

Worldwide Satellite Magazine – October 2015

SatMagazine

Off To Orbit

Arianespace
Galileo 8 + 9 / Sky Muster + ASTRA-2

China
Qianshao-3 / Gaofen-9 / Beidou

India
Astrosat / LEMUR x 4 / LAPAN-A2 / NLS-14

Russia
Express AM-8 / COSMOS MILSATs x3

United Launch Alliance
MUOS-4



SatMagazine

October 2015

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SatMagazine is published 11 times a year by SatNews Publishers, 800 Siesta Way, Sonoma, CA 95476 USA, Phone: (707) 939-9306, Fax: (707) 939-9235 © 2015 Satnews Publishers

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Spaceflight Goes Big For The 'Wee' Ones—Smallsat Ridesharing

Spaceflight, one of the companies reinventing the model for launching small satellites into space, announced the purchase of a SpaceX Falcon 9 rocket and the expansion of its launch services to include dedicated rideshare missions.

Spaceflight's first dedicated rideshare mission, named the "2017 Sun Synch Express," will launch in the second half of 2017 to a sun-synchronous Low Earth Orbit (LEO), which is popular for Earth imaging satellites. Dedicated rideshare is a new launch alternative that blends cost-effective rideshare pricing with first-class service typically associated with buying a private rocket.

Spaceflight's dedicated rideshare missions will deliver customer spacecraft to popular destinations, such as sun-synchronous and geosynchronous transfer orbits, and provide a new solution for smaller satellites that cannot afford a complete launch vehicle.

"By purchasing and manifesting the entire SpaceX rocket, Spaceflight is well positioned to meet the smallsat industry's growing demand for routine, reliable access to space," said Curt Blake, President of Spaceflight's launch business. "Our purchase of a private rocket further continues our mission of providing a customer-focused, full-service launch experience."

Spaceflight's dedicated rideshare routes are not tied to any particular primary satellite mission, so commercial and non-commercial smallsat operators using the service will benefit from the certainty of set launch schedules that were not previously available to rideshare customers, and can thereby avoid delays resulting from geo-political issues or primary satellite schedule changes.

This enables customers with spacecraft that range in mass from 5 to 2500 kg to create long-range mission plans to Sun Synch and GTO with more dependable launch dates. Spaceflight is creating steady access to space with yearly dedicated rideshare missions planned beginning in 2017.



Spaceflight's 2017 Sun Synch Express mission manifest includes satellites as small as 5 kg 3U CubeSat up to 575 kg satellite. Over 20 satellites will be deployed during the mission, with commercial customers pursuing a range of endeavors and government-sponsored scientific research originating from six different countries. The manifest is nearly at capacity.

"Dedicated missions for Rideshare-class payloads are an excellent way to promote space enterprise and research," said Gwynne Shotwell, President and COO of SpaceX. "We are pleased that Spaceflight has successfully brought this multi-faceted partnership together."

Spaceflight has launched 81 satellites to date and has more than 135 satellites to deploy through 2018. The frequency of satellite

launches, combined with Spaceflight's cross-section of customers and variety of mission-applications, is a strong indicator of the growing capabilities of small satellites and the need for more timely and cost-effective access to space.

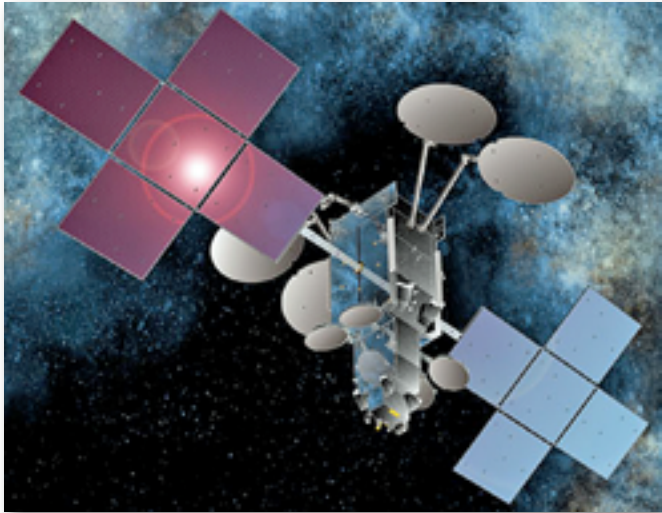
In addition to the new dedicated rideshare service, Spaceflight will continue to manifest small satellites as secondary payloads aboard several launch vehicles around the world to a variety of orbit destinations.

Spaceflight is the only rideshare launch provider that publishes launch pricing and schedules online, aiming to make access to space as easy as booking an airline ticket.

www.spaceflight.industries/

Maneuvers Make Good

Space Systems/Loral (SSL) announces the company's advanced satellite designed and built for nbn, Australia's new broadband network, which was launched yesterday (see the Launch-O-Rama feature in this issue), has successfully performed post-launch maneuvers, all according to plan.



Artistic rendition of Sky Muster. Image is courtesy of SSL.

The high capacity broadband satellite deployed its solar arrays on schedule following its launch aboard an Ariane 5 launch vehicle from the European Spaceport in Kourou, French Guiana. The satellite will initiate the firing of its main thruster tomorrow morning in order to propel the spacecraft toward final geosynchronous orbit.

The satellite, known as Sky Muster, is an all Ka-band, high-throughput broadband satellite (HTS) that uses multiple spot beams in an advanced design that tailors capacity to Australia's widely distributed population. It is designed to provide service to hundreds of thousands of Australians who do not otherwise have access to high speed Internet and will supplement the fixed line and fixed wireless services provided by nbn.

Originally called NBN Co 1A, the satellite was renamed "Sky Muster" by the six-year-old winner of a country-wide contest. The satellite is the first of two that SSL is building for nbn. The two satellites will work in conjunction with one another to deliver fast broadband throughout Australia, and its coastal islands and external territories including Norfolk Island, Cocos Island, Christmas Island, and Macquarie Island in the Antarctic.

Sky Muster is based on the highly reliable SSL 1300 platform, which has the flexibility to support a broad range of applications and technology advances. Sky Muster is the 100th SSL 1300 satellite that SSL has delivered, providing tangible evidence of the platform's evolution to accommodate payload advances. The satellite is designed to provide service for 15 years or more. With this launch, there are 81 SSL-built GEO satellites currently on orbit.

Local Launches For Smallsats In The Middle East... "Space For All" Vision

Swiss Space Systems (Holding) SA, through its subsidiary S3 Middle East, announced a major partnership with D&B Group to deliver access to space with the Middle East.

The goal is to develop, manufacture, certify and operate unmanned suborbital shuttles to locally launch small satellites up to 250 kg by 2019.

Swiss Space Systems (Holding) SA has announced the signature of a major investment and partnership agreement from D&B Group to open an S3 Middle-East subsidiary, and to develop access to Space from the Middle East. This investment has far-reaching implications for S3's continued global expansion plans. The "Space for All" vision of S3 is progressively earning its reputation through a commitment to aerospace excellence.

For this, the ambitions of Middle Eastern countries are complementary and appreciative of Dr. Amin Abbas Forati chairman of the D&B group for his efforts and for selecting the UAE from among the Arab countries to become the first country to have this technology. With the opening of S3 Middle East, the D&B group will introduce the UAE to joining other space launcher countries.

The advanced technology of reusable spacecraft launching systems, combined with recent small satellite innovations, enable applications such as analytics and monitoring of primary resources, pollution, migrations, natural disasters, strategic asset surveillance, and global Internet connectivity.

The D&B Group specialize in financial consulting, natural resource trading and ecology. Today, they are expanding the scope of their activities into space, through their key collaboration with S3. The D&B Group was founded in 1999 by Dr. Amin Abbas Forati, and it has strong presence in Middle East and Africa.

According to D&B Group CEO, Dr. A. Forati, "I live in Dubai and I have seen the



country's spectacular transformation over the last 15 years. The UAE is the country where everything is possible, a country where the vision of a man—of many men—can become reality, a bit like S3. I would like, modestly, to provide the UAE, with the possibility to become the first Arab Nation to own its own spatial technology, not only in the field of launching satellites but in the conception of revolutionary satellites, as well.

Through a recent campaign of seeking for strategic investors, S3 is proud to have now signed a partnership agreement with D&B group to work towards building a successful partnership with the D&B Group.

Pascal Jaussi, founder and CEO of Swiss Space Systems said, "This highlights how S3

is becoming a trusted partner of the United Arab Emirates, where independent access to space is a key priority. I am convinced that S3 and D&B will work successfully towards the goal of opening a new vision for a common space future in the region."

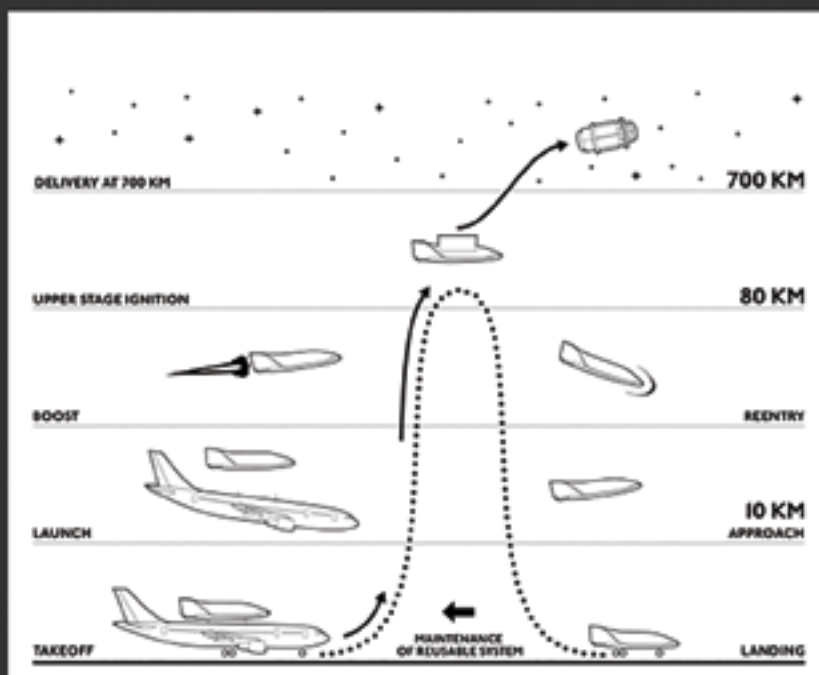
The official inauguration of the S3 Middle East office will occur during the Dubai Air Show in November 2015, at the Emirates Tower on Sheikh Zayed Road, Dubai (UAE), with a live video transmission from S3 Headquarters in Payerne, Switzerland,.

Swiss Space Systems partnerships include space industrial companies such as Dassault Aviation, Kuznetsov, RKK Energia, Thales Alenia Space, as well as academic and scientific networks worldwide.

The academic network of S3 will also be opened to Emirati students in the near future.

www.s-3.ch/

FLIGHT OPERATION



Arianespace Announces AVUM's Arrival

Only recently received at the Spaceport, is the liquid upper stage for a November flight that will use Arianespace's lightweight Vega vehicle.

This upper stage—known as the Attitude and Vernier Upper Module (AVUM)—arrived aboard the MN Toucan, a roll-on/roll-off sea-going cargo ship that is used by Arianespace for the transport of launcher components from Europe to South America.

The AVUM will help push Europe's LISA Pathfinder scientific spacecraft to a 500,000 km-by-800,000 km halo orbit around the first Sun-Earth Lagrange point (located 1.5 million km from Earth). Developed by Italy's Avio, the AVUM is the only liquid propellant system on the four-stage lightweight launcher and



The AVUM for Arianespace's Vega mission with Europe's LISA Pathfinder scientific spacecraft is unloaded from the MN Toucan roll-on/roll-off sea-going cargo ship after docking at the Port of Pariacabo in French Guiana.

Photo is courtesy of Arianespace.

is stacked atop Vega's solid propellant first, second and third stages.

LISA Pathfinder's goal is to help test and validate the technology in space needed for

detecting low-frequency gravitational waves, which are ripples in space-time predicted by Albert Einstein's theory of general relativity.

Test masses carried by the spacecraft will be put in a near-perfect gravitational free-fall, controlled by electrostatic fields. LISA Pathfinder's onboard sensors and systems will control and measure the masses' motion with unprecedented accuracy.

Vega is the smallest vehicle in Arianespace's launcher family, which is in operation from French Guiana along with the medium-lift Soyuz and heavy-lift Ariane 5. Production of Vega is the responsibility of industrial prime contractor ELV—a company jointly owned by Avio and the Italian Space Agency.

SSTL's DMC3/TripleSat's First 1 Meter High Resolution Optical Imagery Released

The first 1-meter high resolution optical satellite imagery from the DMC3/TripleSat Constellation satellites has been released.

This follows the successful launch of the three Earth Observation mini-satellites on an Indian PSLV in July and in-orbit commissioning and calibration by engineers from Surrey Satellite Technology Ltd (SSTL: www.sstl.co.uk/). The very high resolution imager on board the satellites provides 1-meter native ground sampling distance (GSD) in panchromatic mode and 4-meter GSD in multispectral mode with a swath width of 24km.

The Twenty-First Century Aerospace Technology Company Ltd (21AT), a



The three DMC3 constellation satellites, flight ready in SSTL's clean rooms before they were shipped to the launch site in June of 2015. Photo is courtesy of SSTL.

commercial Earth observation satellite operator based in Beijing, has purchased 100 percent of the imaging capacity of the three satellites for seven years to provide their satellite data services from the TripleSat Constellation. 21AT will also create new applications for customers and business opportunities for worldwide partners through its operational information services powered by the TripleSat Constellation.

The wide swath width of the imagers combined with agile off-pointing will enable the TripleSat Constellation to target anywhere on Earth at least once per day and provides the best combination of spatial resolution and time resolution—aiming at stimulating operational monitoring applications, such as urban planning and intelligent management, based on changes detected by timely, regular, cloud-free, very high-resolution imagery.

The DMC3 satellites were placed into a 651km sun-synchronous LEO by a PSLV-XL launch vehicle from the Satish Dhawan Space Center, Sriharikota launch site in India on July 10, 2015. The launch was provided by ANTRIX and the Indian Space Research Organization (ISRO).

The DMC3 satellites in the TripleSat Constellation are phased 120 degrees apart around the same orbit using their on-board propulsion systems. 21AT has contracted SSTL to provide satellite platform services for the Constellation in orbit.

The DMC3/TripleSat Constellation satellites use the 450 kg. SSTL-300S1 series platform, which provides 45 degree fast slew off-pointing and is capable of acquiring multiple targets in one pass using multiple viewing modes. SSTL has already manufactured a fourth SSTL-S1 Earth Observation satellite for another customer and has a production line ready to deliver further satellites of this type. In agreement with 21AT, future satellites may have the opportunity to join the TripleSat Constellation.

Sir Martin Sweeting, SSTL's founder and Chief Executive, welcomed a comment from Dave Parker, Chief Executive of the UK Space Agency, who said, "Congratulations to SSTL on the acquisition of these one meter resolution images of our planet from the DMC3 constellation—a real demonstration of technical precision. SSTL's expertise in small satellites plays a major role in the space sector's 3.6 billion euros contribution to the UK economy through exports."

Milestone: The One Hundredth 1300 Platform

Space Systems/Loral (SSL) announces the company has reached the milestone of 100 satellites built on the SSL 1300, a platform designed to accommodate evolving technology and innovation.

The 100th 1300, which was delivered to launch base on August 26, is a highly advanced broadband satellite that will provide fast Internet service to homes and businesses across the continent of Australia and its external territories.

The first 1300, called SUPERBIRD-A, was launched in 1989 for Space Communications Corporation (SCC), a Japanese provider of commercial satellite services that subsequently became SKY Perfect JSAT. Named after its original dry mass of 1,300 kg., the satellite platform evolved out of a project to develop a 3-kW satellite, which was the highest power ever achieved at the time. Compared to SUPERBIRD, today's 1300 provides eight times the power, 30 percent longer life, and can accommodate four times as many transponders.

As a company that embraces innovation, in the 1980s the engineering team was forward looking in creating a platform that allowed new technologies to be introduced incrementally. The success of this approach, which maintains heritage and carefully manages risk, can be seen in the fact that each generational change has proven to be more reliable than the previous generation. Today's 1300, while readily identifiable as a descendant of SUPERBIRD, is in fact, built on all new technology.

The SSL 1300 is one of the world's most popular satellites and there are more SSL 1300s currently on orbit and providing commercial service than any other model communications satellite. Over the years it was the first platform to incorporate many innovations.

- **The first satellite to use a 100 volt bus and Direct Radiating Collector (DRC) amplifiers, providing the higher power needed for DTH television**



Artistic rendition of the SUPERBIRD-A satellite. Image courtesy of SSL.

- **The first true high throughput satellite, an advance which now enables millions of people around the world to have access to high speed broadband**
- **The first to reach 20-kW of power, which enables satellite broadcast of today's HD and UltraHD television**
- **The first satellite to provide two-way ground based beam forming, which increases a satellite's flexibility to meet changing business requirements**

Other advances...

- **The 1300 was one of the first platforms to use shaped antenna reflectors, which enable precisely defined coverage areas**
- **The 1300 was the first Western satellite to use electric propulsion, which reduces mass allowing for more payload power or a less costly launch. Today there are 18 1300s with electric propulsion on orbit**
- **The 1300 was one of the first platforms to incorporate lithium-ion batteries, which have 50 percent less mass than the nickel-hydrogen batteries they replaced and helped to enable higher power satellites**

- **The world's two highest capacity broadband satellites currently providing service are built on the 1300 platform**

The 100th 1300 for the new broadband network (nbn™) in Australia, exemplifies how the platform has evolved. It is the first 1300 to mount eight large antenna reflectors using a unique boom configuration providing 101 spot beams in two different sizes.

With more than 125 transponders, throughput capacity is precisely tailored to a highly varied geographic user distribution. Other innovations include advanced low noise amplifiers to improve RF performance and it is the first satellite to use a third generation high capacity battery for reduced mass. SSL continues to qualify advances for future use on the 1300 with a focus on adding flexibility and standardization.

The company is working closely with its customers to incorporate innovations that will support the high performance, better economics, and increased accessibility that will broaden the appeal of satellite-based solutions. The 1300 will continue to provide the value and adaptability that satellite operators need to support next generation applications and SSL is working to ensure that the next one hundred 1300s reflect dramatic improvements in cost, schedule, mass and flexibility.

