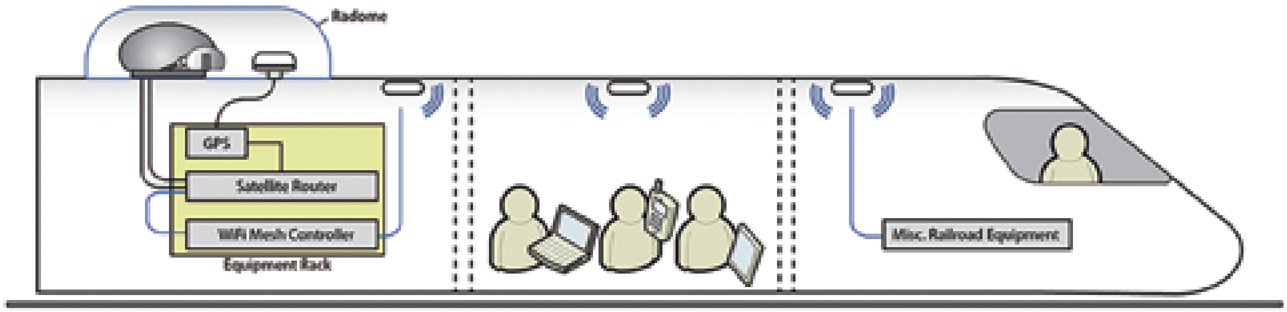


Figure 5.

Assessing Mobility Solutions

Choosing the right IP broadband satellite system to address these challenges requires doing some homework to ensure the solution can satisfy all the mobility requirements. Some of these include:

- *Full IPv6 support to future proof the network and accommodate a virtually unlimited number of user devices on board.*
- *Adaptive Coding and Modulation (ACM) to allow the downstream satellite channel to be continually optimized as the train travels through the various contours of the satellite footprint.*
- *TDMA Channel Spreading to overcome issues with off-axis emissions and enable the use of very small antennas to mitigate adjacent satellite interference.*