"Over the 30 plus years that I have worked in the industry, the demand for satellite services has seen considerable growth," said John Celli, president of SSL. "At the time of the first 1300 we had no idea that there would be demand for high definition television, or that people on planes and ships would want to browse the web. The delivery of the 100th 1300 is tangible evidence of the success we have had in implementing new technology to serve changing markets, while at the same time preserving the heritage and on orbit performance that our customers require."

www.sslmda.com

More Launches For Arianespace

Arianespace announces the company has signed a contract with the Argentinean operator ARSAT (Empresa Argentina de Soluciones Satelitales Sociedad Anónima) to launch its next geostationary satellite, ARSAT-3, plus options on two more launches.

This strategic long-term agreement follows last year's successful launch of ARSAT-1 on October 16, 2014, and comes a few hours before the now-successful launch of ARSAT-2. The agreement will cover Argentina's satellite launch requirements until 2023.

With a liftoff mass of approximately 3,000 kg., ARSAT-3 will be the first satellite launched, delivered to geostationary transfer orbit in 2019. It will be injected by an Ariane 5 from the Guiana Space Center, Europe's Spaceport in French Guiana.

The two options involve two geostationary satellites that are similar to ARSAT-3, and for which their launches are planned for the 2020-2023 timeframe. These new ARSAT satellites will complement the services already offered by ARSAT-1 and soon ARSAT-2. They will provide a wide range of telecommunications services, including data transmission, telephony and TV broadcasting.

Following the signature of this contract, ARSAT Chairman and CEO Matias Bianchi, said, "Today, we have once again chosen the world's most reliable launch service provider, Arianespace, to orbit our upcoming satellite, thereby strengthening Argentina's dual role as constructor and operator.

Through this planned new satellite, ARSAT supports Argentina's policy for the development of the national satellite industry, as expressed in

the bilateral space cooperation agreement signed by the Argentine Minister of Planning, Mr Julio De Vido, and the French ambassador to Argentina, his highness Jean-Michel CASA.



NASA's Smallsats To Push The Boundaries Of Space-To-Earth

NASA is preparing to launch a set of miniature satellites that push the boundaries of space-to-Earth communications for CubeSats, as well as testing the ability of two small spacecraft to fly in close proximity to each other.

The Optical Communications and Sensor Demonstration (OCSD) project is funded by NASA's Small Spacecraft Technology Program (SSTP) within the agency's Space Technology Mission Directorate (STMD).

The OCSD effort includes two flight demonstrations: a single satellite in the first demonstration and two satellites in the second demonstration.

Yes, space is big...but these satellites are ultra-small. As built, each OCSD CubeSat weighs just 5 pounds (2.5 kg) and measures 10 cm x 10 cm x 17 cm (about 4 inches x 4 inches x 6.7 inches). The Aerospace Corporation in El Segundo, California, manages the OCSD project.

"This first OCSD demonstration will be very important," notes Andres Martinez, deputy program manager for Small Spacecraft Technology at NASA's Ames Research Center at Moffett Field, California.

That first CubeSat, Martinez explains, carries a 6-watt laser to demonstrate high-speed optical transmission of data from Earth's orbit to the ground. The laser system is much more compact than anything previously flown in space.

"Laser communications is very important, not just for NASA but for other U.S. government agencies as well," said Martinez. Optical data rates achieved by OCSD spacecraft are expected to be a speedy 200 megabits per second (Mb/s) or higher, he adds—100 times faster than current high-end CubeSat communications systems. "This little mission is a huge achievement for STMD and for small satellites in general," Martinez notes.

The initial OCSD mission, with the one satellite, is slated for launch on October 8 aboard an Atlas rocket from Vandenberg Air Force Base in California.



The Optical Communications and Sensor Demonstration (OCSD) project uses CubeSats to test new types of technology in Earth's orbit. This work was funded by NASA's Small Spacecraft Technology Program under the Space Technology Mission Directorate.

Image is courtesy of NASA/Ames Research Center

Once in orbit, the small satellite will evaluate the ability to precisely point itself as it demonstrates data transfer by laser. That laser is hard-mounted to the spacecraft and beam steering is accomplished through precision pointing of the spacecraft as a whole, says Richard Welle, director of the Microsatellite Systems Department at The Aerospace Corporation.

"Laser communications is very important as it enables the transmission of data from high value science experiments, imaging and other sensors," Welle observes. "Also, watching how well the attitude control system on the satellite operates is also critical," he points out. "There's no auxiliary steering system. You just point the whole spacecraft at the target on the ground," Welle says.

Bursts of laser data from the satellite will be received high atop Mt. Wilson in California, north of Pasadena, at The Aerospace Corporation's Mt. Wilson Optical Communications and Atmospheric Measurements (MOCAM) station. It houses a 12-inch (30-centimeter) diameter Cassegrain telescope outfitted with a photodiode detector.

"It looks nothing like a traditional satellite communications system. It makes use of an optical telescope rather than your typical radio frequency dish antenna," Welle points out.

The Optical Communications and Sensor Demonstration (OCSD) project uses CubeSats to test new types of technology in Earth's

orbit. This work was funded by NASA's Small Spacecraft Technology Program under the Space Technology Mission Directorate. Credits: NASA/Ames Research Center

Optical downlink sessions between the small spacecraft flying overhead and the ground station are expected to last no more than three minutes.

The second OCSD mission—using two satellites—is slated for launch early in 2016. Lessons learned from the earlier flight are to be rolled into the second mission. But along with laser communications testing, the dual CubeSats are also to perform proximity operations.

"The whole concept of being able to fly small satellites in close proximity and in a controlled fashion is a big deal too," said NASA's Martinez. Using special sensors and camera gear built for this mission permits relative position measurement between the two small satellites, which is a capability not previously demonstrated.

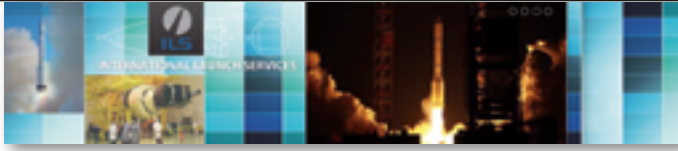
The capacity to maneuver CubeSats relative to each other makes possible a diversity of tasks. In-space observation of other satellites becomes feasible. That ability also opens the door to servicing or connecting small spacecraft together to form larger systems or networks in space.

There's little doubt that the OCSD project is a harbinger of things to come.

"But we need to learn how to crawl before we walk," Martinez emphasizes, and OCSD provides just that type of progress.

Without the support of NASA and STMD, Welle says, there would have been a significant delay in terms of getting this satellite technology into orbit.

"I think the key value of small satellites is the way it encourages very rapid turnover of technology," Welle adds. "It's kind of like the electronics revolution where you achieve next generation technology in a few months, instead of years."



International Launch Services (ILS) has appointed Jim Kramer as Vice President of Engineering and Mission Assurance and Thomas Carroll as Vice President of Sales.

ILS has implemented an organizational realignment to strengthen the critical functions required to re-establish customer trust and confidence in using Proton launch services.

As a result, ILS is expanding the role of engineering and mission assurance to directly address customer concerns relative to reliability, insight and oversight.

Kramer's appointment as Vice President of Engineering and Mission Assurance will leverage his 30 years of experience to focus on mission assurance, and technical insight of production processes, procedures and mission assurance initiatives.

Kramer will also be responsible for oversight and insight into ILS Proton and Angara product development activities at Khrunichev State Research and Space Production Center (Khrunichev). Kramer will be the primary interface with our customers and the insurance community to communicate the plans, status and progress of initiatives targeted at improving mission assurance and product improvements within Khrunichev.

Kramer previously served as ILS Vice President of Sales, Marketing and Communications and prior to that as the ILS Chief Engineer.

Carroll, as the new Vice President of Sales, is responsible for leading global sales of Proton and Angara launch services. Carroll joined ILS in 2000, and served in various roles, most recently as the regional sales director covering Asia, Australia, Africa, the Middle East, and the Americas.

Carroll has more than 30 years of global sales experience and well established relationships with our customer base. Prior to ILS, Carroll's sales and marketing experience involved working with regional and global satellite operators with Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO) satellites.

www.ilslaunch.com/

Launch-O-Rama

Arianespace Galileo Geminat

Arianespace successfully launched the ninth and tenth satellites in the Galileo constellation for the European Commission, under a contract with the European Space Agency (ESA).



The company's eighth launch of the year, and the 12th Soyuz launch from the Guiana Space Center (CSG), Europe's Spaceport in French Guiana, occurred on September 10, 2015, at 11:08 pm local time, from the ELS launch complex, carrying two European Galileo navigation spacecraft.

In post-launch comments at the Spaceport, Arianespace Chairman and CEO Stéphane Israël noted these are the ninth and tenth Galileo spacecraft orbited by Arianespace, joining a constellation that will ultimately consist of 30 satellites.

These latest passengers for Soyuz, which are named Alba and Oriana, are the latest FOC (Full Operational Capability) satellites that are to operate in Galileo's Orbital Plane A—one of three orbital planes being populated by the European navigation spacecraft. There are three navigation signal bands: E5, E6 and #1, and a COSPAS SARSAT search and rescue transponder mission is included in the payload mix.

The European Commission is managing and funding Galileo's FOC phase, during which the network's complete operational and ground infrastructure is being deployed. Design and procurement agent responsibilities have been delegated to the European Space Agency (ESA) on the Commission's behalf.

Europe initiated the Galileo program to develop a new global satellite navigation system. Under civilian control, the constellation will offer a guaranteed, high-precision positioning service, with performance outpacing current solutions. Galileo is the first joint infrastructure developed by ESA and financed by the European Union and features innovative technologies



Artistic rendition of Galileo satellites in formation. Image is courtesy of OHB Systems.

developed in Europe to benefit all citizens by offering multiple applications and solutions.

Five distinct services will be provided, all offering global coverage: general public, commercial, safety of life, public regulated, search and rescue. The first services will be available during 2016.

The Galileo FOC (Full Operational Capability) satellites are built in Europe by OHB System of Bremen, Germany, as prime contractor, with all payloads supplied by SSTL (Surrey Satellite Technology Ltd.), a British subsidiary of Airbus Defence and Space.

Following this latest successful mission, Arianespace has now launched one-third of the satellites that comprise Galileo, or 10 out of a total of 30. The next Galileo launch is planned for December 2015, once again using a Soyuz launch vehicle.

The ES version of Ariane 5 will then take over, carrying four satellites on each mission, with a launch scheduled for the second half of 2016. In 2017 and 2018, one Soyuz and two Ariane 5 ES launchers will be used to orbit another ten satellites.



Shortly after the official announcement of this successful launch, Stéphane Israël said, "As a benchmark partner in the Galileo program, responsible for the constellation deployment, Arianespace upholds its commitment to guaranteeing independent access to space for Europe. This evening's launch, the sixth of eight scheduled European governmental missions this year, marks a further step towards European independence in satellite navigation—and we are very proud of our contribution.

"I would like to thank the European Union, especially the Commission's DG Growth, as well as ESA for continuing to place their trust in us. I would also like to thank the Russian space agency Roscosmos for their commitment to our partnership based on the Soyuz launcher, which reaffirms its dual vocation for commercial and governmental missions. And, of course, thanks to CNES/CSG, to all staff at the space center, and to the teams at Arianespace for the availability of the launch facilities and this very successful eighth launch of the year."

Soyuz' flight with Galileo's Alba and Oriana satellites occurred during the eighth of 12 Arianespace missions planned for 2015, which will be a new record for the company's launcher family. Preparations at the Spaceport included the first use of the new FCube fueling facility, which is part of the improvements in French Guiana to increase launch capacity, flexibility and schedule robustness.

Israël acknowledged those who contributed to this latest Arianespace success, including the Russian federal space agency, Roscosmos, and the country's industrial partners; along with the European support companies; the French CNES space agency, and Arianespace's own teams.

OHB's Build

The satellite manufacturer, OHB System AG, added that Alba and Oriana reached their planned orbit at an altitude of around 23,000 kilometers just under four hours after launch.

The satellites then sent their first "sign of life" to the ESOC Control Center in Darmstadt, Germany. Over the next few days, the two satellites underwent preliminary function testing.

Marco R. Fuchs, CEO of OHB, said, "Even though we've, meanwhile, developed a certain launch routine, each and every launch in itself is a very special moment. I'd like to thank all the Galileo teams who participated in this success story for doing a great job once again."

Dr. Ingo Engeln, the member of OHB System AG's Management Board responsible for navigation, said, "Now we already have six OHB navigation satellites in orbit—what an amazing success! And the past satellites have all delivered compelling proof of the full functionality and performance."

Aliac Jojaghian, Head of the OHB team for the early operational phase at the ESOC Control Center in Darmstadt, said, "We were all absolutely thrilled with the successful initialization sequence of the satellites. We have a good connection, the solar panels have unfolded properly and are correctly aligned with the sun."



The Galileo Control Centre at DLR's Oberpfaffenhofen site. Photo is courtesy of DLR.

The Galileo Control Center in Oberpfaffenhofen now assumes responsibility for Alba and Oriana on behalf of the ESA and the European Commission—this includes the later commissioning of the payload. As the industrial prime contractor, OHB is responsible for 16 additional Galileo FOC navigation satellites.

The next Galileo FOC satellite pair has also already passed all functional, performance and environmental testing. Both satellites are ready for delivery to Kourou and for their launch scheduled for December. A further pair of satellites is already at the test center at Noordwijk to pass the environmental test campaign. At OHB in Bremen, work continues on building the Galileo satellites in parallel on a total of seven production islands.

OHB System AG belongs to the high-tech group OHB SE, where around 2,000 specialists and executives work on key European space programs. With more than three decades of experience, OHB System AG specializes in high-tech solutions for space. These include low-orbiting and geostationary satellites for Earth observation, navigation, telecommunications, science and space exploration as well as systems for manned space flight and aerial reconnaissance.

Moog Makes Movement

Another partner in the Galileo launch success was Moog Inc.'s Space and Defense Group—their work enables Galileo's Full Operational Capability (FOC) satellites, Galileo 9 and 10, to maintain their orbit 22,522 km above Earth.

Launched atop a Soyuz-STB Fregat-MT rocket, the satellites provide accurate, guaranteed global positioning service, all interoperable with the US GPS and Russian GLONASS systems. The complete satellite system will consist of 30 satellites in three planes of Medium Earth Orbit (MEO) and a ground infrastructure.

Moog built the entire Galileo Propulsion System, which includes monopropellant engines, fill and drain valves, latch valves and pressure transducers including the complete thermal control system installation and harnessing. The propulsion system is a critical subsystem to the satellite, providing orbit maintenance and control capability, support of spacecraft de-tumbling, as well as attitude control in contingency cases.

Moog leveraged the experience gained from the unique Fermi Gamma-ray Space Telescope (formerly GLAST) and critical Landsat Data Continuity Mission (LDCM) propulsion systems with successful launches in 2008 and 2013, respectively, and the high production volume experience from the

ORBCOMM Generation 2 (OG2) constellation. Moog delivered all 14 propulsion systems for the first portion of the constellation, with the second batch of eight currently in the process of delivery. The complete system design, analysis, qualification, fabrication, acceptance testing, and delivery of this propulsion system was performed by Moog.

The design incorporates Moog-built components with robust designs and heritage such as fill and drain valves from the United Kingdom; latch valves from East Aurora, New York; pressure transducers from The Netherlands; and thrusters from Niagara Falls, New York. Final assembly and test is performed at the Niagara Falls facility that has been delivering spacecraft and missile propulsion systems for critical national assets for over four decades.

The Galileo satellites also include fine and cosine and fine sun sensors supplied by Moog. Sun sensors are designed to deliver exact information about the position of the sun. This vital information is used for yaw steering of the spacecraft and therefore applied in Earth pointing, solar array orientation and orbit control maneuvers.

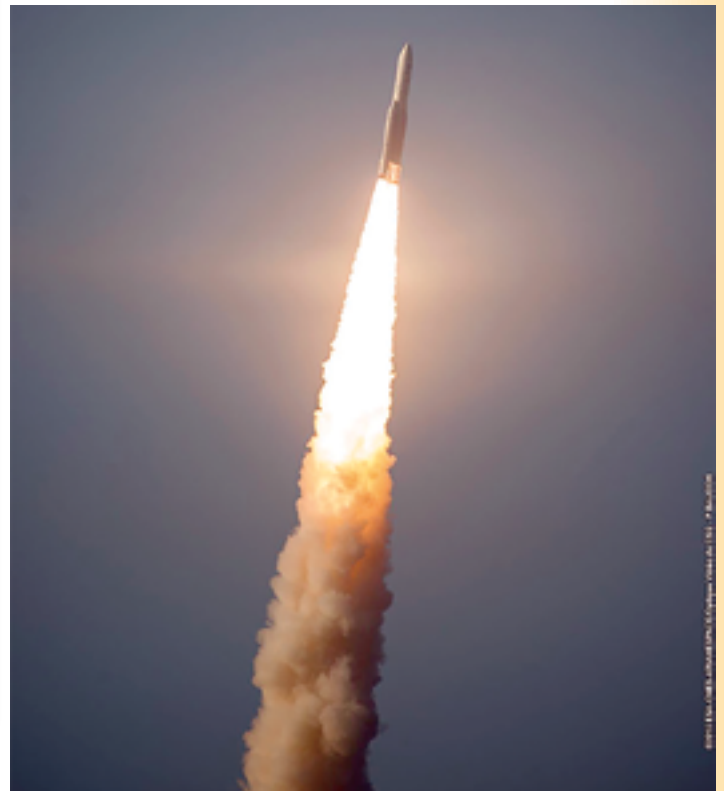
The Full Operational Capability phase of the Galileo program is managed and fully funded by the European Union. The Commission and ESA have signed a delegation agreement by which ESA acts as design and procurement agent on behalf of the Commission. The views expressed in this Press Release can in no way be taken to reflect the official opinion of the European Union and/or ESA. "Galileo" is a trademark subject to OHIM application number 002742237 by EU and ESA.

Arianespace' Major ARSAT-2 + Sky Muster Moment

There's certainly no rest for Arianespace following the aforementioned Galileo twins launch, as the company remains on track for a record number of launches at the Spaceport during 2015.



Moog-ISP offers a wide range of monopropellant thrusters suited for spacecraft and flight vehicle attitude control applications. Photo is courtesy of Moog.



Two telecommunications satellites that will provide expanded relay capacity for Australia and Argentina were orbited on September 30 for Arianespace's ninth mission in 2015—this places the company on track to perform a record 12 flights this year using its three-member launch vehicle family, which consists of the heavy-lift Ariane 5, medium-lift Soyuz and lightweight Vega.