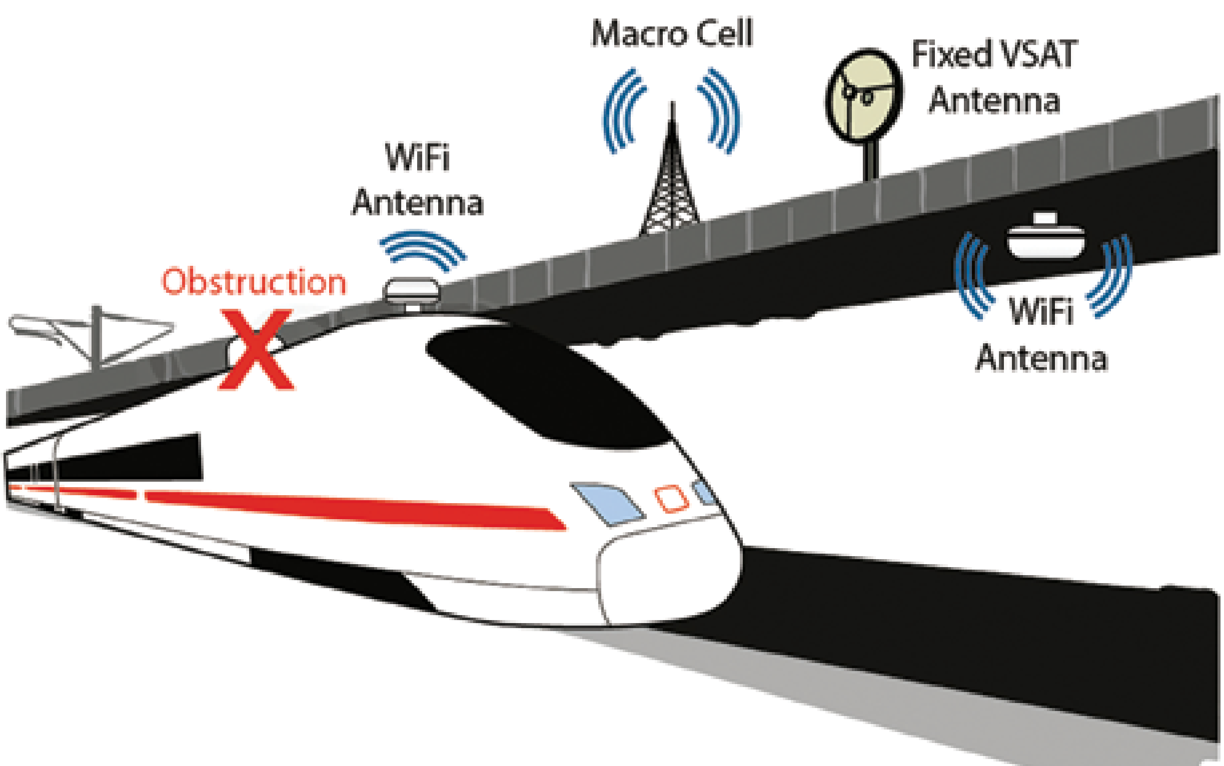


Figure 6.

- *Doppler Compensation to counter balance frequency shifts.*
- *IP Steady State to maintain IP sessions during even prolonged periods of link outages, such as when a train travels through a tunnel.*

- *Ruggedized Chassis to withstand environments of high heat, humidity, dust, and vibration.*
- *Automatic Beam Switching to determine location and timing to command the antenna to switch to a new satellite.*

Linking All Together

The basic satellite infrastructure required on board the train includes a stabilized very small aperture satellite terminal (VSAT) antenna, a GPS receiver, and the satellite gateway/router system (*Figure 4, two pages back*).

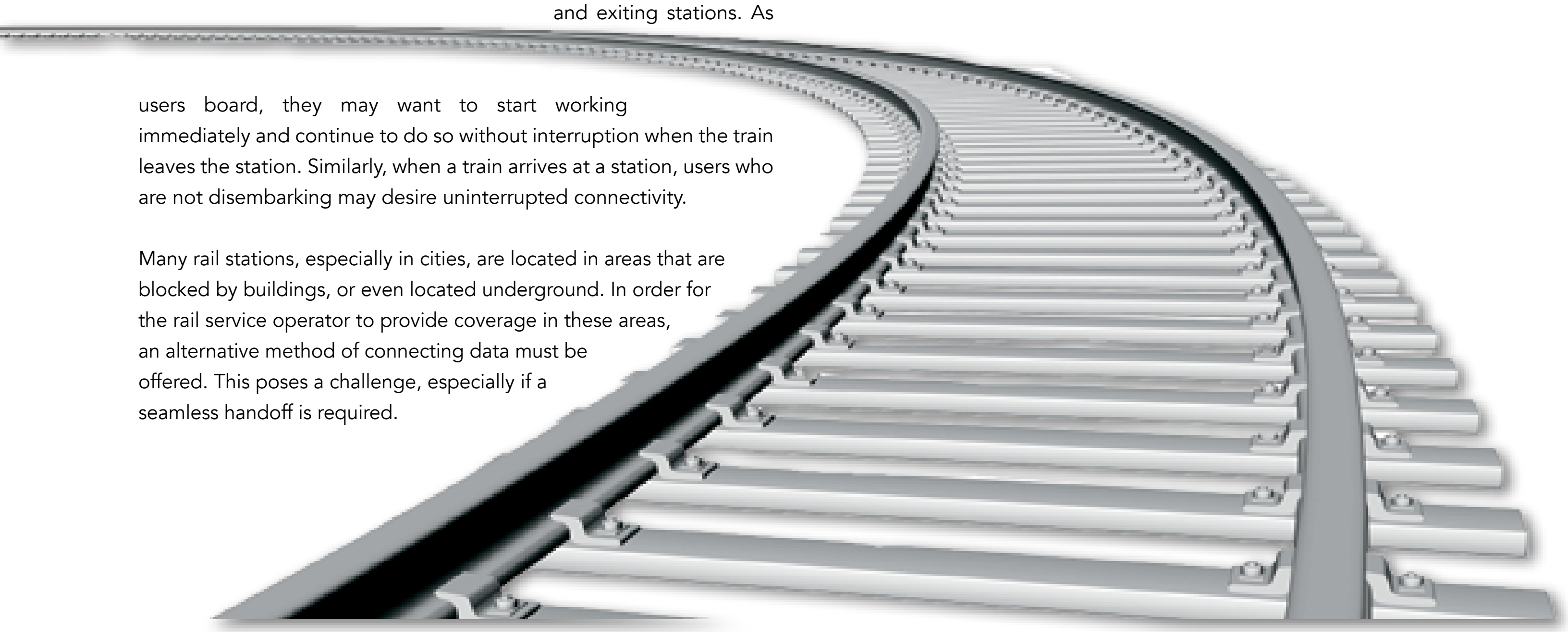
Because the network traffic shares a single transmission path, it is vital that the services be differentiated. A good satellite system should provide support for VLANs, QoS and rules-based routing in both directions. This allows the highest-priority traffic, such as train telematics and voice traffic, to take priority over lower priority traffic, such as passenger Internet access.