Lifting off exactly on time during a daylight departure from the Spaceport in French Guiana, the heavy-lift Ariane 5 used for today's mission deployed the Sky Muster and ARSAT-2 satellite passengers during a 32-minute flight sequence. This launch marked the 82nd mission overall using Arianespace's workhorse launcher, as well as the 68th consecutive Ariane 5 success.



*The Sky Muster satellite.
Photo is courtesy of the manufacturer, Space Systems Loral (SSL).*

The First Satellite — nbn's Sky Muster

The first-released passenger on this mission was Sky Muster, which is the initial satellite to be operated by nbn, a service provider owned by the Commonwealth of Australia. This company's objective is to ensure all Australians have access to fast broadband as soon as possible, at affordable prices and at the least cost to taxpayers.



*Artistic impression of the Sky Muster satellite on orbit.
Image is courtesy of nbn co.*

Built by Palo Alto-based SSL (Space Systems Loral), Sky Muster is scheduled to operate from geostationary orbit. Sky Muster is designed to deliver broadband services to more than 200,000 rural and remote Australians, providing coverage to the entire country—including the Norfolk, Christmas, Macquarie and Cocos islands. The launch of nbn's second spacecraft has also been entrusted to Arianespace.

The Second Satellite — Argentina's ARSAT-2

Completing Arianespace's VA226 mission was the deployment of ARSAT-2, which is the second of three geostationary satellites that will increase Argentina's telecommunications capacity and guarantee the same level of connectivity quality across the country's regions. Arianespace successfully orbited the first of these relay platforms—ARSAT-1—on an Ariane 5 flight in October 2014.

Built under the responsibility of Argentina's INVAP, ARSAT-2 will be operated by the state-owned Argentinian operator ARSAT (Empresa Argentina de Soluciones Satelitales Sociedad Anónima) to provide DTH television, Internet access services for reception on VSAT antennas as well as with data transmission and IP telephony.



*Artistic impression of the ARSAT-2 satellite.
Image is courtesy of INVAP.*



The upper payload component—containing Australia's Sky Muster spacecraft mounted on the SYLDA dispenser system, both of which are enclosed in an ogive-shaped fairing—is lowered over the ARSAT-2 satellite for Argentina, which is installed atop Ariane 5's central core.

Photo is courtesy of Arianespace.

Arianespace will have the opportunity to go “three-for-three” after concluding a launch contract for the third ARSAT telecommunications satellite, ARSAT-3. Signed at the Spaceport just hours before Flight VA226, this agreement also includes options on two more missions. ARSAT Chairman and CEO Matias Bianchi, who spoke after the confirmation of today's success, thanked Arianespace for another on-target mission, and added that ARSAT-3 is scheduled for launch from the Spaceport in 2019. This launch, which in the Arianespace flight nomenclature was designed VA226, further extending Ariane 5's track record of highly accurate payload delivery, the estimated orbital parameters at injection of its cryogenic upper stage for Flight VA226 were:

- Perigee: 249.2 km for a target of 249.5 km
- Apogee: 35,911 km for a target of 35,927 km
- Inclination: 5.99 degrees for a target of 6.00 degrees

Following this launch success, Arianespace's mission pace will continue with two flights from the Spaceport, both of which are to be performed this November: a heavy-lift Ariane 5 launch with the Arabsat-6B and GSAT-15 payloads (Flight VA227); and a mission with the light-lift Vega carrying Europe's LISA Pathfinder (Flight VV06).

Chairman and CEO Stéphane Israël, in comments regarding Sky Muster, said, “We know how critical these satellites are for the nbn project, and therefore we are very grateful for being recognized as the reference launch solution in your development plan,” he added. “We will be on track to deliver into orbit your second satellite next year.”

“A huge amount of work has gone into this moment, and thousands of people across the world have worked tirelessly to make this launch successful,” said Dr. Ziggy Switkowski, Chairman of nbn Co Limited, in his post-launch comments. “This is a significant moment for all of us Australians and truly a historic moment for our country.”

Regarding ARSAT-2, Arianespace's Israël expressed his gratitude to both ARSAT and INVAP and offered a special word of thanks to the Argentinian government, which was represented at the Spaceport by Julio de Vido, Minister of Planning and Public Investment.

Israël also confirmed that Arianespace was on pace for a record-setting operational performance this year (12 flights from the Spaceport in 12 months) and he also highlighted the company's continued commitment to quality. Launch after launch, success after success, Arianespace demonstrates its capability to increase its launch rates while remaining the most reliable space transportation solution for all customers, whether commercial and institutional, whether GTO or non-GTO,” he said.

Such successes are possible due to the company's launcher family—the Ariane 5, Soyuz and the lightweight Vega—and the Spaceport's capability to conduct multiple missions that are parallel with one another.

Airbus Defence & Space Adds...

“Airbus Defence and Space has been tightly linked with the Ariane program from the outset, and it will remain Ariane's main partner through the Airbus Safran Launchers joint-venture,” said François Auque, Head of Space Systems.

“The 68th successful launch in a row confirms the outstanding capabilities of our launcher teams and our ability to use our experience to put in place the industrial organisation for future European launchers. We intend to remain the driving force for one of Europe's greatest industrial success stories.”

Airbus Defence and Space, a 50 percent shareholder in Airbus Safran Launchers, is the main industrial partner in the Ariane 5 program, one of the world's largest and most ambitious space programs. The industrial network brings together more than 550 companies in 12 European countries.

Drawing on the expertise the company has acquired, and the investments it has made over more than 10 years, Ariane 5 has become the most reliable commercial launcher on the global market and has increased its geostationary orbit payload capacity by almost two tonnes. Representing cutting-edge European expertise, the Ariane 5 launcher has been specially designed to inject heavy payloads into orbit.



Aerial view of Ariane 5 Launch Zone (ZL3).
Photo is courtesy of ESA/CNES/Arianespace-S. Corvaja

For 40 years, the Guiana Space Center (CSG), Europe's Spaceport in French Guiana, has offered a complete array of facilities for rocket launches. It mainly comprises the following:

- *CNES/CSG technical center, including various resources and facilities that are critical to launch base operations, such as radars, the telecom network, weather station, receiving sites for launcher telemetry, etc.*
- *Payload processing facilities (EPCU), in particular the S5 facility.*
- *Ariane, Soyuz and Vega launch complexes, comprising the launch zones and launcher integration buildings.*
- *Various industrial facilities, including those operated by Regulus, Europropulsion, Air Liquide Spatial Guyane and Airbus Defence and Space, are all involved in the production of Ariane 5 components. A total of 40 European manufacturers and local companies are involved in operations.*

Europe's commitment to independent access to space is based on actions by three key players: the European Space Agency (ESA), French CNES space agency and Arianespace. ESA is responsible for the Ariane, Soyuz and Vega development programs. Once these launch systems are qualified, ESA transfers responsibility to Arianespace as the operator. ESA has helped change the role of the Guiana Space Center, in particular by funding the construction of the launch complexes, payload processing buildings and associated facilities. Initially used for the French space program, the Guiana Space Center has gradually become Europe's own Spaceport, according to the terms of an agreement between ESA and the French government. To ensure that the Spaceport is available for its programs, ESA takes charge of the lion's share of CNES/CSG fixed expenses, and also helps finance the fixed costs for the ELA launch complexes.

The French CNES space agency has several main responsibilities at the Guiana Space Center. It designs all infrastructure and, on behalf of the French government, is responsible for safety and security. It provides the resources needed to prepare the satellites and launchers for missions. Whether during tests or actual launches, CNES is also responsible for overall coordination of operations and it collects and processes all data transmitted from the launcher via a network of receiving stations to track Ariane, Soyuz and Vega rockets throughout their trajectories.

In French Guiana, Arianespace is the contracting authority in charge of operating the family of three launchers, Ariane, Soyuz and Vega. For Soyuz, Arianespace supervises the integration and functional checks of the launcher in the MIK facility, carried out by RKTs-Progress for the three lower stages, and by NPO-Lavochkin for the Fregat upper stage. It also coordinates Fregat propellant loading operations in the Fregat

Fueling Facility (FCube), and satellite preparations in the EPCU payload preparation facility operated by CNES/CSG. Arianespace then integrates the satellite(s) on the Fregat stage in the S3B building, transfers the launcher and upper composite to the Soyuz Launch Zone and, along with the Russian entities in charge of the launcher, conducts the final countdown and liftoff operations from the Soyuz Launch Center (CDLS). Arianespace deploys a top-flight team and technical facilities to get launchers and satellites ready for their missions.

China's Charge Continues

The Xichang Satellite Center's Launch Area Two in China's Sichuan province—known as China's Aviation City—was the stage for the latest lift-off of a Long March 3B rocket, otherwise known as a Chang Zheng 3B. Aboard was what was described as an "experimental" satellite that will be involved in Ka-band technology testing.





China's Xichang Satellite Center. Photo courtesy of Xinhua.

This successful launch occurred on Saturday, September 12th, and continues China's aggressive push into space. Due to the secretive nature of this launch, and rumors being posted throughout a number of space-oriented infosites, the hearsay is that this satellite is one that will form one of the important cogs within a new Chinese early warning system.

Various information outlets on the Internet named the new satellite Great Wall One, Qianshao-3, with the name "Communication Engineering Satellite One" popping up online in China several hours after the launch—unsurprisingly, no official nomenclature for the satellite has been posted by the Chinese government as of this writing.

The importance of this launch can also be surmised from the fact that the Chinese used one of their more potent rocket launchers to boost this satellite to orbit, a Chang Zheng-3B. This launcher boasts newly improved computer control systems, a larger fairing, four strap-on boosters as well as larger launch propellant tanks. The Chang Zheng-3B is more than capable of propelling a payload of as heavy as 24,691 pounds (11,200 kilograms) into LEO, or 11,244 pounds (5,100 kilograms) into a geosynchronous orbit.

The Xichang Satellite Center construction was completed in 1983, with full operations underway one year later. There are two launch pads at this location. One pad is for geosynchronous and meteorological satellite pushes via Long March CZ-3 launch vehicles, and the other is for both Long March CZ-2 and CZ-3 rockets.



China's Chang Zheng-3B launch vehicle. Photo courtesy of Chinanews.com.

One Of Seven... Maybe...

Then, on September 14, China sent another—according to the Xinhua News Agency—remote sensing satellite into space... the Gaofen 9.

The claim is that this is a Communications Engineering Test Satellite, as well, and will be used by the government to assist authorities and their optical imagery needs. The satellite was built by the Shanghai Academy of Spaceflight Technology and is based on the CAST-2000 platform, which is actually the civilian version of the Yaogan 2 military reconnaissance satellite. This satellite is one of seven hoped-for satellites that should be in service by 2020 that will comprise the China High Resolution Earth Observation Systems, or CHEOS. The stated "clients" of the satellites are the Ministry of Agriculture, Ministry of Land and Resources and the Ministry of Environmental Protection.



Gaofen-9 launch from Jiuquan Satellite Launch Center. Photo is courtesy of Xinhua—Zho Yingquan

Launched via a Long March 2D (Chang Zheng-2D) launch vehicle, this event occurred at the Jiuquan Satellite Launch Center from the 603 Launch Pad at that location. There are two launch pads at this center, the other



China's Jiuquan Satellite Launch Center. Photo courtesy of china.org.cn/. A Long March 2F carrier rocket is on the launch pad.

being pad 921, from which manned launches are conducted. This launch vehicle can manage payloads up to 1,300 kg that are intended for Sun Synchronous Orbit (SSO) or Low Earth Orbit (LEO).

Good Timing For China

China launched a new-generation satellite into orbit that will support its global navigation and positioning network on September 30.

Launched from Xichang Satellite Launch Center in the southwestern province of Sichuan, the satellite was boosted by a Long March-3B carrier rocket. This was the 20th satellite for the Beidou Navigation Satellite System (BDS) and puts China one step closer to providing an alternative to the US-operated GPS.

For the first time, the satellite featured a hydrogen atomic clock. A series of tests related to the clock and a new navigation-signal system will be undertaken, according to a statement from the center. Named after the Chinese term for the plough or the Big Dipper constellation, the Beidou project was formally launched in 1994, some 20 years after GPS.



China's launch of their Beidou Navigation Satellite.

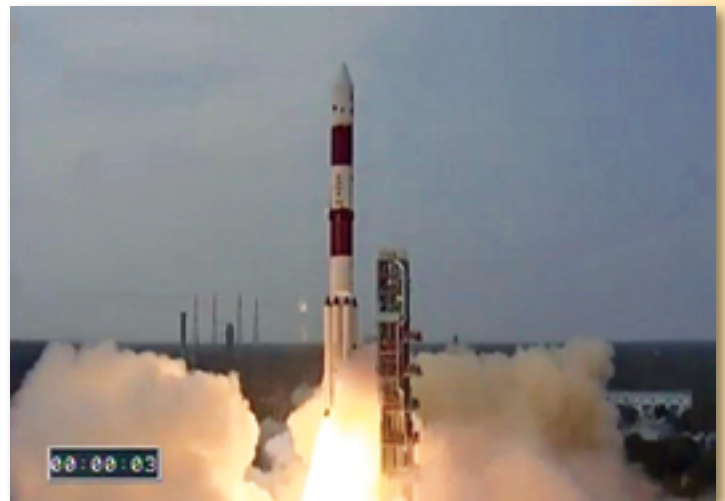
The first Beidou satellite was not launched until 2000. Nonetheless, by 2012, a regional network had already taken shape, providing positioning, navigation, timing and short message services in China and several other Asian countries.

China plans to expand the Beidou services to most of the countries covered in its "Belt and Road" initiative by 2018, and offer global coverage by 2020.[Article information is courtesy of Xinhuanet.]

India's ISRO In The Club

Astrosat, India's first dedicated, multi-wave, space observatory, was launched on September 28 from the spaceport of Sriharikota in Andhra Pradesh—according to the Indian Space Research Organization (ISRO), the spacecraft will study celestial objects. Astrosat is packing five scientific payloads.

A Polar Satellite Launch Vehicle (PSLV-C30) carried Astrosat, along with six co-passengers (one satellite each from Indonesia and Canada, and four nanosatellites [nanos] from the US). Astrosat is India's first dedicated multi-wavelength space observatory.



India's Astrosat launch. Photo is courtesy of ISRO.

The lift-off mass, with the seven satellite payload, was approximately 1,631 kg. and was launched into a 650 km orbit inclined at an angle of 6 degrees to the equator. This was actually the third time India's PSLV rocket has launched seven satellites into orbit.

Twenty-two minutes into the flight, Astrosat was placed into orbit, followed by the remaining six satellites, with the entire mission lasting just over 25 minutes in duration.

This scientific satellite mission will, hopefully, uncover a more detailed understanding of our universe. One of the unique features of Astrosat mission is that it enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite, ISRO said. Astrosat will observe the universe in optical, ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum, whereas most other scientific satellites are capable of observing a narrow range of wavelength band.

The mission is also to detect new briefly bright X-ray sources in the sky and to perform a limited deep field survey of the universe in the ultraviolet region. Astrosat is scheduled for five years of flight and carries four X-ray payloads, one UV telescope and a charge particle monitor.

According to ISRO, after injection into orbit, the two Astrosat solar panels automatically deployed in quick succession. The spacecraft control center at Mission Operations Complex (MOX) of ISRO Telemetry, Tracking and Command Network (ISTRAC) at Bengaluru will manage the satellite during its mission life.



India's PSLV-C30 launch vehicle.

ISRO said the scientific objectives of Astrosat mission are to understand high energy processes in binary star systems containing neutron stars and black holes, to estimate magnetic fields of neutron stars and to study star birth regions and high energy processes in star systems lying beyond our galaxy.

Apart from ISRO, four other Indian institutions—Tata Institute of Fundamental Research, Indian Institute of Astrophysics, Inter-University Centre for Astronomy and Astrophysics and Raman Research Institute—were involved in the payload development. Two of the payloads were built in collaboration with the Canadian Space Agency (CSA) and the University of Leicester in the UK.

The Five Scientific Payloads Aboard Astrosat

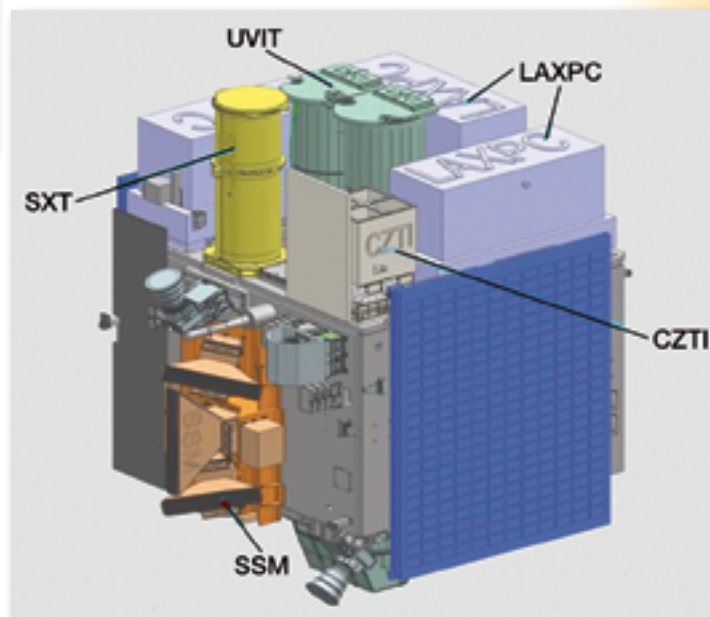
The Ultraviolet Imaging Telescope (UVIT) that was developed by Indian Institute of Astrophysics at Bangalore and Inter University Centre for Astronomy and Astrophysics, in collaboration with ISRO and the Canadian Space Agency (CSA). UVIT will observe the sky in the visible, near ultraviolet and far ultraviolet regions of the electromagnetic spectrum via two large field of view telescopes.

The second payload is the Large Area X-ray Proportional Counter (LAXPC), which will study X-ray emission variations from sources such as X-ray binaries and other cosmic sources. The instrument is able to measure the spectral characteristics of various classes of X-ray sources over a wide, spectral range of from 3 to 80 kilo electron Volts (keV). This payload was developed by the Tata Institute of Fundamental Research (TIFR) of Mumbai and Raman Research Institute (RRI) of Bangalore.

In collaboration with the University of Leicester, UK, and the ISRO, the Soft X-ray Telescope (SXT) was developed especially to study how the X-ray spectrum of 0.3 to 8 keV range comes from distant celestial bodies and how such varies over time. There is a 2 meter focal length telescope and a cooled Charged Coupled Device aboard SXT.