In some cases, the constant addition and removal of rail cars from a train prohibits the use of a wired (LAN) infrastructure on the train. A WiFi mesh network may be better suited to implement the onboard LAN/WLAN, especially for shorter trains (*Figure 5 on previous page*). However due to the inherent linear nature of trains, inter-car wiring may be required—particularly for longer trains—in order to prevent WLAN bottlenecks. Enterprise-grade WiFi mesh systems should support multiple VLANs, Service Set Identifiers (SSIDs) and simultaneous multi-band in order to provide the separation of data, connectivity for devices, and other features necessary to implement this architecture.

Continuity Of Services

Continuous connectivity onboard a train may be desired when entering and exiting stations. As users board, they may want to start working immediately and continue to do so without interruption when the train leaves the station. Similarly, when a train arrives at a station, users who are not disembarking may desire uninterrupted connectivity.

Many rail stations, especially in cities, are located in areas that are blocked by buildings, or even located underground. In order for the rail service operator to provide coverage in these areas, an alternative method of connecting data must be offered. This poses a challenge, especially if a seamless handoff is required.



One solution is to use a fixed VSAT terminal at each station and switch the onboard connectivity to the fixed VSAT. The system then hands off the WiFi users from the onboard access points to those located in the stations

(*Figure 6 on the previous page*). (Fixed VSAT installations can also be used to provide coverage via WiFi relay in tunnels.)

Cellular handoff would not require any additional infrastructure from the rail operator; however, the handoff from the onboard microcells or picocells to the macrocells in the rail stations may not be completely seamless to users. Dropped calls may occur when calls are handed off from the relatively high-latency backhaul provided by the satellite connection to the relatively low-latency connection that the macrocell uses.

Conclusion

Everybody expects connectivity everywhere, especially while traveling. Train operators seeking to provide mobility solutions for operational use and customer enjoyment are best served by adopting Satellite-On-The-Move (SOTM) broadband, due to the technology's ability to provide high bandwidth, broad coverage and uninterrupted service in an always changing, unpredictable railway environment.

About the author

Sunil Gupta is a Senior Product Director in the International Network Products Division of Hughes Network Systems

Futron's 2014 Space Competitive Index—
An Executive Summary

Nearly 60 years after Sputnik, we live in a world transformed by space. Communications satellites link the globe, providing information and connectivity to hundreds of millions of people instantly. The weather forecast that determines our weekend trip, the electronic map that plans our route, and the global positioning system that guides us along the way are all enabled by spacecraft orbiting overhead. Beyond these practical applications, space activity has greatly enlarged our understanding of the universe. By reaching beyond Earth, humanity has traced its own origin story back to the cosmos.

Today, the same impulse that led our ancient ancestors to seek out what was beyond the next mountaintop animates governments, enterprises, entrepreneurs, scientists, and citizens to pursue frontiers beyond our planet. Relentless curiosity, the quest for resources, the desire for knowledge, and an instinctive drive to push outward toward new horizons all combine to inspire space activity.

Alongside these, of course, are the motivations of the modern nation-state: competitive advantage, technological development, scientific understanding, economic growth, global prestige, and security enabled by command and control of the strategic environment offered by space.

At the national level, space has always represented simultaneously a competitive and collaborative endeavor. Countries accrue tangible benefits from space activity—benefits that can set them apart from their peers. At the same time, space by its very nature reinforces the notion that people across separate societies are more united in their similarities than divided by their differences. Just as the Earth appears small when viewed against the enormity of outer space, human disputes can seem trivial alongside the promise of combined space exploration efforts. Accordingly, since the dawn of the space era, countries have sought to balance between unilateral and multilateral space activity, calibrating their approaches over the decades depending on both the larger geopolitical context and their own respective capabilities and limitations in resources, technology, and national will.