Developed by TIFR and IUCAA, in collaboration with ISRO, is the Cadmium Zinc Telluride Imager (CZTI), which also functions in the X-ray region and senses X-rays of high energy in the 10 to 100 keV range. This payload may also be able to detect gamma ray bursts and then study such characteristics.

The ISRO Satellite Center at Bangalore and IUCAA developed the fifth Astrosat payload, that being the Scanning Sky Monitor (SSM), which will scan for bright X-ray sources in binary stars as well as detect and locate sources that become bright in X-rays for short durations of time. These X-ray sources will then be studied in greater detail by the other instruments on Astrosat.



Commenting on the launch, Indian Space Research Organisation Chairman AS Kiran Kumar, said, "What it means for India is this: it is one of the first scientific missions which will be available to the Indian researcher community as an observation opportunity. This is a starting point for such things."

The Other Six Satellites Include...

- LEMUR nanosats, four of them, are remote sensing satellites that will be primarily focused on gathering intelligence regarding global maritime activities through the tracking of vessels via AIS. The satellites are from Spire Global Inc., which is based in San Francisco, California. LEMURs will also engage in weather forecasting through the use of GPS radio occupation technology.
- LAPAN-A2, an Indonesian microsatellite that will perform maritime surveillance using AIS. Additionally, the satellite will offer support for disaster mitigation via the amateur radio user community in the country as well as Earth observation with the spacecraft's video and digital camera. The satellite was built by the National Institute of Aeronautics and Space.
- NLS-14 is from the University of Toronto's Institute for Advanced Studies. This 14 kg. Space Flight Laboratory will monitor maritime activities, also via next generation AIS.

The Indian PSLV rocket has launched 84 satellites during the 1994 to 2015 time period, including the seven satellites that comprised this mission.

Russia's Footprints Express To Space

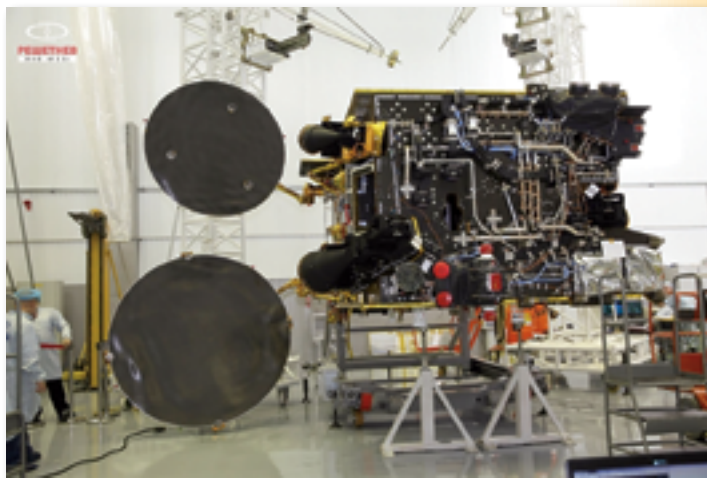
The Russian communications satellite Express AM8 (Ekspress-AM8) was successfully launched by a Proton M launcher on September 15, 2015.



The Russian launch of Express AM8 on a Proton M launcher. Photo is courtesy of Roscosmos.

This 2,100 kg satellite was built by ISS Reshetnev, who is the prime contractor for RSCC (Russian Satellite Communications Company). The Express AM8 includes a 641 kg. C-, Ku- and L-band payload that was designed and built by Thales Alenia Space. Based on the ISS Reshetnev Express 1000N platform, Express AM8 was assembled, integrated and tested at ISS Reshetnev's plant in Zheleznogorsk, Russia.

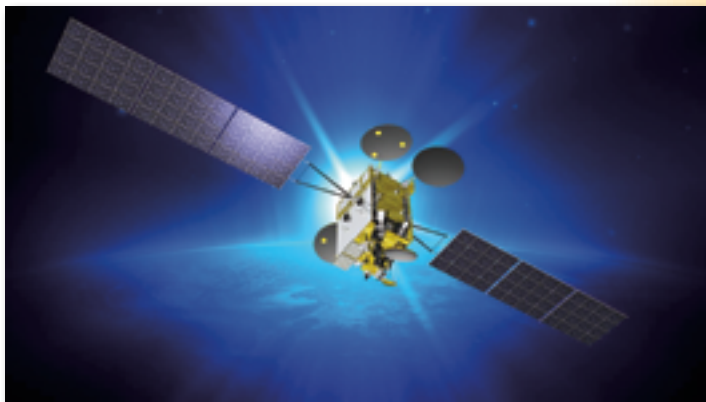
The payload is rated at 5.9 kW and offers a design life of 15 years and is comprised of 28 active C-band transponders, providing two footprints of coverage: one in Europe, Africa and the Middle-East, and the second in Latin America and along the East coast of North America. The satellite also includes 20 active Ku-band transponders with three footprints: Europe/Middle-East, Africa/Middle-East and Latin America/East coast of North America. In addition, this payload has three L-band transponders.



Express AM8 during the manufacturing process.

Operated by RSCC from an orbital slot at 14 degrees West, Express AM8 will provide high quality fixed and mobile communication services as well as broadcast services for digital television and radio, plus data transmission, high-speed Internet access and secure government communications.

The successful cooperation between the Russian space industry and Thales Alenia Space stretches back more than 20 years, starting with the SESAT program, which pioneered this East/West industrial collaboration. RSCC is a major customer for Thales Alenia Space, which has provided payloads for a large number of satellites: Express A1, A2, A3, A4 and A4R, Express AM11, AM22, AM33 and AM44, Express AM2 and AM3, Express AT1 and AT2 (on ISS platforms), as well as Express MD1 and MD2 (on Khrunichev platforms).



Artistic rendition of the Express AM8 satellite.

"This new success reflects our ability to work efficiently with our partners from the Russian space industry, especially RSCC and ISS Reshetnev," said Jean-Louis Galle, President and CEO of Thales Alenia Space. "We have demonstrated our adaptability in the frame of an international cooperation as well as during launch campaigns. Our partnership is now continuing through our joint venture, Universum Space Technologies, dedicated to the production of world-class equipment for payloads used in both domestic and export markets. Operating in eight European countries and aiding the development of space industries in several other countries around the world, Thales Alenia Space is the natural partner to support the development of national space programs in emerging countries."

Russia's Rockot 'N Roll

Three Russian Strela-3M/Rodnic military communications satellites were pushed into orbit from the Plesetsk spaceport's launch pad #3 into orbit on September 24. The launch vehicle used was a Rockot with a Briz-KM booster stage.



The ULA launch of the Lockheed Martin built MUOS-4. Image is courtesy of United Launch Alliance.

The satellites are designated as Cosmos-2507, Cosmos-2508 and Cosmos-2509 and are registered by NORAD as 40920, 40921 and 40922.

The Rokot light rocket was created under the conversion program on the basis of decommissioned intercontinental ballistic missile RS-18. The first launch of the Rokot rocket occurred from the Plesetsk Space Center on May 16, 2000. The Defense Ministry plans to stop using these rockets from 2016 in favor of the light rocket Angara and Soyuz-2.1v. Rokot rockets have been launched from Plesetsk 23 times since.

ULA's MUOS Family Addition

A United Launch Alliance (ULA) Atlas V rocket carrying the fourth Mobile User Objective System satellite for the US Navy launched from Space Launch Complex-41 at 6:18 a.m. EDT on September 2nd.

A Lockheed Martin-led initialization team, stationed at Naval Base Ventura County, Point Mugu, California, is operating the satellite from its transfer orbit to its test slot.

The MUOS-4 spacecraft will bring advanced, new, global communications capabilities to mobile military forces, as well as ensure continued mission capability of the existing Ultra High Frequency satellite communications system. This is ULA's eighth launch in 2015, the second MUOS satellite launched in 2015 and ULA's 99th successful launch since the company was formed in December 2006.

MUOS-4 is the fourth of a five satellite constellation to be launched and operated by PMW 146, the Navy's Communications Satellite Program Office. The MUOS satellites are the heaviest payloads to ride into space atop any of ULA's Atlas V launch vehicles. The Atlas V generates more than two and half million pounds of thrust at liftoff in order to meet the demands of lifting the nearly 7.5 ton satellites.

Jim Spornick, ULA vice president, Atlas and Delta Programs, said, "This successful launch will enable the MUOS constellation to reach global coverage. The Lockheed Martin-built MUOS-4 satellite will deliver voice, data, and video communications capability, similar to a cellular network, to our troops all over the globe."

This mission was launched aboard an Atlas V Evolved Expendable Launch Vehicle (EELV) 551 configuration vehicle, which includes a 5-meter diameter payload fairing along with five Aerojet Rocketdyne solid rocket motors attached to the Atlas booster. The Atlas booster for this mission was powered by the RD AMROSS RD-180 engine and the Centaur upper stage was powered by the Aerojet Rocketdyne RL10C-1 engine.

The US Navy's MUOS is a next-generation narrowband tactical satellite communications system designed using a combination of orbiting satellites and relay ground stations to significantly improve communications for US forces on the move. MUOS will provide new beyond-line-of-sight communications capabilities, with smartphone-like simultaneous voice, video and data—to connect military users almost anywhere around the globe.

The EELV program was established by the US Air Force to provide assured access to space for Department of Defense and other government payloads. The commercially developed EELV program supports the full range of government mission requirements, while delivering on schedule and providing significant cost savings over the heritage launch system

This is actually a first... United Launch Alliance (ULA) and the US Air Force (USAF) performed off-site vertical integration (OVI) of several structural elements and the Centaur upper stage for the Atlas V launch vehicle in order to minimize the number of lifting operations performed at the Vertical Integration Facility (VIF) at Cape Canaveral. This also is a positive action as it reduces one week's worth of time between launches.



United Launch Alliance transports a five-story stack of rocket hardware approximately six miles from the Delta Operations Center to the Vertical Integration Facility using Off-site Vertical Integration.

Photo courtesy of ULA.

"We are very pleased to have successfully completed the first Off-site Vertical Integration for the upcoming Mobile User Objective System launch. With OVI, the team developed an innovative process that provides safer and more efficient launch processing of the Atlas vehicle," said Jim Spornick, ULA vice president, Atlas and Delta Programs.

"The associated one-week reduction in the launch-to-launch processing spans enables us to better meet the launch needs of our customers."

For a 500-series Atlas V rocket, such as the one launching the MUOS-4 mission, the OVI process accomplishes the integration of six structural



An aerial view of the Launch Complex 41 at Cape Canaveral Air Force Station in Florida. At left is the Vertical Integration Facility. Photo is courtesy of NASA.

elements along with the Centaur upper stage inside a test cell in the Delta Operations Center (DOC), rather than conducting major portions of these

complex hardware lifting and mating tasks outside at the VIF. Moving these operations inside provides a safer working environment for employees and mitigates weather impacts to launch schedules. In the last six years, there were 25 days of weather delays to launch vehicle stacking operations at the VIF.



One of the innovations required to enable OVI was the development of a transporter to safely move the five-story stack of rocket hardware approximately six miles from the DOC to the VIF. The transporter includes a tank pressure control system for the Centaur upper stage.

"The Off-site Vertical Integration process, including ground support equipment designs and operational procedures, were developed in collaboration with our Air Force customer to support launch manifest needs and enable continuous improvement to these critical launch operations," said Spornick.

Space and Missile Systems Center commander Lieutenant General Sam Greaves said, "The Air Force is pleased to partner with ULA to find and implement efficiencies. The associated one-week reduction in the launch-to-launch processing spans enables us to better meet the launch needs of our customers. We are fully onboard with efforts to implement continuous process improvement, a key tenant of better buying power 3.0."

MUOS is a constellation of five planned communications satellites designed to provide tactical mobile communications to the United States military. Although not yet complete, the introduction of MUOS-4 will give the MUOS system worldwide coverage for the first time, with the final satellite intended to serve as an on-orbit spare. The constellation is expected to be fully operational in 2017.

The MUOS constellation replaces the seven UHF Follow-On (UFO) satellites that were launched between 1993 and 2003.

In-Space Trucking With VASIMR® Engines

By Dr. Mark Carter, Senior Vice President for Technology Development, Ad Astra Rocket Company

Throughout history, improved logistics have been needed to conquer new frontiers.

The frontier of space will be no different. Advanced in-space propulsion capabilities are needed now to cost effectively increase the mass of new payloads destined for high orbits and to enable the remote servicing of previously positioned assets.

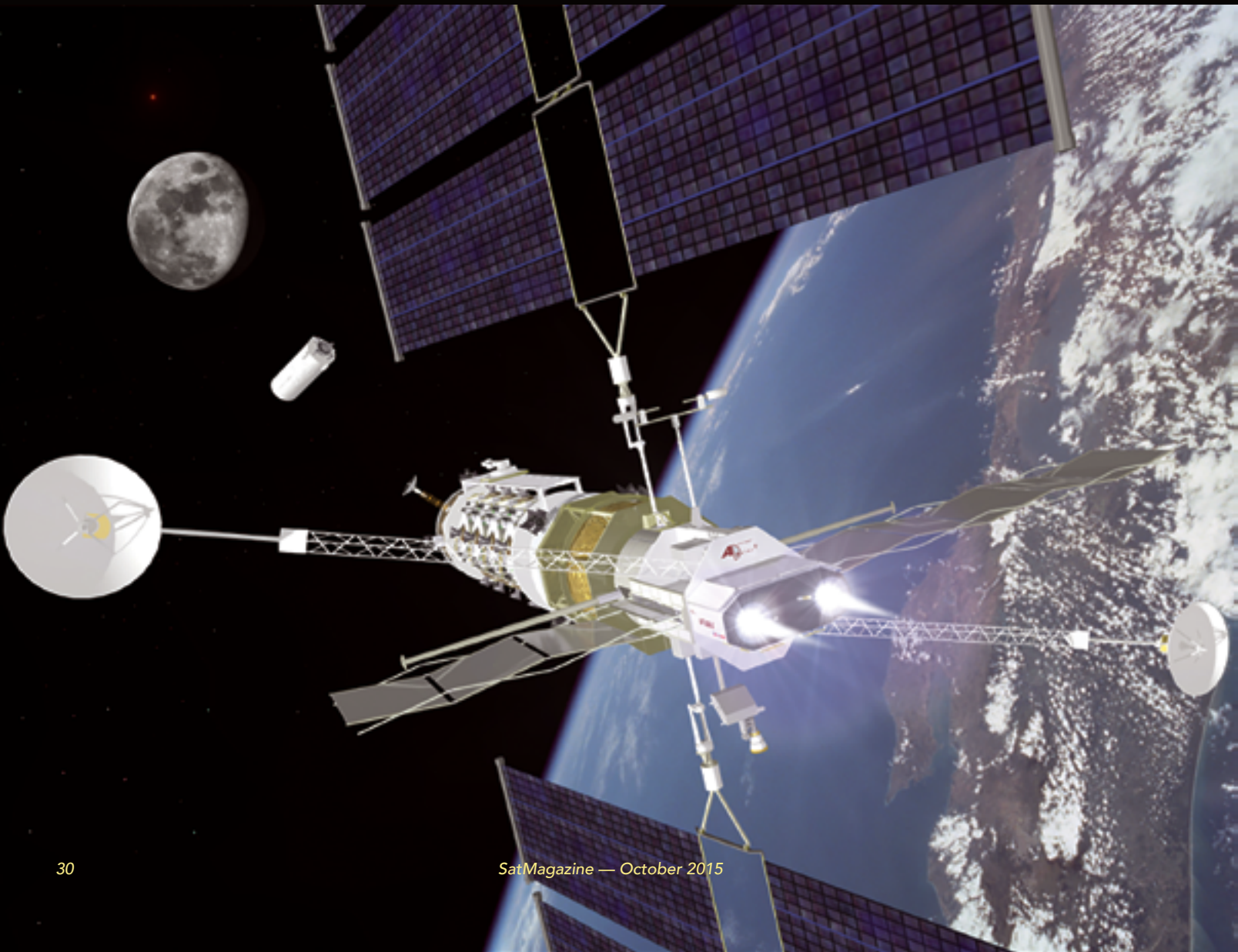
Traditional chemical rockets are not practical for satellites to evolve into maintainable units that can be routinely refueled, repaired, upgraded or repositioned autonomously. Enhanced cargo delivery and resupply capabilities are also needed to sustainably expand our horizon for human exploration beyond Low Earth Orbit (LEO).

A new “in-space trucking industry” will emerge when powerful electric vehicles are developed to efficiently use the recent advances in solar arrays for space. Variable Specific Impulse Magneto-plasma Rocket (VASIMR®)

engines will push those trucks in space much in the same way that powerful diesel engines are used for ground-based logistics.

A VASIMR® engine provides steady-state thrust using an electrical power source to create a directed plasma jet. VASIMR® technology is much different from other electric propulsion systems based on the familiar Hall or ion engines.

Instead of using a direct current bias, VASIMR® engines ionize the propellant and accelerate the resulting plasma using Radio Frequency (RF) waves. These waves couple power into naturally occurring resonant modes that heat the magnetized plasma to temperatures of millions of degrees, comparable to interior regions of the sun. The strong magnetic fields in the VASIMR® design protect material surfaces from these temperatures.





The very high temperatures in the VASIMR® plasma produce jet exhaust velocities more than ten times higher than the best liquid hydrogen-oxygen engines available today. This high specific impulse allows orbital maneuvers using one-tenth the propellant that would otherwise be needed using chemical engines.

With those high exhaust speeds, the propellant mass no longer dominates the total mass of the spacecraft. Entirely new options become available to solve orbital mechanical problems.

In contrast with chemical propulsion, the power source for a VASIMR® engine is also completely independent of the propellant. This independence makes power available for non-propulsive purposes and allows complete reuse of power and propulsion assets with only chemically inert propellant needed for resupply.

The VASIMR® engine somewhat uniquely allows its specific impulse and thrust to be tuned over a wide range, while maintaining a constant input power. This capability allows mission flexibility during operation.

The specific impulse range can also be tailored to support a particular mission by selecting the propellant from a variety of materials without significant changes in the technology. A propellant with lighter ion mass results in a higher range of specific impulse with lower thrust, while heavier ions provide a lower range of specific impulse with higher thrust.

For example, argon or krypton stored at mildly cryogenic temperatures (argon freezes below 83 K, krypton below 115 K) provide excellent performance with specific impulse ranging from 2500 s to more than 5000 s. Xenon can also be used for propellant if very low specific impulse and high thrust is required, but xenon is typically a poor choice for VASIMR® engines because Xenon is expensive and requires more powerful magnetic fields than lighter gases.

Possible alternatives without cryogenic storage include iodine substituting for xenon and bromine substituting for krypton. Other compounds that provide lighter propellant ion mass, such as ammonia or water, may also serve as possible propellants.

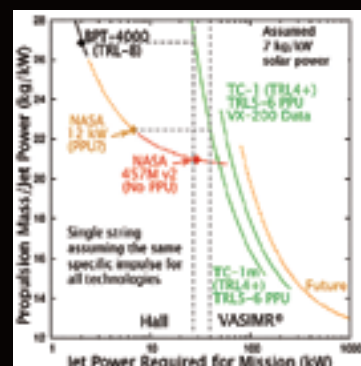
The High-Power Regime

VASIMR® engines occupy the high-power niche for electric propulsion. A convenient way to visualize the natural power regimes for VASIMR® and Hall technologies is to plot the ratio of total propulsion mass to jet power versus the jet power required to accomplish the mission.

The comparison must account for the total mass of the propulsion system, including the solar electric power plant, the power processing unit and the thruster itself. The goal is, of course, to reduce the overall propulsion system mass as much as possible.

By assuming the same specific impulse for both systems and the same weight for the solar array, the salient features of the two technologies can be assessed side-by-side and favorable power regimes for each can be readily identified.

The figure at the right reveals that different technologies have advantages in different power regimes. The controlling physics behind each technology is responsible for this difference.



Hall technology uses a weakly magnetized direct current discharge with space-charge limitations on density and power. VASIMR® technology exploits naturally occurring resonant behavior in a strongly magnetized plasma with no space-charge limits.

The technological trade-off is the investment required for a strong magnet to handle VASIMR® power levels. With present-day magnet technology, a Hall system has an advantage for power levels well below 50 kW, but above 50 kW, the VASIMR® system is clearly the better choice.

This transition to the VASIMR® power regime will shift to lower values of power as the thin-film technology supporting high-temperature superconducting magnets continues to improve. The mass of the solar electric power plant, assumed here to be 7 kg/kW, will also begin to dominate the total mass of the propulsion system as magnet technology improves and as power levels increase.

VASIMR® technology has additional operational advantages. One is its very high power-to-thrust conversion efficiency, which allows more than 65 percent of the solar electric power to be converted into thrust-producing jet power.

Other advantages are the absence of any direct current bias and the nearly linear behavior of the underlying RF wave physics. These attributes minimize coupling between the plasma, the RF power processing units, the solar arrays, and other parts of the vehicle.

The RF power processing units are also straightforward and robust, using extremely efficient field-effect transistor technologies widely utilized throughout the commercial broadcast industry. Additional information regarding the VASIMR® mass scaling may be found at:

<http://adastrarocket.com/infographics/VASIMR-Hall-Power-Niches-07-03-14.pdf>

http://www.adastrarocket.com/IEPC13-149_JPSquire_submit.pdf

<http://www.adastrarocket.com/Jared-Space2014.pdf>

Orbital Debris Removal

A demonstration of the mission capabilities enabled by solar electric propulsion in the VASIMR® power regime is the removal of orbital debris; specifically, the spent upper stages jettisoned in multiple orbit planes during the long history of satellite launches to polar orbit. Mathematical tools for the traveling salesman problem were used to optimize the specific impulse for a mission while minimizing mission time and propellant usage for a solar electric tug equipped with a 200 kW VASIMR® engine.

The resulting concept was able to capture 19 known Zenit rocket upper stages and de-orbit them in a controlled manner over the Pacific Ocean. Each Zenit upper stage is large, approximately 4 m in diameter, 10 m long, and weighs approximately 8 tons.

The concept outfits the electric propulsion tug with a specialized service module containing a tray holding 20 solid rocket motors and a detachable chemical robotic pod. The tug, with service module, climbs to the altitude of a drifting Zenit, approximately 800 km, and positions itself at a safe distance from the debris.

The chemical robotic pod then detaches, carrying a solid rocket motor with it, to perform the proximity operations needed to stabilize the Zenit. The pod attaches the solid rocket motor to the Zenit's exhaust nozzle and tows the now cooperative Zenit back to berth and locks onto the solar electric tug.

The tug's VASIMR® engine is then used to efficiently lower the orbit of the Zenit to approximately 400 km, a location from which the implanted solid rocket motor can detach and complete the controlled atmospheric reentry of the Zenit into the Pacific. The VASIMR® engine then repositions the tug with its service module at the next Zenit upper stage and the de-orbiting process is repeated 18 more times before the VASIMR® engine requires a resupply of propellant from the ground. Alternative scenarios could park the Zenit upper stages in safer orbit locations.

The optimum specific impulse range for the debris de-orbiting mission was found to be between 4,500 and 5,000 seconds, well suited for a VASIMR® engine operating with low-cost argon propellant. Lower specific impulse cases resulted in a substantial increase in the initial mass of propellant launched to Low Earth Orbit for the mission, which dramatically increases the time and overall cost of the mission.

The high performance of a VASIMR® engine for this application makes the debris removal both faster and less expensive than with other electric propulsion technologies. For more information, read <http://adastrarocket.com/infographics/VASIMR-Orbital-Cleaner.pdf> or watch the video at <http://www.adastrarocket.com/aarc/media-and-gallery>.

VASIMR® Engine Development Status

Since the company's inception in 2005, Ad Astra Rocket Company has advanced the Technical Readiness Level (TRL) of the VASIMR® engine almost exclusively with private funding. In 2013, after more than \$30 million in private capital investment, the company completed more than 10,000 successful high power firings of its most advanced VASIMR® prototype, the VX-200™, in Ad Astra's Houston vacuum chamber facility.

These tests with argon propellant demonstrated the engine's excellent firing repeatability and performance (6 N thrust, 5000 s specific impulse, and a thruster efficiency greater than 70 percent) with no measurable signs of engine wear. To optimize company resources at the time, these earlier tests were all of short duration, less than 1 minute, but sufficient to reliably establish the rocket's performance and measure thermal loads.

Technical information about Ad Astra's VX-200 experiment performance is available at:

<http://www.adastrarocket.com/Ben-JPP-2014.pdf>

Ad Astra Rocket Company was recently selected by NASA as one of the winners of its Next Space Technologies for Exploration Partnerships (NextSTEP). Authorization to proceed was granted on August 7, 2015, and work is now well underway.

This three-year partnership with NASA, valued at approximately \$9 million, will advance the VASIMR® engine to a TRL greater than 5, a major step closer to spaceflight. The project will build and demonstrate a fully integrated system, the VX-200SS™ laboratory prototype, by operating continuously at 100 kW for a minimum of 100 hours.

The long duration test under the NextSTEP partnership will thoroughly evaluate the engine's new proprietary core design and thermal control subsystem. The test will also provide a better estimate for component lifetime.

Visit Ad Astra Rocket Company at www.adastrarocket.com to find out more about the development of the VASIMR® engine.

Dr. Mark Carter is the Senior Vice President of Technology Development for Ad Astra Rocket Company where he has worked since 2006. The company's focus is on commercial space applications, especially the development of the VASIMR® engine, and renewable energy storage and generation in Costa Rica.

Prior to joining Ad Astra, Dr. Carter spent over 23 years as part of the research staff at Oak Ridge National Laboratory where his research focused on high-performance computer modeling of plasma processes. His work contributed to radio frequency coupler designs and analysis for experimental devices around the world as part of an international program for the US Department of Energy. His interest in VASIMR® physics and technology began in the late 1990s as a part of interagency agreements between NASA and the US Department of Energy.

Dr. Carter received his Ph.D. in Nuclear Engineering with a minor in Physics from the University of Wisconsin at Madison and a B.S. in Nuclear Engineering from the University of Missouri at Rolla.



A New Gun For Hire: An Interorbital Systems Perspective

By Randa Relich Milliron, Co-Founder, Interorbital Systems

The realm of New Commercial Space is like a foreign land to those who have been approaching launch vehicle development in the conventional manner: using unlimited funding and wildly expensive 'standard industry practices'. These elements bear astronomically high price-tags from suppliers who simply get on the gravy train, or as a representative of a prime contractor once facetiously related to an IOS founder, "I'll bet you think we just back our big vacuum cleaner up to NASA and the DoD, hook it up and turn it on and suck all the money out... we'll, you'd be right!"

The DoD and NASA have been victimized so long by the Primes' approach that the real cost of what it actually takes to build and qualify a launch system—particularly one built and dedicated to lowering launch costs—has long been lost.

A New Commercial Space company such as Interorbital starts its design phase by learning how to work within the constraints of a limited and sometimes nearly non-existent budget. The component, or engine, or ground support unit has to be cheap or the company cannot afford to build it.

That's where the heavy thinking starts... Question number one, "How can we do this?" then, more specifically, Question number two, "How can we make a \$20 million dollar bi-propellant liquid rocket engine for under \$1,500?"

However, Big Aerospace and the agencies who serve it never look back, never think of cost-cutting, and continually feed the fires of doubt and fear



Loading smallsats into Interorbital's CPM.
Photo is courtesy of Interorbital Systems (IOS).





Pre-flight qualification run of Interorbital's 7,500-lb thrust main engine. Propellants: Turpentine/Nitric Acid. Photo: IOS.

by claiming that less money will make a rocket system unsafe. So far, that line has worked well for them to keep launch high-priced and 'safe.' This has been to the detriment of those trying to make a price-point breakthrough by developing a dedicated smallsat launcher and delivering the benefits of low-cost space access to all, particularly the not-so-well-heeled groups of cash-strapped students and struggling experimenters who are just entering launch-world.

Through innovative and completely unorthodox analysis, the proponents of the Commercial Space movement look at a billion dollar launcher and think, "What's wrong with this picture?" Why should this vehicle cost so much?" How can we get to the same place—space, that is—and do it for less?"

Interorbital answered those questions by creating a design, manufacturing, testing, qualification, and launch philosophy based on Aerospace Corporation's 1960s breakthrough study on Minimum Cost Design; by following instructions given by John London III, in his iconoclastic book, *LEO on the Cheap*; by adopting mass-production of identical modules to produce a rocket that could be configured to meet any mission requirement by adding modules, such as Lutz Kayser's OTTAG. Components of the approach were then added that are used by the Subtractive Design architectural movement and by adding elements of manufacturing processes from the ship building, locomotive, and automotive industries to create a Minimum-Cost/Minimalist design approach.

The key to this take on design is to perform a phenomenological reduction on the system—to strip-down rocket design to its essentials, then combine and apply some of the best manufacturing approaches from past players who tried to build rockets that could and would, if allowed to flourish, bring launch costs down.

If, through history, people have proposed cost-cutting methodologies and designs, why are launch prices still so high? Perhaps the question should be, "Were these innovations even accepted?" Because the Space Industry is a multi-billion dollar behemoth, no one involved at the high-dollar end wants any upstarts rocking the boat with cost-lowering approaches; there are consequences (the engineer who invented Minimum-Cost Design was made into an 'un-person' and removed from the public eye).

A New Commercial Space company such as Interorbital expects backlash and significant resistance from the major players who would like to suppress anyone who would dare to disrupt the global launch cartel, with its price-fixing and 100 mile-high barriers to entry. Surprisingly, the brainwashing that campaigns against commercial space entities experience has been so thorough that even potential customers who could benefit by having another, cheaper, launch vehicle in operation have, for the most part, bought into this charade.

The favorite killing ground for a truly transformational project is the proposal review process. Many in the alternative space movement were convinced that government agencies gave contracts to commercial companies who presented 'paper' or 'PowerPoint' rockets—stuff that looked great to an office worker, but would never be built or were obviously doomed to fail if examined in any great engineering detail. These were the projects selected to win development awards as representatives of the commercial space sector—projects that would fail and be used to discredit the whole New Commercial Space community. That practice remains alive today.

When, on the one hand, a potential government customer requests that industry create a breakthrough, game-changing innovative launch vehicle that will dramatically lower launch costs for the new class of smallsats, while on the other hand, that same entity complains that the 'offeror is not following standard industry practices,' or 'knows nothing about what it costs to create a launch vehicle' in accordance with those same undefined 'standard industry practices' that triggered the current escalating cost-spiral of anything bearing the name 'aerospace,' something is definitely amiss.

For companies with viable and logically designed low-cost rocket systems, a whole other damnation practice is applied to keep their lower cost, positive showpiece, launch vehicles off the market.

Interorbital has actually been told during a review that flying a launch vehicle is not considered a proper way to validate a rocket. The truth is: Commercial Space is a new industry with a new set of standard practices. In fact, many of the 'new' standard practices IOS has adopted are those of the pre-Shuttle days when the first wingless rockets were being invented and qualified.



The problem: No low-cost launches for smallsats. The solution: Create a low-cost rocket... Photo: IOS.

The Interorbital team has drawn on the best of these practices from concepts and companies that were attempting to break the stranglehold of the Primes and actually build a low-cost launch vehicle that enables space access for the student, scientist, inventor, artist, musician, soldier, space traveler, and anyone else who was creative enough to find a use or need for an on-orbit platform or trip above the Karman line.

The operative message here to aspiring rocket manufacturers: Don't depend on the government for your development and operational funding—raise your own money and go purely commercial. Interorbital has done it, and it works, without a helicopter 'customer' hovering over your every move.

Low-Cost Launches For Smallsats

To bring value to customers, IOS created and offered personal satellite kits with an eye to a launch on the rocket system the company was already developing to specifically serve the smallsat market sector. The NEPTUNE modular rocket (available as an N5, N9, and N36) has been called the Holy Grail for the smallsat industry. NEPTUNE is the missing link—offering inexpensive, quick-turnaround launch... and lots of launch.

NEPTUNE will enter the orbital transport market in 2016, and during the current flight test phase, already serves the suborbital market with numerous satisfied customers. Most of these customers are already repeat-booked on all upcoming IOS suborbital and orbital flights, with a total of 119 payloads on the manifest.

Hundreds of smallsat companies have sprung up around the world; the center of their business are the affordable picosats (CubeSats or TubeSats)—for less than the price of a used car, a budding entrepreneur can build and launch (with Interorbital) his or her own space anchor in orbital commerce. This democratization of space seriously 'messes with the rice bowls' of the entrenched mega-aerospace corporations and space agencies that launch a majority of industry's and government's satellites.

In many cases, the government agencies and DoD simply don't know how to—or even if they should—interact with New Space companies—or, as the John London affectionately refers to IOS and a handful of others, "representatives of the radical rocket underground." Radical? Absolutely, bent on bringing launch costs down through any means necessary.

Why should those who are tall on promise, but short on resources continue to strain to prop up the existing extortionate price structure? When that type of 'standard' launch operation is the only game in town, that type of price abuse will continue. Those posing this question are the people and companies that are the core of IOS' customer demographic: high potential/low-resource. Interorbital serves the undeserved.

The NEPTUNE launchers will open orbital participation for many who a few years ago could not even consider the possibility of engaging in what was prohibitively expensive space-based science. The low-cost, rapid-response NEPTUNE will also make life easier for NASA, DoD, and other Government entities, domestic and global: more frequent launches; low academic pricing; high-capacity payload opportunities for U-Class sats, if they can learn how to cut the red tape and buy launches from New Space entities.

Remember the FEDEX analogy for sending a payload to orbit? Bring it to the launch provider, weigh it, sign your disclaimers and attestations, pay your freight, go back to the lab and get ready to download data from your sat that will have been launched on the next available flight. This is a beautiful model and one that Interorbital espouses. Government agencies could take a lesson and realize that the dedicated, small launch industry is made up of 'space truckers'—its transportation that matters—and they are customers, buying passage for freight.

Customers don't ask for 100 page reports about how the truck is managing after an afternoon of deliveries, or require the design specs of the truck's transmission, before assigning their payload for hauling. This is what space launch operators encounter when dealing with bureaucrats who simply don't know how to behave as customers.

Acceptance, Activation, Ascent—The Recipe For Launch

With the NEPTUNE's imminent entry into the launch market, the time for scientific experimentation in space is now—launch booking companies world-wide can offer satellite customers the affordable rides they've been waiting for—think of the scientific advancement that will come from these new operators, many of whom have or will start their own STEM-based companies based on building that first satellite and sending it to space. Accept the risk, activate your program—and ascend.

Interorbital Systems (IOS), founded in 1996 by Randa and Roderick Milliron, designs, develops, and manufactures spacecraft and orbital space launch vehicles (SLVs) for both cargo and crew. A one-stop-shop, Interorbital also provides end-to-end space launch services, including licensing and mission design.

IOS is headquartered and maintains manufacturing, prototyping, and rocket engine test facilities at the Mojave Airport and Spaceport (MASP), in Mojave, California. The company's current focus is to serve the smallsat industry by creating a new generation of mass-produced modular rockets called NEPTUNE.



NEPTUNE Modular Rockets + CPM

A completely new mental attitude is required to build launch vehicles that are truly different. To try to create or even copy an existing launch vehicle in a conventional way, using conventional means or 'standard industry practices,' while paying extortionate 'aerospace' rates to approach the problem like nearly all conventional space companies have done to date, will simply not get the job of lowering launch costs done.

Adoption of a completely new approach in the philosophy of aerospace design, manufacturing, testing, and launching is required in order to effect a sweeping change in the industry's mindset of risk-aversion and ultimately, of propping up the existing launch-cost price structure.

In the modular NEPTUNE orbital rocket system, launch vehicles are built using the primary component of all N-System rockets: the Common Propulsion Module (CPM). A CPM is composed of a single gimbaled bipropellant liquid rocket engine, a valve unit, two propellant tanks stacked in tandem, a pressurant tank and regulator, a CPM controller, and an optional bipropellant thruster steering unit.

The CPM is the testbed and basic building-block for all IOS vehicles. It is cheap to build and can be used to prove rocket systems in flight. Multiples of these modules are bundled to create a complete orbital launch vehicle.

IOS' propulsion team has also developed solid rocket kick-motors for orbital-stage insertion, and small COTS solid-propellant spin-up motors. After two-years of intense rocket engine and systems ground testing and qualification, Interorbital's CPM was successfully flight tested on March 29, 2014—and was flown with completely American-made engines.

IOS will start orbital service with its NEPTUNE N9SM4 modular launch vehicle variant in during the 2016 to 2017 timeframe. This rocket system is capable of launching at least 75-kg to a 425-km circular polar orbit. That translates to carrying between 40 and 50 CubeSats and/or TubeSats per launch.

IOS proposes possible launch dates as early as August of 2016 for its 5-module NEPTUNE 5 (N5)—30 kg lift to 310 km—launch-license dependent. Price: \$1 million. Orbital service with IOS NEPTUNE N9SM4 (N9) modular launch vehicle variant is projected for early 2017.

The N9 rocket system is capable of launching 75 kg to a 425 km circular polar orbit. That translates to carrying between 40 and 50 CubeSats and/or TubeSats per launch. Dedicated launch price: \$2 million.