Whether nations have conducted space activity together or separately, the effect on the everyday lives of people has been profound. Yet these uses of space services by individuals are the legacy of even greater, and ongoing, demands from governments, militaries, enterprises, and institutions: for launch vehicles capable of sending missions into orbit or beyond; spacecraft to connect globally dispersed populations, armies, and assets; systems to geo-locate people and equipment anywhere in the world; imagery of the Earth and its resources from above; and technology to serve a US$300 billion market.

In the 21st century, space has been transformed from an object of wonder to an arena of geopolitical, economic and strategic consequence. To understand this arena, and the motivations informing the national and business actors operating within it, a structured framework is required. Leaders who seek to maximize their investments in space activity require a nuanced and rigorous analysis of its changing dynamics. Futron Corporation, a premier provider of decision management solutions, created its annual, independent, and self-financed Space Competitiveness Index (SCI) for this express purpose.

The Space Competitiveness Index is a decision management tool. It offers decision-makers an ongoing benchmark to continuously re-assess the competitive landscape of space activity—and to contemplate its meaning for their respective governments, enterprises, and institutions in an organized way. Now in its seventh year, the SCI methodology has been annually updated and refined. The accumulated seven years of data and analysis contained in this report offer salient insight into the strengths, weaknesses, trends, recent developments, and likely trajectories of 15 leading space-participant nations.

Futron's Space Competitiveness Index is a globally-focused analytic framework that defines, measures, and ranks national competitiveness in the development, implementation, and execution of space activity. By analyzing space-related government, human capital, and economic drivers, the SCI framework assesses the ability of a country to undertake space activity, and evaluates its performance relative to peer nations, as well as the global space arena.

The SCI considers comparative space activities for 15 leading space actors, offering a comprehensive overview of their recent, current, and planned future activities, their national capabilities and competitiveness

Space Competitiveness Index (SCI) Report Elements

	Nation / Space Actor	Notes	2014 SCI Findings Summary	Review of 2013 Activities	Projection of the Year(s) Ahead	National Space Capability and Competitiveness Overview	Government Profile	Human Capital Profile	Industry Profile	Strengths, Weaknesses, Opportunities, and Threats
	Argentina	3 years of data (added 2012)	✔	✔	✔	✔	✔	✔	✔	✔
	Australia	3 years of data (added 2012)	✔	✔	✔	✔	✔	✔	✔	✔
	Brazil	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Canada	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	China	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Europe	As Integrated Space Actor	✔	✔	✔	✔	✔	✔	✔	✔
	India	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Iran	3 years of data (added 2012)	✔	✔	✔	✔	✔	✔	✔	✔
	Israel	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Japan	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Russia	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	South Africa	3 years of data (added 2012)	✔	✔	✔	✔	✔	✔	✔	✔
	South Korea	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔
	Ukraine	3 years of data (added 2012)	✔	✔	✔	✔	✔	✔	✔	✔
	United States	7 years of data (2007-2013)	✔	✔	✔	✔	✔	✔	✔	✔

dynamics, their government, human capital, and industry attributes, and their relative strengths, weaknesses, opportunities, and threats.