Both the N5 and N9 are dedicated smallsat launchers expressly created to provide economical space access for multiple CubeSat/TubeSat 1U to 4U payloads. Late in 2017, the Google Lunar X PRIZE Moon launch of the NEPTUNE 36 (N36) for Interorbital's GLXP Team, SYNERGY MOON, will occur.

How Interorbital Does It

The Modular Mind-Set Design Advantages: Interorbital launch vehicle design criteria are the direct result of the application of Subtractive Design combined with a Minimum Cost Design manufacturing approach, therewith producing breakthrough, game-changing technology that will alter the price and launch scheduling structure of the global space launch industry.

The best way to reduce cost and failures of components and subsystems is by their elimination or subtraction. Compared to conventional rocket technology, an IOS CPM-based launch vehicle has increased reliability, reduced cost, and by far, less parts—which translates into a safer and less parts to fail agenda.

The following are the rocket design and operational conventions that Interorbital Systems has eliminated or subtracted in order to create a more reliable, less expensive rocket:

1. *No expensive and unreliable pumps to feed propellants into the combustion chambers*
2. *No expensive and unreliable gas turbines to drive the pumps*
3. *No catastrophic pump explosion at propellant depletion*
4. *No hold-down requirement causing Stage-1 performance loss and expensive launch pad additions*
5. *No expensive and unreliable regenerative cooling of the combustion chamber*
6. *No failure-prone electrical or pyrotechnic engine ignition*
7. *No limitation to fuel-rich mixture ratio due to regenerative combustion chamber cooling*
8. *No unreliable hydraulics*
9. *No low-density liquefied gas cryogenic propellants causing large tank volumes*
10. *No expensive and unreliable sealing, insulation, and vent valves required by cryogenics*
11. *No limit of fueled launcher hold-time caused by cryogenics*



12. No slow fueling of cryogenics
13. No defueling need in case of launch delay
14. No need for stage-separation auxiliary propulsion
15. No limit of payload diameters allowing design of cheaper payloads
16. No long and slender launchers requiring expensive launch towers
17. No payload reduction by non-optimal staging for varying mission objectives
18. No economic reason for stage-reuse caused by overly expensive engines
19. No expensive retooling for manufacture in case of changing performance requirements
20. No expensive oversize transport for large propellant tanks or stages
21. No expensive ground support for launcher assembly on pad
22. No tank pressurization during transport

This new approach to rocket design and manufacturing must be done by an unconventional, innovative, new commercial space organization such as Interorbital. A calcified, lock-step, giant aerospace company could not create a low-cost, smallsat launcher because there wouldn't be enough time in the universe to get all the managers' permissions to complete such a project.

IOS is a long-time advocate of subtractive design, of radical simplification of systems, Spartanization, and Minimum Cost Design (MCD) and applies these philosophies, to enhance best practices from the entire history of aerospace development. The company employs and blends methods from industries other than aerospace to achieve a fresh look at how to build rockets, launch rockets and run a rocket company.

MCD emerged as a direct attack on the waste, fraud, and abuse rampant in the aerospace contracting sector during the 1960s. Many of those in the business have, year after year, decade after decade, watched with disgust as funding went to vaporware projects, to regurgitations of failed, glitzy forgotten (and previously rejected) concepts from the past, watching as new con-men thrived by banking on the public's inability to recognize the re-packaged pork-barrel projects of bygone ages.

Stepping into the commercial arena with a truly 'different' space launch vehicle is always a threat to those individuals who are looking for the fast buck, but the new vehicles offer hope for those seeking space-lift based on logical design and prudent con-ops.

The Interorbital Systems Launch Manifest may be viewed at:

www.interorbital.com/interorbital_06222015_014.htm

IOS had a choice: try to build a rocket that imitates the conventional rockets in use today and end up with just another highly complex and unaffordable launch vehicle, or to follow the Steve Jobs' mantra, actually 'Think different' and really create something that actually is different. Interorbital did, and the result is the NEPTUNE launch system. Don't fear it—embrace it... exactly what the smallsat industry needs.

Interorbital's kind of thinking produces a practical 'service' rocket: less sleek, but stronger—not a racehorse, but a workhorse that approaches reaching orbit as a brute-force endeavor. IOS' approach is radical, unorthodox, risk-tolerant, iconoclastic, and truly game-changing.

The NEPTUNE rocket is approaching operational readiness and it is here for the taking. Its very existence answers government's mandate to introduce lower launch prices and provide more frequent launch opportunities.

In addition to these hardware-related cost-cutting measures, IOS has determined that low launch costs can only be achieved if the launches originate from private spaceports or from the ocean. IOS has been quoted launch costs from US ranges including Vandenberg, Wallops, and Kodiak, in the two-million-dollar-plus range, with the extra negative



IOS crew building ocean deployment unit segment at MASP. Photo: IOS.

of long scheduling delays. Because of the terrifically expensive and concentrated space launch assets at the Cape and Vandenberg, insurance costs may remain tremendously high because of the infrastructure that could be impacted in the event of a launch failure.

For the low-cost launch provider, high insurance is too much of a cost-driver. IOS rockets are designed to launch from unimproved land sites or from the ocean, areas devoid of infrastructure, traffic, and people. The Vertical Ocean Launch System solves a multitude of these problems, significantly diminishes launch and operational costs, and allows IOS to provide true rapid-response launch-on-demand.

From its inception, Interorbital's goal has been to create the world's lowest cost launch system. The founders of Interorbital Systems responded to the complete lack of space access experienced by the private-sector scientific and academic communities: launch was only for the rich; only for the military; only for Government; only for a small cluster of mega-corporations; and only accessible at enormous cost. Definitely a closed-door policy to those not already hooked in and able to jump the highly restrictive entry requirements.

People often talk about democratizing space—well, Interorbital is already doing it. IOS' first commercial launches have given two satellite companies a jumpstart on their business operations. They are now bringing their own clients to IOS for launch. This is a pattern IOS sees repeating with a majority of its clients. The buzz has started and Interorbital is interacting with new and repeat customers every day, selling satellite kits and booking launches in ever-increasing numbers—without advertising.

How does Interorbital keep costs down? The company does not out-source propulsion systems. IOS builds its own engines and does not buy expensive foreign engines, nor engines from other domestic manufacturers. Interorbital's founders believe that all key components should be produced in-house to insure economic freedom and price control of the most vital of launch vehicle components.

Interorbital uses only American-made rocket engines, made by Interorbital itself. IOS saves by keeping its prototyping and launch teams small. The company does not have massive overhead or immense salaries.

If IOS were to simply follow the standard industry practices of the huge corporations and build to the highest spec possible, or even to build a copy of an existing conventional high-complexity launch vehicle, no cost savings would be possible. IOS would return to the stalemate the industry currently finds itself: lots of payloads to launch and no one to launch them in an affordable manner.

Killer of Creativity: The Review Process

Several commercial providers have thrived in what was touted to be a new era of risk-tolerance—an era that was all-too-brief before the undertow of strategic gossip started. The mania and hysterical finger-pointing that resulted from the two recent SpaceX and ATK/Orbital accidents is just another example of how the anti-commercial space propaganda machine works.

Even though these two companies have respectable track records of launch success, and there is always a probability of eventual launch vehicle failure; there exists a component in service to the Status Quo that faithfully chants a message to keep the public mind focused on the risk and danger of any new rockets. That message is that New is bad. New might blow up. New means the contract might not be satisfied so let's not try anything New at all. Let's keep paying millions and billions to be safe with the not-New.

If government wishes to have the low-cost launcher it keeps asking for, if there is really a new attitude in the various agencies, that means they would consider actually tolerating additional risk in order to try launch systems that solve the problem of ride scarcity in the CubeSat community. The government must also be courageous enough to take a chance with a new approach that has the potential to bring immense breakthroughs in space access for all.

NEPTUNE is the launch system that will provide the smallsat community with rapid-response passage to orbit for an ultra-low price-point that was heretofore undreamt of. IOS has intentionally built its rockets to serve the smallsat market. Perhaps it would be a good example for space agencies worldwide to exercise as much boldness as the 119+ launch customers on Interorbital's launch manifest have done: taking their place on a new launch system and choosing to fly over not-flying.

The other option for seekers of launch is to live paralyzed by fear of failure and never launch at all. It's time for government to man-up. Entering the Space Biz is an order to be brave—to venture, to dare, to put skin in the game, to take a chance, to be like Jobs and think 'different'—taking this well-calculated leap into the unknown is the only way to activate the much anticipated paradigm shift and promise of Space 2.0.

www.interorbital.com/



Image is courtesy of Bryan Versteeg.

Effective Maintenance + Troubleshooting Of Earth Stations

By Dan Dunn, General Manager, RF/Microwave Handheld Instruments, Component Test Division, Keysight Technologies, Inc.

If recent forecasts come to pass over the next few years, governments and commercial entities around the world will be placing hundreds of new satellites into orbit—they also will be constructing new ground stations and teleports to manage the satellites and their high-volume data traffic.

Ensuring the smooth operation of this new infrastructure will depend on the fast, efficient and cost-effective maintenance and troubleshooting of crucial Earth station equipment. In the past, testing the various radio frequency (RF) and microwave elements has typically required five or six pieces of test equipment, including a spectrum analyzer, a vector network analyzer (VNA) and a cable and antenna tester (CAT).

Today, Keysight's handheld combination analyzers can replace the full set of instruments previously used for measurements in the field. The latest models can be configured to deliver precise measurements at millimeter-wave frequencies virtually anywhere satellite maintainers need to go.

Outlining The Essential Measurements For Earth Stations

Although every satellite system has two major parts—the space and Earth segments—the focus here is on the Earth-bound side. A ground station sends uplink signals and receives downlinks, and Figure 1 below provides

a simplified block diagram that highlights the RF and intermediate frequency (IF) portions of each signal path.

Effective maintenance and troubleshooting requires testing of the overall system and its key elements: antennas, transmitters, receivers and transmission lines. Example measurements include return loss (antenna), fault location (transmission lines), high-power amplifier performance (transmitter), low-noise amplifier (LNA) performance (receiver), and carrier-to-noise measurements (system-level).

Although Table 1 (on the next page) provides more detail for each major subsystem, these lists are still a subset of what is required for system installation, verification, maintenance, and troubleshooting. Completing the full complement of tests requires six essential instruments: power meter, spectrum analyzer, vector network analyzer (VNA), line sweeper (return loss, distance-to-fault and time-domain reflectometry), RF source, and DC source with voltage and current meter.

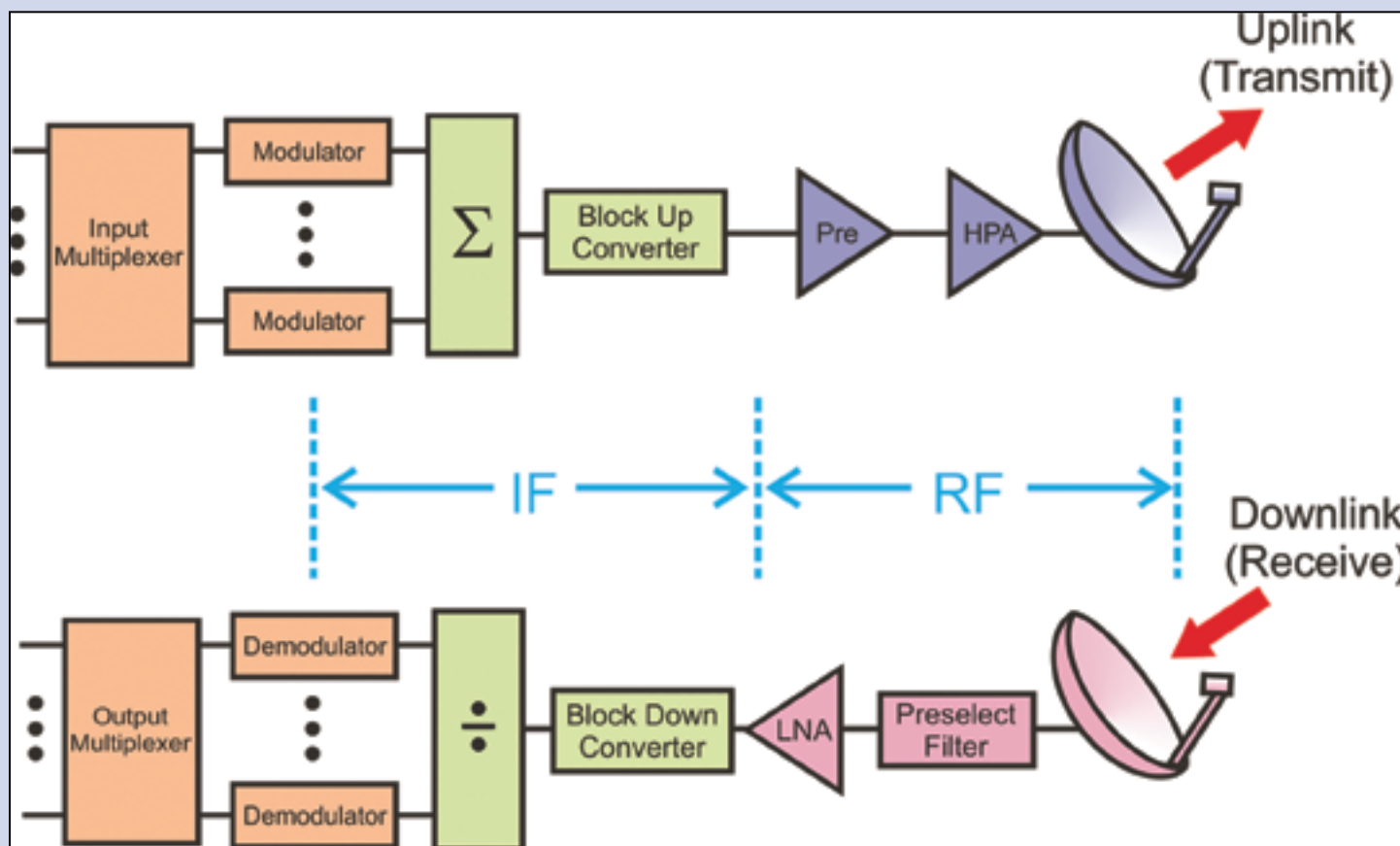


Figure 1. These simplified block diagrams of transmitter and receiver channels illustrate the elements field personnel can measure, characterize and troubleshoot using an all-in-one handheld analyzer.

	Antenna	Transmission lines	Transmitter	Receiver	System-level
Test requirements	<ul style="list-style-type: none"> • Return loss • Alignment • Polarization • Cross-polarization • Sidelobe levels 	<ul style="list-style-type: none"> • Cable & waveguide loss • Rotary joint VSWR • Fault location 	<ul style="list-style-type: none"> • HPA performance • Converter performance • Frequency stability 	<ul style="list-style-type: none"> • LNA performance • Converter performance • Interference • GPS (mobile applications) 	<ul style="list-style-type: none"> • Equivalent isotropic radiated power (EIRP) • Gain/temperature (G/N) • Carrier-to-noise ratio (C/N) • Bit error ratio (BER) • Radio frequency interference (RFI)

Table 1. This listing of the essential tests for an Earth station is a subset of the total test requirements.

Equipping Support Personnel

Users can configure Keysight handhelds to perform CAT, VNA, signal analysis, and more. This range of essential, accurate and timesaving capabilities enables faster diagnosis and repair of faults.

For example, calibrated CAT and VNA measurements help field personnel maintain cable, waveguide and antenna systems consistently and efficiently. Focusing on spectrum analysis highlights the advantages of Keysight's FieldFox microwave analyzers. For more than 20 years, operators around the world have relied on "portable" spectrum analyzers that were, in reality, a "luggable" solution.

For example, the widely used HP 8565E/EC weighed a hefty 17.3 kg, (38 lbs) and measured 34 x 43 x 19 cm (13.3 x 16.8 x 7.4 in). In contrast, a FieldFox handheld analyzer weighs just 3.2 kg, (7.1 lbs) and measures about 29 x 19 x 7 cm (11.5 x 7.4 x 2.8 in).

These units offer exceptional durability, using a mechanical design that includes no fans or vents. For example, FieldFox has a rugged, fully sealed enclosure that's compliant with US MIL-PRF-28800F Class 2 requirements. The analyzers have also been type tested to IEC/EN 60529 IP53 requirements for protection from dust and water, extending instrument durability in even the harshest environments.

Warm-up time was another inconvenient aspect of the previous-generation luggable analyzers. This is no longer an issue: with an "instant alignment" feature, a FieldFox microwave analyzer is ready to make highly accurate spectrum measurements at power-up and during ongoing changes over a specified temperature range (e.g., -10 to +55 degrees C or 14 to 131 degrees F). This feature also enables the built-in power meter to make accurate measurements without using an external power sensor.

Carrying Precision Into The Field

Compared to traditional analog designs, a modern digital architecture provides important advantages. For example, there are none of the log-fidelity errors that affect amplitude linearity. Gone, too, are the span-accuracy errors that affect frequency accuracy.

A digital architecture also helps ensure results that match up with those obtained using benchtop analyzers. As a result, today's best handhelds deliver time- and frequency-domain measurements that correlate with benchmark data acquired using benchtop instruments in the development lab and at system installation. This level of correlation increases confidence in measured results and also reduces the risk of accepting bad systems, subsystems or components, or of failing good ones.

The FieldFox family also supports remote operation through an application that runs on a variety of iOS devices. This feature enables collaboration between personnel, one example being an engineer working at the dish flange and another engineer down below, analyzing measurement results through an iPad or iPhone.

Reducing Capital Expenditures And Operating Expenses

Another benefit of migrating to modern, field-ready technology is a reduction in capital expenditures (CAPEX) and operating expenses (OPEX). Even though a handheld analyzer can replace multiple instruments, some are priced such that each function—CAT, VNA, spectrum analyzer—is about one-half the cost of a comparable benchtop unit. Upfront, this can provide tremendous savings in CAPEX.

A combination analyzer also simplifies the maintenance process, requiring just one calibration per year. This reduces annual OPEX compared to the traditional array of equipment, which may require multiple calibrations per year plus calibrations of any spare instruments. Handhelds that include a standard three-year warranty also reduce the cost of repairs, if needed.

The All-In-One Solution

As new-generation Earth stations come online, handheld microwave analyzers offer a powerful all-in-one solution for field personnel tasked with onsite maintenance and troubleshooting. With a robust array of essential, accurate and timesaving capabilities packed into a portable and durable design, engineers and technicians can be equipped for faster diagnosis and repair of today's most advanced installations.