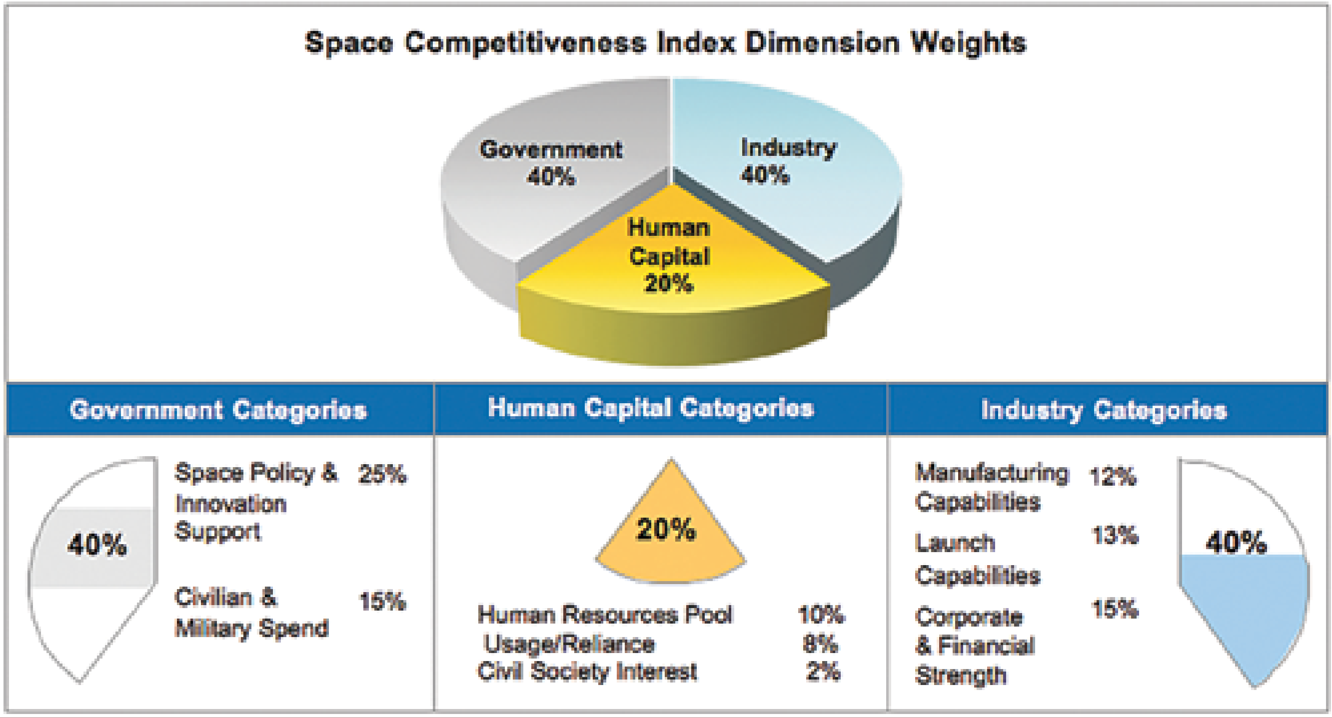
These nations are compared across some 50 individual qualitative and quantitative metrics, each collected for all 15 nations. These metrics are divided among three overarching competitiveness dimensions: government, human capital, and industry.

Futron evaluates these indicators using a proprietary data model whose assumptions are annually reviewed and refined. The resulting scores form the foundation of the index itself, which is then interpreted through a written analysis featuring country-by-country profiles of national space activities and competitiveness dynamics. The integrated result is an annual report, published by Futron Corporation each year since 2008: Futron's Space Competitiveness Index.

Since Futron's inaugural study in 2008, space globalization has only accelerated. Some countries with zero participation in space seven years ago now have space agencies; others with negligible space involvement have significantly increased the scope of their activities. Recognizing this change, in 2012, for the first time, Futron added five new emerging nations to its Space Competitiveness Index. These five nations are retained, and tracked alongside the original 10 countries, in the 2014 SCI.

One distinction of the SCI is its assessment of Europe as an integrated space actor. The activities that European countries undertake through individual space agencies such as ASI, CNES, and DLR are significant. Nonetheless, recognizing that the whole is more than the sum of its parts, Europe has chosen to pool national resources for a multilateral space approach through ESA. While the

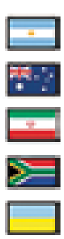
Space Competitiveness Index (SCI) Basic Model Framework



SCI considers European national activities, our analytic focus is on Europe as an integrated space actor.

In 2014, Futron has reviewed its foundational 2008-2013 studies to provide a fresh perspective, surveying multi-year trends to enhance discussion of national dynamics. Futron's 2014 SCI expands its country profiles, providing added data on space assets, infrastructure, budget, and commercial sector revenues. In addition, the 2014 SCI continues to use an optimized written analysis structure, designed to accommodate the interests of both casual readers and executive decision-makers.

- Argentina
- Australia
- Iran
- South Africa
- Ukraine



Key Space Competitiveness Themes

Global space activity drives a substantial economic engine, fosters national pride, and advances science and exploration. Some countries invest in space for the domestic esteem and international respect associated with independent technological and infrastructure capabilities. Others focus more on the benefits derived from satellite science, communications, imagery, and resource management.