Keysight recently introduced a line of six millimeter-wave instruments. The lineup includes three combination-analyzer models that cover 32, 44 or 50 GHz, and there are also three spectrum-analyzer models that cover the same frequencies.

www.keysight.com/find/first50sat

Dan Dunn is a General Manager at Keysight Technologies, responsible for worldwide RF and microwave handheld instruments. He joined Keysight (formerly Agilent Technologies & Hewlett-Packard) in 1995 as an antenna systems engineer. Dan has held various leadership positions at Keysight including marketing manager, global sales manager, product marketing manager and product manager for the 8510 and PNA network analyzer families.

Prior to joining Keysight, Dan worked for Lockheed Martin from 1986 to 1990 as a radar engineer developing test systems for low altitude terrain-following radars for the F-16 and F-15E. From 1990 to 1995, Dan was the Engineering Manager at Technical Systems Associates, an engineering, manufacturing and consulting firm that specialized in the design and development of antennas and tracking systems.

Dan earned Bachelor's and Master's degrees in electrical engineering from the University of Central Florida and attended executive education at Harvard University.

Advanced Smallsat Technologies Take On Commercial Markets

A Tyvak Perspective

The small satellite (smallsat) industry is receiving significant attention these days, specifically when it comes to the US military and NASA-based applications.

The commercial world hasn't yet embraced widespread use of this technology; however, the expectation is that, by 2019, the smallsat market will reach \$1.8 billion, with the commercial sector comprising the largest portion of this market (Source: "Nanosatellite and Microsatellite Market—Worldwide Market Forecast (2014-2019)").

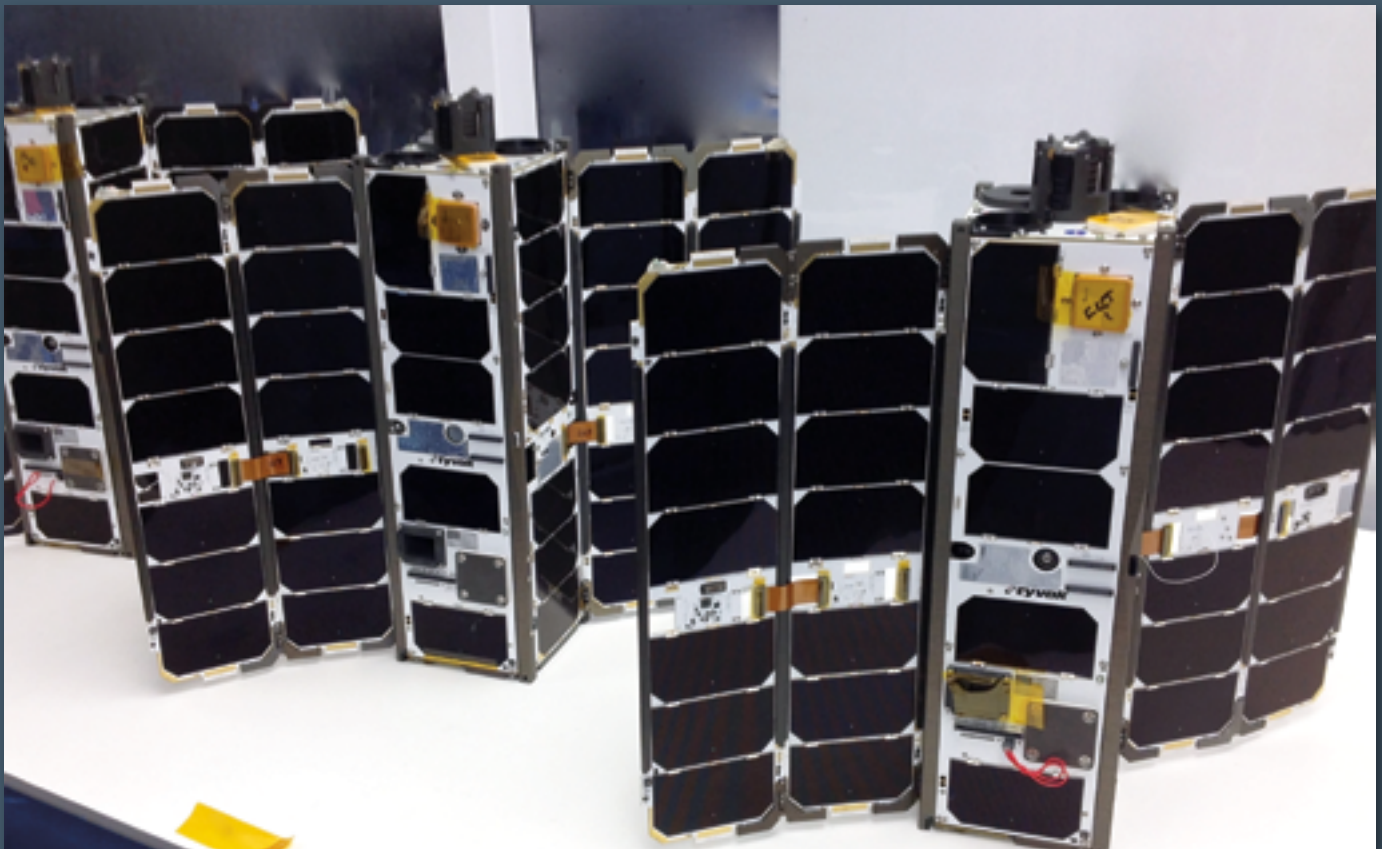
There are numerous benefits when employing smallsats—from providing inexpensive, space-based data collection to troubleshooting and repairing large, individual satellites and constellations that are already on orbit. They are able to provide servicing operations and refueling capabilities to other space vehicles; awareness and notification of space and Earth-based natural and manmade threats; formation flying activities; innovative telecommunications platforms; collection of weather pattern data; and fast, low-cost space debris inspection and removal, just to name a few of the many smallsat solutions.

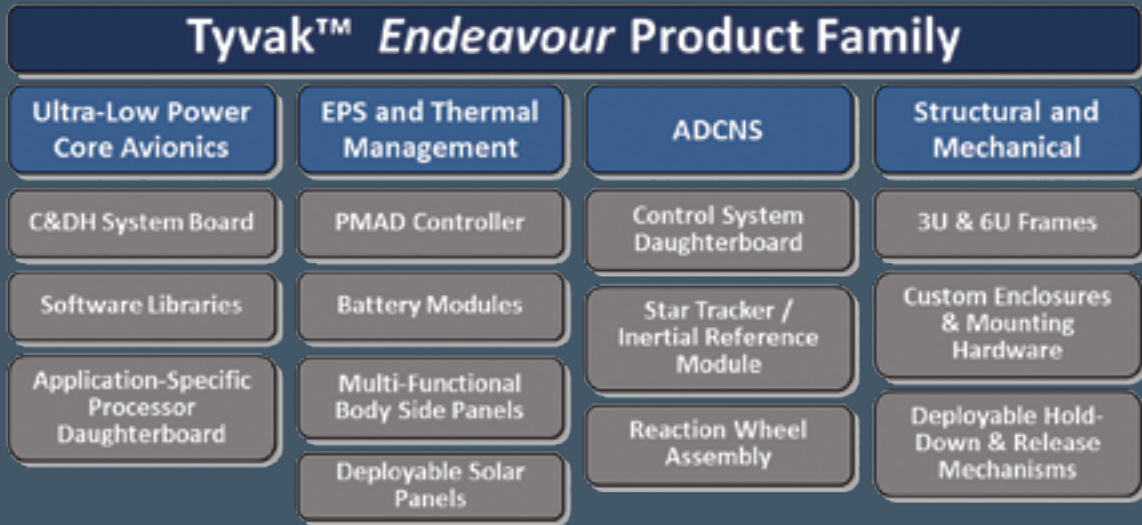
Commercial companies can also leverage smallsats to protect larger space systems, which can represent a significant investment of time and resources. Smallsats can maneuver autonomously up to a larger spacecraft in orbit, assess that satellite's health, repair noted malfunctions and broken hardware, resupply fuel and also assist with de-orbiting tasks.

There have been multiple attempts to bring smallsat implementation projects to fruition by more traditional commercial companies, as well as through government projects such as the Air Force "ANGELS" program and the canceled DARPA F6 formation-flying satellite demonstration. The key, missing element throughout these programs was the inclusion of a company that specialized in the design, development, deployment and operations of smallsat technology. The potential success of these missions is now about to get a significant boost.

In the spring of 2016, a unique, first-of-its-kind mission will occur. NASA's CubeSat Proximity Operations Demonstration (CPOD) mission, led by Tyvak Nanosatellite Systems (a Terran Orbital Company), will demonstrate rendezvous, proximity operations, and the docking of two 3U nanosatellites on behalf of the NASA Small Spacecraft Technology Program, and Space Technology Mission Directorate. This mission will employ a novel, universal docking and grapple system that has been developed by Tyvak engineers. Each satellite will use its space-to-ground data link to transmit visual images of the other satellite.

The ability of satellites to operate in close proximity to one another is an important capability to enable on orbit inspection, servicing and maneuvering of target satellites. Such also enables the rescue of tumbling satellites and satellite de-orbiting.





spacecraft and then forcing a de-orbit if and when such is needed.

High Frequency Re-Flight

The ability to obtain short re-flight time via smaller satellites is unmatched among larger spacecraft. Smallsats ensure effective agility in dynamic mission profiles. The monitoring of crops, weather patterns,

Tyvak has already developed these capabilities through its smallsat architectures that are based on the company's "Endeavour" platform, which is adaptable for missions from five to 50 kg, with high-power capabilities, precision attitude control, high-data communication rates and fault handling/autonomy. While CPOD is a NASA-focused demonstration, this mission will prove the viability of smallsat capabilities that will have a broad range of valuable applications within the commercial sector.

The Commercial Benefits of Smallsats

Formation Flying

There are significant benefits in a broad availability of the technology needed to have "swarming" capabilities. The multitude of antennae and image-gathering technologies in a cluster of smallsats creates a wider surface in which to transfer larger, clearer images to ground-based customers, de-facto mimicking what is already being done on the ground.

Smallsat swarms also increase the footprint for each mission and provide redundancy that has clear implication toward a more secure on-orbit architecture. A successful NASA/Tyvak CPOD mission in early 2016 will demonstrate a nearly 100 percent formation flying capability that can then be leveraged into commercial applications currently being evaluated by multiple customers.

Sentinel Capability

Smallsats can be sent on sentinel deployments, ahead of more expensive missions, to collect measurements, video and images of an intended target (an asteroid for example). The ability to gain early intelligence on a mission can save time and money, or even the entire mission.

Resupply + Troubleshooting

Smallsats can provide on orbit fuel resupply and also have the ability to repair other spacecraft on orbit, as needed.

Orbiting + De-orbiting Spacecraft

Smallsats can significantly contribute toward solving the space debris problem by grabbing inactive objects or decommissioned

wildlife migrations, asteroid trajectories, orbital debris and near real-time communication are but a few of the applications that will maximize smallsat usage in the near future.

Currently, there are few companies that provide a true smallsat turnkey solution to commercial customers. Interested parties can easily purchase off-the-shelf satellite components and hardware, engineering services, launch coordination and launch insurance through separate companies across the globe. However, only Tyvak offers a complete, one-stop solution—this solution lowers cost and timelines for commercial customers who are interested in using these leading edge technologies.

"We continue to lead the way in developing and deploying a total solution for commercial customers. The capability is available, now. It's inexpensive, it's timely and it's available," said Tyvak President and COO, Dr. Marco Villa. One company that has availed themselves of Tyvak's turnkey, smallsat solution is GeoOptics, an environmental data and weather monitoring company based in Pasadena, California. The company is leveraging Tyvak's Endeavor platform to assure the proper delivery of environmental data to scientists and decision-makers around the world.

"Tyvak really stood out as the company with the best technology and systems approach to meet our customers' demanding mission goals," said GeoOptics CEO Admiral Conrad Lautenbacher. "No other company in the market today offers a comparable, integrated approach for high performance, affordable missions."

Moving forward, there may well be other companies who are similar to California-based Tyvak Nanosatellites that are developing full-service solutions to commercial customers—for now, Tyvak stands out in an industry laden with off-the-shelf component manufacturers.

To learn more about Tyvak, visit www.tyvak.com and www.terrannorbital.com.

Protect C-Band Satellite Networks—An AsiaSat Perspective

By Vicky Wong, Senior Engineer, AsiaSat



C-band frequencies (3 400-4 200 MHz (space-to-Earth), 5 725-6 725 MHz (Earth-to-space) have been shared with terrestrial applications throughout the entire satellite era.

Traditionally, the terrestrial applications were microwave links providing connectivity for a limited numbers of stations at fixed, well defined locations and using directional antennas with controlled emissions and well-designed ground equipment. However, the new applications, which now are threatening C-band Fixed Satellite Service (FSS), are different in nature in that they are deployed ubiquitously, using non-directional antennas and often without individual licensing of stations, in particular user terminals.

As a result, the interference scenario and the capability for FSS to take into account, and co-exist, with these is completely different from that of the earlier terrestrial applications using the same band. In addition, the ignorance of the existence of the C-band FSS by new terrestrial applications worsens the sharing situation.

For example, for some terrestrial communications, instead of having their antenna pointing down on the surface and improving isolation to building tops, terrestrial operators choose to put their antennas on high grounds to service wider coverage. These terrestrial applications no longer have a sharing desire (co-exist) but a ground strategy to dominate the satellite FSS C-band frequencies.

There are two different groups of new terrestrial applications that are threatening C-band satellite networks. These groups are principally different in the way they are introduced and authorized by administrations.

Each of these groups encompasses several types of applications and technologies. The groups discussed are:

- **Broadband Wireless Access (BWA) / Fixed Wireless Access (FWA), WiMax**
- **International Mobile Telecommunications (IMT), LTE**

Out of these groups, it may be the IMT/LTE applications that have caught the most attention lately. However, very few networks in this group have been implemented and, as of today, the numerous interference cases encountered mainly stem from BWA/WiMax types of applications.

1. Broadband Wireless Access / Fixed Wireless Access / WiMax Broadband

Broadband Wireless Access (BWA) / Fixed Wireless Access (FWA) / WiMax systems encompass a range of systems, normally aimed at providing broadband Internet access to groups of users through what might be seen as a large-cell WiFi system. User terminals are fixed, nomadic or mobile and deployed ubiquitously.





BWA networks are seen introduced country by country, in direct contact with individual administrations, without any involvement of ITU or World Radio Conferences, and with no particular mention in the Radio Regulations.

Currently, in the Asia-Pacific region, BWA is seen introduced predominantly in the 3.4-3.6 GHz band. Nevertheless, the interference from BWA operating in this band has been the main source of terrestrial interference for reception in the entire C-band¹ with many cases of interference leading to outages and loss of service for many customers.

2. International Mobile Telecommunications (IMT) / LTE

IMT is a generic term used for mobile networks adhering to certain ITU standards and can operate in several frequency bands. The ones considered for C-band are in the IMT Advanced category and are foreseen for high capacity, providing 100 Mbit/s connections for handheld user terminals and 1 Gbps for nomadic user terminals. Practical implementation is forecast for around 2020.

Some WiMax networks are operating within the IMT standards and are seen to bring a significant overlap between the BWA and IMT types of networks. However, in terms of how these networks are recognized and introduced, the approach is completely different.

While BWA networks are introduced country by country, completely outside ITU and without any particular recognition in the Radio Regulations, IMT has become the subject for specific agenda items of World Radio Conferences (WRCs) to identify specific frequency bands for IMT. Furthermore, several ITU-R Recommendations and Reports are seen to have been developed, describing IMT technical standards and compatibility with other services.

As a result of these studies; when WRC-07 (Year 2007) identified the 3.4-3.6 GHz band for IMT in some countries, power flux density (pfd) limits were imposed at the borders of these countries to protect FSS in neighboring countries. This is a very important element of the IMT identification and is very different from non-IMT BWA where no such pfd limits exist.

In the preparations for WRC-15, several players on the mobile side have advocated lifting these pfd limits and, certainly, when considering additional parts of C-band downlink for IMT they would not like to see the same pfd limits applied.

Both C-band downlink and C-band uplink have been proposed as possible candidate bands for IMT identifications by WRC-15. In particular, C-band downlink has been seen targeted because of its lower frequency and, thus, better penetration compared to C-band uplink and because, in the C-band downlink band, terrestrial applications will, in practice, receive no interference from satellite links and will only create interference into these. Therefore it is not their problem, it is the satellite users' problem. For the C-band downlink, proposals have been made for changing the identification in the 3.4-3.6 GHz to a global allocation.

In terms of interference into FSS reception, IMT is very similar to BWA. ITU studies conducted in preparation for WRC-07 and new studies conducted in preparation for WRC-15 show that in respect of in-band operation, separation distances, when taking into account the short-term quality objective for FSS, in the order of 100–500 km are required for regular outdoor macro-cell IMT deployment.

If IMT is confined to low-power indoor deployment only, the separation distances are reduced to about 5 to some tens of km (120 km in one study). It can thus be seen that by deploying IMT in an area, vast areas around become unusable for FSS reception. This also illustrates the importance of pfd limits at the national borders as currently in the Radio Regulations for the 3.4-3.6 GHz band, such that as a minimum, FSS is protected in neighboring countries.

So far, FSS friendly countries and FSS operators are working very hard to propose "No Change" (NOC) in the C-band since the sharing studies have again demonstrated that the coexistence of the IMT service with FSS, in the same geographical area is not feasible. It should be emphasized that C-band is heavily used for satellite communications throughout the world for a multitude of services including very small aperture terminal (VSAT) networks, Internet services, point-to-multipoint links, satellite news gathering, TV broadcasting to satellite master antenna television (SMATV), direct-to-home (DTH) receivers and feeder links for mobile satellite service.

The wide coverage of satellites in C-band enables services to be provided to developing countries, to sparsely populated and geographically remote areas and over large distances (e.g., providing program content and data distribution between continents). Due to its ubiquitous coverage, high availability and instant connectivity, C-band FSS plays a key role on the

socio-economic development of many countries to provide vital services and is also crucial for disaster relief operations.

This band is also used by governments in conjunction with international commitments; for example, the World Meteorological Organization (WMO) uses this band to distribute meteorological data throughout the world and maritime and aeronautical safety related information is relayed through stations operating in this frequency band. Furthermore, due to its lower frequency, in particular in regions characterized by high rain attenuation, C-band is the only realistic satellite band where FSS services can be provided with high availability.