While nations engage in space to pursue different outcomes, the overarching themes of space competitiveness share common linkages: government policy, national security, science and technology, educational infrastructure, workforce mobilization, and economic strength. Together, the civilian, military, and commercial space sectors focus the broader space discourse around key questions such as the relative competitive position of traditional space leaders, the role of emerging space powers, and the aims of newer or smaller space participants. This study seeks to address pivotal and timely strategic questions about space power and competitiveness:

- *What are the core elements of space competitiveness? Are they changing, and if so, how?*
- *As space participation decentralizes from governments to companies, and even to individuals and entrepreneurs, how will the nature of space activity evolve?*
- *In this second decade of the 21st century, how will nations leverage both competitive and collaborative strategies to achieve or accelerate their space goals?*
- *How does space competitiveness impact the broader socio-economics of nations and regions?*
- *As the global economy recovers from the slowdown of the past few years, how has the focus of government and enterprise space plans evolved to keep pace with the changing environment?*
- *How deeply has U.S. space competitiveness been impacted by the loss of its domestic human spaceflight capacity, and what will be its effects on the future of the U.S. space program?*
- *What dynamics will shape the interplay among the three traditional, and current, leading space actors: the United States, Europe, and Russia?*
- *How will China's rapid achievement of space milestones shape its behavior in the coming decade?*
- *As Japan builds on its Basic Space Law and subsequent reforms, will it convert positive administrative momentum into stronger mission tempos and deeper regional space leadership?*

- *Will India's new launch and spacecraft platforms finally expand its commercial market share?*
- *Will Canada sustain increased levels of space funding tied to the RCM, or revert to lower levels?*
- *How smoothly will South Korea transition from the recent success of its KSLV rocket to its next set of very ambitious space goals, including the landing of a rover on the Moon by 2020?*
- *Will Israel's new higher civil space budgets provide sufficient underpinning for its entrepreneurial startup sector and established prime contractors to expand their international market presence?*
- *As Australia transitions from intensive space policy formulation to more gradual implementation, will slower momentum and political distraction reduce its tempo of space development?*
- *As its international profile rises, will Brazil follow through on its Alcântara plans, even as its two launch partners, Russia and Ukraine, are distracted by geopolitical conflict with each other?*
- *Will Argentina leverage its commercial satellite manufacturing niche toward a more global role?*
- *How can Ukraine use its space industrial base to gain first-mover advantage in emerging markets?*
- *How can Iran collaborate with other nations in civil space while assuaging military space fears?*
- *Will the South African private sector assume a larger role in the country's new space investments?*
- *How will the geopolitical crisis between Russia and Ukraine affect the space competitiveness of both countries? How will it affect Brazil and other partner nations? And how will it affect the global launch and satellite manufacturing supply chain?*

To offer perspective on such questions, Futron Corporation has provided this 2014 update of its Space Competitiveness Index. Some top-level findings of the SCI follow.

Summary Highlights

- Argentina continues to adapt its satellite manufacturing sector for the international marketplace, exploring both commercial and government-to-government deals. It stands to benefit from increased investment in spacecraft subcomponents.
- Australia's space re-emergence continues, with the government reviewing national policy segment-by-segment, focusing on the uses of space to Australian society—although momentum may be stalling as Australia pivots from policy formulation to implementation. The Australian private sector is assuming a larger role, including non-traditional entrepreneurial startups.
- Brazil is re-examining its national space priorities, but also reducing its civil space funding. As the global spotlight falls on Brazil in 2014 and 2016, its next space steps are a wide open question.
- Canada has experienced a small bounce in its space competitiveness, and retains a skilled space workforce, but ongoing implementation challenges threaten to offset these advantages.
- China trailed the United States in orbital launches in 2013 for the first time in two years, yet continues to far outpace others emerging in the speed with which it achieves new space milestones. Yet its commercial space role lags behind, and is beginning to reduce its competitiveness.
- Europe's governance approach is organized enough to mobilize competing national priorities into collective action, yet flexible enough to fluidly accommodate new member states. How well it mediates the fateful question of Europe's next-generation launch vehicle will be an important test.
- India has raised its game, developing fully indigenous launch vehicles and a mission to Mars.
- Iran has made faster progress than any new space participant since the Cold War, but fairly or unfairly, questions about the tenor of its program—civilian or military—impede collaboration.
- Israel has finally implemented civil space funding increases and published new policies, but lack of industry scale continues to limit its commercial space presence, despite a vibrant startup sector.
- Japan continues to improve, thanks to its thorough space policy reforms, and has enjoyed recent commercial progress. Its ability to increase its launch and mission frequency and assertively market its commercial benefits are important to its future competitiveness and regional leadership.
- Russia has surged, largely restoring its launch success rate, remaining vital to ISS resupply, weighing long-term independent space station plans, and developing its new Vostochny Cosmodrome. Yet its annexation of Crimea strains its relationships, and may stall its resurgence.
- South Africa continues to develop its space policy and human capital base, but its technology and industrial base remain negligible despite the important Square Kilometer Array (SKA) project.
- South Korea's KSLV success has helped bolster its credibility. The key now is to ensure this success does not go unnoticed, but instead build upon it to pursue commercial space goals.
- Ukraine has advanced in competitiveness even while suffering turmoil domestically. Yet it struggles to commercialize its space industrial base, and overlooks key emerging markets.
- The United States remains the leader in space competitiveness, but is the only nation to decline for seven straight years. As other countries enhance their space capabilities while the U.S. undergoes uncertain transitions, it should not view its unique space agenda-setting power as guaranteed.
- International collaboration is increasingly taking shape as a concerted competitiveness strategy.
- Four distinct space competitiveness tiers have emerged. The first tier of traditional space leaders is dynamic, but relatively stable. The second tier of Asian space powers is intensely competitive: each country could plausibly surpass its near-peers within a short period of time. The third and fourth tiers are

highly diversified: nations with disparate activities can attain similar scores, but for different reasons. And throughout, small gaps in score results can lead to large gaps in rankings.

Relative Space Competitiveness Changes By Country

A critical benefit of the SCI is the ability to track competitiveness trends over time, supported by statistical analysis. Since introducing the SCI in 2008, Futron has identified notable movements among leading space-participant nations, now supported by seven years of tracking data, which are detailed in the 2014 edition of the report. For instance, of the 15 countries analyzed, only the United States has shown seven straight years of competitiveness declines. By contrast, China, Japan, Russia, and India have improved their own space competitiveness by 35 percent, 44 percent, 20 percent, and 16 percent, respectively, over their own relative starting points from when Futron's benchmarking process began in 2008.

The SCI also allows direct comparisons between individual nations. The table below offers a preview of relative competitiveness changes. Positive scores (in green) indicate competitiveness gains, while negative scores (in red) indicate competitiveness losses. For instance, Japan gained 0.14 basis points in overall space competitiveness relative to China, while Canada lost 2.31 basis points against Russia.

2014 SCI—Historic Trends

In addition to providing a framework for analyzing current space competitiveness, Futron's 2014 Space Competitiveness Index equips decision makers with the ability to review trends over time.

To provide background and context, Futron has analyzed the past decade of space activity, based in part on spacecraft manufacturing and orbital launch activity among the 15 nations assessed in the SCI. The results are shown on the following page. Additional historic data and discussion are included in the full report.

The Full Report Outline

Although data analysis from the past decade can show us where we have been, the real question is: where are we going?

The full report version of Futron's 2014 Space Competitiveness Index features approximately 160 additional pages of research and analysis including:

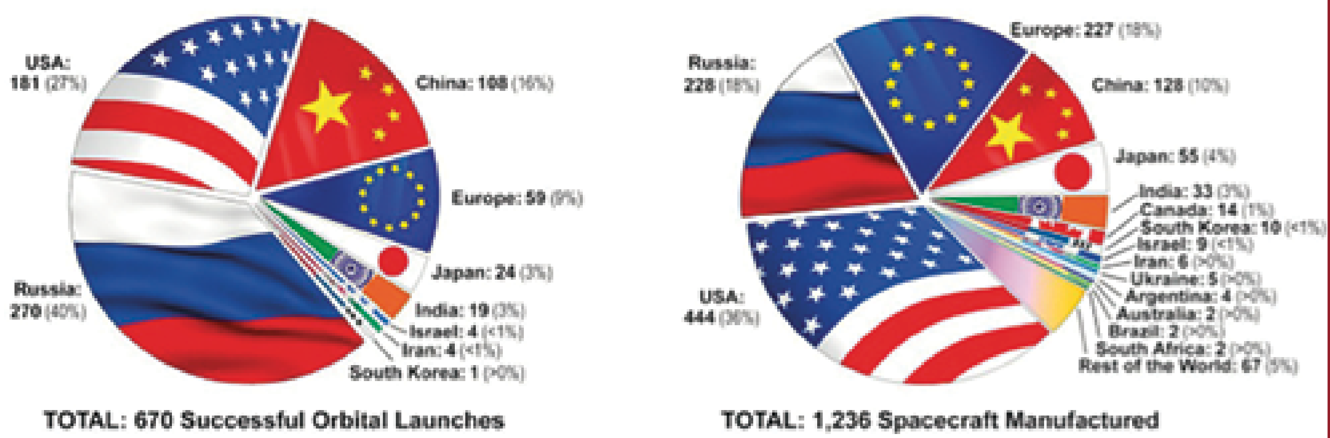
- *An Introduction offering insight into the SCI concept, purpose, methodology, and structure, as well as overarching themes driving the evolving discourse regarding space competitiveness.*

  » *Newly added in 2014, the introduction features a longer discussion of emerging countries besides those assessed in the 2014 SCI. Futron briefly speculates on which countries could constitute "The Next 15," and includes highly abbreviated mini-profiles of four Southeast Asian space-participant nations—reflecting a region whose space activity has increased notably in the past few years.*

RELATIVE COMPETITIVENESS CHANGES BY COUNTRY, SCI 2013 TO SCI 2014

	Argentina	Australia	Brazil	Canada	China	Europe	India	Iran	Israel	Japan	Russia	South Africa	South Korea	Ukraine	USA	
Argentina	0.00		-0.30													
Australia		0.00										-1.02				-0.92
Brazil			0.00											-0.38		
Canada				0.00							-2.31					+0.66
China					0.00				-1.01							
Europe						0.00									+1.53	
India							0.00						-1.07			
Iran		+0.35						0.00								
Israel								+0.60	0.00							
Japan					+0.14					0.00						
Russia							+3.05				0.00					+2.98
South Africa	+0.92											0.00				
South Korea										+1.84			0.00			
Ukraine						-0.95								0.00		
USA				-1.39											0.00	

Orbital Launch and Spacecraft Manufacturing Trends, 2004-2013



- *Added data on national space assets, infrastructure, budget, and commercial sector revenues.*
- *Optimized country-by-country profiles of each nation's space activities and plans, featuring:*
    - » *2014 Index Findings*
    - » *Competitiveness Changes Relative to Other Leaders*
    - » *Overview of 2013 Activities*
    - » *Preview of The Year Ahead*
    - » *National Space Capabilities and Competitiveness Overview*
    - » *Government*
    - » *Human Capital*
    - » *Industry*
    - » *Strengths, Weaknesses, Opportunities, and Threats Analysis*

In addition, the extensive full data set used to produce the 2014 SCI, featuring more than 60 spreadsheets of supporting metric information, is also available.

For further details, please visit the Futron website at **http://www.futron.com**.

Illustration of Space Competitiveness Index (SCI) Concept

Collection of Space Indicators	Structured Data Analysis Model
• Collects 50+ metrics on space activity • Provides statistical benchmark for future studies • Develops method to quantify non-numeric indicators • Assesses proxy metrics where raw data is unavailable • Identifies areas of metric incongruity across countries • Provides a reference point for future analysis • Creates robust database of space indicators	• Aggregates data into three categories: - Government, Human Capital, and Industry • Weighs statistics into a robust model • Provides a point-in-time ranking • Includes 15 leading space-participant nations • Offers decision-makers quantitative benchmarks • Creates discourse around space competitiveness
Country-By-Country Written Profiles	**Structure for Segment "Deeper Dives"**
• Reviews 10 years of launch and manufacturing data • Compares top space companies and transactions • Tracks data trends year-over-year • Details country-by-country space sector • Evaluates core drivers of national competitiveness • Surveys space markets throughout the world • Assesses national strengths, weaknesses, opportunities and threats (SWOT)	• Provides framework for analyses of multiple space segments and stakeholders • Enables summarized assessment of each segment • Sets stage for detailed indexes for strategic sectors: - For example: Exploration, Military Space, PNT, Remote Sensing, and Space Technology Base • Identifies indicators specific to an industry segment • Opens door to segment-specific issues and drivers