The current use of C-band by BWA is causing significant interference and disruption of satellite networks. Further identifying C-band for IMT would mean even more disruption to all these vital services which would have a huge impact on the socio-economic development of many countries. To protect the vital FSS services operating in C-band and to avoid the detrimental impact due to the loss of these, it is instrumental that WRC-15 says no to any further IMT identification in C-band.

3. What Can Be Done To Reduce The Effect Of Interference From BWA/IMT?

1. Take into account the usage/license situation when deploying a new service

To avoid interference from BWA/IMT, it would be beneficial to take into account the usage/license situation in the countries and its neighboring countries where C-band FSS services are intended to be deployed to identify the best appropriate frequencies or select the appropriate site for reception antennas.

There are two reports developed in APT (Asia-Pacific Telecommunity) which provide an overview of the usage of the 3.4-3.6 GHz band in the Asia-Pacific area as reported as of 2014 (No. APT/AWG/REP-37 [Rev.1]) and the information of mobile operators' frequencies, technologies and license duration in Asia-Pacific countries as of 2015 (No. APT/AWG/REP-15 [Rev.2]), the latest version of these reports can be downloaded in www.apt.int/AWG-RECS-REPS.

In addition, the individual market summaries in www.casbaa.com/regulatory/satellite-issues/c-band-invasion is also a very good reference source.

2. Register Your C-Band Earth Station

For those who have already deployed C-band FSS service, it would be beneficial to register your C-band Earth station in the ITU databases to obtain international recognition and protection of your Earth stations. As the registration of an Earth station into the Master International Frequency Register (MIFR) entails the procedures of coordination as well as notification, it is inefficient and impractical to register all FSS Earth stations, as this would involve an enormous workload.

AsiaSat's presentation material provides some general guidelines for identifying the potential FSS Earth stations to be registered and suggestions on how to minimize the number of Earth station registrations, without compromising on the required protection levels. Registration of C-band Earth Stations to Acquire Protection from Terrestrial Interference [[download](#)].



3. Select Proper Pre-LNA/ pre-LNB Waveguide Filter With The Proper Rejection Levels

Satellite LNAs and LNBs are designed for reception of very low satellite signals and the dynamic range is set accordingly. BWA or IMT signals can produce much higher power (e.g. 45dB higher) than the satellite signals at the LNA/LNB input and can thus overdrive or bring it into non-linear operation. This can block reception of signals anywhere in the entire 3 400-4 200 MHz band, even if the terrestrial signal is not overlapping with the FSS signal.

To avoid LNA/LNB overdrive from BWA/IMT, it may be possible to install pre-LNA/LNB waveguide filter. The filter should have:

- *High rejection (e.g., 60dB or more) in the bands where BWA/IMT is operating*
- *Low insertion loss (e.g., 0.5dB) in the intended receivable frequency range*

According to our experience, an integrated filter with the LNB cannot provide the same levels of rejection as an external filter. An external filter is therefore recommended. Some typical filters:

www.microwavefilter.com/7893_chart.html
www.norsat.com/product/c-band-band-pass-filter-2/

4. Report Any Interference To Your Satellite Operator Or Local Regulatory Authority

If your C-band FSS service receives interference from BWA/IMT, it is very important to report that to your local regulatory authority and/or satellite operator as soon as possible so that they can take action. Your incident report will also serve as valuable information for the satellite friendly countries and satellite operators in the battle to defend C-band spectrum for FSS.

For additional information on protecting C-band satellite networks, please contact: Asia Satellite Telecommunications Co. Ltd.

(852) 2500 0888

as-mkt@asiasat.com

www.asiasat.com

Reference

¹ *Adjacent band interference, which is caused by out-of band emissions of BWA transmitters and/or BWA emissions overloading the FSS receivers, bringing them into non-linear or saturated operation.*

Vicky Wong is AsiaSat's Senior Engineer. Vicky has extensive experience in frequency coordination and International Telecommunication Union (ITU) activities. She has engaged in many administrations' and operators' coordination meetings, providing technical assessment on interference scenarios and expertise advices to resolve challenging interference issues.

The Growing Value Of VSAT At-Sea: An iDirect Perspective

By Terry Neumann, Director of Market Strategy, iDirect

High throughput capacity and efficient ground infrastructure meets rising demand for staying connected aboard maritime vessels.

Today, more than 20,000 maritime vessels sailing around the globe are online—thanks to satellites. Going forward, an additional 51,000 could be set to communicate ship-to-shore using this technology—representing 71 percent of the total market.

This is a significant figure, cited within the fourth annual comsys Maritime VSAT Report, especially when you consider that the addressable market for maritime once stood at only 10,000. In fact, between 2012 and 2013, VSAT installations

increased by 25 percent, while service revenues grew by 15 percent, now totaling \$1.3 billion.

You could say that the days of maritime operators being hesitant to invest in onboard communication technology due to a lack of Return On Investment (ROI) are becoming an element of the past—more and more, VSAT is being viewed as a cost saver rather than a costly investment aboard all types of maritime vessels.



WAVE OF GREATER BANDWIDTH REQUIREMENTS

Markets demanding higher throughput



CRUISE INDUSTRY

Demand for higher throughput rates primarily driven by larger number of passengers onboard.

KEY APPLICATIONS

- Interactive guest services
- Entertainment and streaming video
- High-speed Internet
- Onboard wireless service



OIL AND GAS

Skyrocketing throughput requirements needed to support heavy-bandwidth applications.

KEY APPLICATIONS

- Crew training
- System automation and cloud computing
- Seismic data transmission
- Live video monitoring and conferencing

On average, VSAT service typically represents only about 1 percent of a vessel's operating costs. However, the ROI can be compelling. Take crew welfare, for example: comsys states that many maritime operators experience turnover rates of 35 percent; the lack of connectivity is a common reason crew jump ships to work on a vessel offering better connectivity. Replacing crew takes a major toll on acquisition and training costs, which can also include screening, visa arrangement and immigration expenses.

For global maritime operating companies, the key to investing in VSAT comes down to balancing connectivity spending on business objectives with tangible measured results. These results can span from improving crew welfare and passenger connectivity to now supporting a wide range of business applications, such as monitoring weather patterns to help cut fuel costs, filing regulatory documents and ordering supplies from sea to save

time in port and generating business intelligence through a growing range of software applications, among others.

Higher Throughput Comes Aboard

As the value of VSAT increases, so does demand from maritime operators for higher throughput services. Subsequently, this drives revenue growth from the installed base. According to figures from comsys, VSAT data rates in various segments have skyrocketed from 10Mb in 2007 to 100Mb in 2013, due in large part by streaming video and bandwidth-intensive business applications.

The introduction of High Throughput Satellite (HTS) capacity has been a driving factor. The advent of HTS addresses two critical challenges that have plagued VSAT operators for years: the rising price and lack of availability



WAVE OF INCREASED MARKET ADOPTION

Market primed for greater usage.

COMMERCIAL SHIPPING

Better coverage, more affordable bandwidth and lower-cost equipment will drive increasing levels of adoption.

KEY APPLICATIONS

- Crew welfare
- Remote IT services
- Electronic charting and weather
- Electronic port and customs documentation



FISHING INDUSTRY

New applications designed to bring commerce on board will raise adoption level.

KEY APPLICATIONS

- Online sales of catches/auctions
- Vessel monitoring
- Regulatory reporting
- Telemedicine



of satellite capacity. For end-users, HTS lowers the cost of capacity per MB, which is projected to make VSAT service more economical, along with higher data rates and more affordable, compact terminals and antennas.

According to Northern Sky Research (NSR), nearly 30 Gbps of HTS capacity will come online from GEO and Non-GEO orbits across C-, Ku- and Ka-bands—with an average compound annual growth across both orbits and frequencies of 40 percent.

Furthermore, NSR sees an average 46 percent compound annual growth rate for HTS VSAT in-service units over the next 10 years. The number of units will experience a dramatic increase, from roughly 100 units in 2014 to reaching nearly 16,000 units by 2024. Add to that the projection that HTS VSAT revenues will increase from around \$10 million in 2014 to more than \$1.2 billion by 2024, the result is an outlook that is considered to be extremely healthy.

Look no further than the launch of new HTS constellations targeted at the maritime sector as reinforcement of this trend:

- *Inmarsat Global Xpress (GX) will provide seamless global coverage over Ka-band based on a managed service model. With GX, service providers can procure high-speed capacity over any maritime route, delivering a consistent network experience. And they can do so without needing to manage HTS ground infrastructure, which can be very complex and capital-intensive due to spot-beam architectures.*
- *The IntelsatOne Flex network, a high-performance managed service that leverages Intelsat's new Epic fleet of spot-beam satellites, along with its existing global Ku-band fleet. The Intelsat offering will allow service providers to manage the customization, contention and prioritization of sub networks and end-user terminals with tiered Committed Information Rate (CIR) plans.*
- *Telenor's THOR 7 takes a more regional approach and delivers a Ka-band HTS payload of up to nine Gbps of throughput across 25 spot beams over the North, Mediterranean and Baltic Seas. Blend these trends together and the result is a significant shift in the way maritime companies will leverage VSAT in the years ahead.*

The Right Moves On The Ground

Not to be lost amid all the talk of innovation in the sky via HTS and other advances is the role of the satellite ground infrastructure. For satellite operators and service providers alike, selecting the correct ground infrastructure can be one of the most important decisions they make in regard to meeting their market needs:

For satellite service providers, it's about being in position to best capitalize on every opportunity as HTS introduces an influx of new capacity, as well as a new set of dynamics. This means the need to scale networks, provide faster speeds and look at different business models to meet their customers' needs.

For satellite operators, it's about tackling a new set of challenges, ranging from the ability to manage capacity in a spot-beam environment to operating the ground infrastructure to offer capacity via a managed service. Satellite

operators must consider both the fundamental system design, as well as its ability to handle unique HTS challenges.



iDirect (www.idirect.com) plays a leading role for satellite operators and service providers. For service providers, iDirect's Evolution® TDMA platform cost-effectively helps with the sharing of bandwidth across multiple vessels, while prioritizing each ship's dynamic requirements without compromising quality and reliability.

Today, more than half of all VSAT remotes deployed on vessels are built by iDirect—eight of the 10 largest maritime VSAT service providers by revenue rely on iDirect's Evolution platform to run their networks.

The iDirect Velocity™ platform enables satellite operators to capitalize on their HTS investment. iDirect Velocity is designed to enable Satellite Operators the global delivery of high-performance capacity over spot-beam satellites. Each of three aforementioned HTS services—GX, IntelsatOne Flex and THOR 7—are taking their HTS solutions to market via iDirect Velocity.

iDirect Velocity's global bandwidth management technology allows satellite operators to stitch together multiple spot beams as one unified bandwidth pool. This allows the ability to offer managed Mega bits per second (Mbps) services to customers across the total bandwidth pool, rather than operating strictly within individual beams.

Service providers can operate simultaneously on both iDirect's Evolution and iDirect Velocity to manage a blended portfolio that uses dual-mode remotes.

The Future At-Sea

These days, VSAT technology means significant business modernization in the maritime industry. The market is growing. Currently, there are more than 150 service providers, increasing the competitive offerings and value-added services across the maritime market. Stabilized VSAT antennas are becoming far more cost effective and easier to install and that helps to make VSAT more attractive to a larger number of maritime vessels.

As economics improve from both a hardware and a service perspective, and the benefits of connectivity reach every section of a vessel, VSAT will become a primary requirement for getting things done at-sea.

Commercial Launch Sector's Rapid Growth For Smallsats

By Jamie Welton, Program Director, Space Launch Services (SpaceLS)

As 2016 approaches the horizon, the varied range of potential launch options for small satellites grows exponentially—what are they and what does this mean for the launch sector?

Space Launch Services (SpaceLS) name has been added to the ever growing list of commercial companies aiming to broaden the opportunities for small satellites (smallsats). The aim of SpaceLS is similar to most of the current crop—the developments being focused on are low cost and reusability.

The route for SpaceLS with the Prometheus 1 rocket and Raptor engine varies by some margin when compared to other companies; specifically in the area of propellants and tolerances.

The initial propellant combination for the Prometheus 1 launch vehicle will be a flight validated combination of Hydrogen Peroxide (HTP) and Kerosene. Although not currently used in any commercial launchers,

HTP/Kerosene was popular in the early days of space flight, with the British Black Arrow rocket being a notable success.

In October 1971, a 66 kg satellite called Prospero was launched atop the Black Arrow into Low Earth Orbit (LEO) from Woomera, South Australia. The favorable cost implications of using historic designs are massive; building upon old technologies with new manufacturing methods and materials makes for a streamlined process and predictable results.



The Prospero satellite.



SPACE⁺LS
SPACE LAUNCH SERVICES

RAPTOREX

Rocket engine name: Raptor.
Rocket engine thrust: 75,000lbf.
Pump: Gas generator turbopump.
Propellant: Hydrogen Peroxide (HTP) & Kerosene.
Rocket engine type: Regeneratively cooled bi-propellant.



In the race to provide a low cost, smallsat launch capability are a range of companies which include: SpaceLS Prometheus 1, Virgin Galactic LauncherOne, RocketLab Electron, Orbital ATK Pegasus, Swiss Space Systems SOAR and many more.



Every company and proposed vehicle in this sector is offering compromised solutions in order to provide a service which will be cost effective.

The Virgin Galactic offering has limitations in rocket design and potential air launch vehicle size/design.

RocketLab's electron has limitations on scalability due to the use of electronic motors as opposed to a gas generator turbopump.

Orbital ATK is nearly the same price as a SpaceX Falcon 9, which effectively eradicates the company's potential in the smallsat launch category.

Swiss Space Systems' somewhat beautiful and well-funded SOAR concept is a space shuttle for the 21st century which encompasses all of the same problems of sending a large vehicle into space to place a smallsat.

SpaceLS is willing to compromise on fuel efficiency because, in most launch vehicles, the propellant represents only a fraction of the cost of sending the payload to orbit.

There is a temptation to narrow focus on one potential victor in any burgeoning market; however, if one examines history, a range of services will end up being viable for a variety of reasons. SpaceLS will be one of the most cost effective, yet launch capacity will be limited due to geographic location.

If governmental support and private finance are interlinked within the new space race, the entire industry will benefit with reduced cost, increased capacity and new capabilities that have not yet even been fathomed.

SpaceLS will start accepting orders for 1U CubeSat payloads for just £10,000 GBP (\$16,000 USD) as of October 2015 for launch in the autumn of 2017. When compared to existing and potential competitors, this pricing represents a fourfold decrease in cost.

The initial pricing will likely be increased when launch schedules become specific. Yet, even at that point, the costs will still be heavily reduced when compared to alternative options. Major press announcements will follow over the coming months regarding SpaceLS endeavors.

For additional information, contact the author at jamie@spacels.com

Is GaAs Dead?

By Sheri Morita, Senior Product Manager, Norsat International Inc.



Every other day there seems to be an article story regarding a new gallium nitride (GaN) based microwave communications device that has just been released to the market.

Words such as “small”, “efficient”, and “next generation” abound, and to be sure, GaN-based technology has its share of advantages. But what about gallium arsenide (GaAs), the previous darling of the industry? Has the time come and gone for GaAs? In this article, a closer examination of these two technologies is presented with an exploration of the pros and cons of each one.

GaAs and GaN semiconductors that can be used in a variety of different applications, including the manufacture of microwave and millimeter-wave integrated circuits (MMICs). MMICs are used extensively in the satellite communications industry to perform a variety of functions that include power amplification in BUCs and SSPAs.

MMICs have had an interesting history and have been around for a surprisingly long time. Robert A. Pucel co-authored a paper in March of

2002 that delved into this history. In summary, the first proto-MMIC made its appearance in 1964 as the result of a government-funded program to develop a transmit-receive module for an aircraft phased-array antenna. The program was not particularly successful as the silicon substrates that were available at the time were not good enough for use in microwave circuitry; however, the program did provide a starting point for the technology.

Shortly thereafter, research into the use of GaAs as a substrate was initiated. GaAs showed promise in solving the problems that had become apparent during the 1964 program, but it wasn't until the late 1970's that the first GaAs-based MMICs began to appear in the market.

Once the initial GaAs MMICs had been developed, years were required for the technology to evolve beyond the proof-of-concept phase. GaAs MMICs, as we know them today, would never have been developed

without the assistance of computer-aided design (CAD) techniques, which were required to deal with the complexity of circuit design.

Much of this effort was driven by the US Department of Defense (DoD), which injected nearly \$450 million into programs between 1987 and 1995 for CAD program development and to improve the manufacturability of GaAs MMICs.

By 1996, the MMIC field had reached a reasonable level of maturity and MMICs were being broadly used in the microwave industry.

In the 1990s, GaN arrived on the scene and is now widely used in MMICs. Andrew Moore, Jose Jimenez and Elias Reese recently published Qorvo's excellent *GaN RF Technology for Dummies* booklets which explain the technology behind GaN and when and how to use it. The authors point out that GaN provides many advantages over GaAs-based MMICs, most notably the much higher efficiency of GaN.

GaN's higher efficiency is because GaN transistors operate at a much higher voltage than GaAs transistors—about five times higher—which ultimately maximizes the power transfer from the device into the load. GaN-based devices will provide the highest gain, signal level, and efficiency at a specific frequency or the highest frequency, gain, and efficiency at a specific signal level.

What is responsible for this higher voltage capability? GaN's chemical bond is about three times stronger than that of GaAs. This means that GaN has a higher band gap, which is the energy required to free an electron to conduct electricity within a semiconductor.

This high band gap results in the higher operating voltage for GaN MMICs and leads to lower current requirements. This, in turn, means that less power is needed to drive a GaN-based device than would be required to obtain equal output from a GaAs-based device.

An additional benefit of lower current is that smaller traces and fewer, less robust components are needed in a GaN-based device, driving down the size, weight and overall component cost of the device. The ability to operate at higher voltages also means that GaN-based devices can be used at much higher power levels without the risk of damage to the device. GaN technology is clearly superior to GaAs technology at high power levels, or if overall power consumption needs to be minimized.

In addition to higher voltage capabilities, GaN MMICs also have a higher power density. This means more power can be produced using a smaller IC than is possible with GaAs MMICs, resulting in a few advantages.

Most obviously, a smaller IC results in space savings and also reduces in the number of gain stages that are required to achieve the same amplification, which, in turn, reduces design complexity and combining losses.

Another win in the GaN column? There are some drawbacks—with all of GaN's advantages, high power density also brings thermal management challenges, due to the need to dissipate large amounts of heat in a highly compact volume. For GaN-based devices, good thermal design is as important as solid electrical design. High power density also reduces capacitance, which enables GaN-based devices to deliver wider bandwidth capability than GaAs-based devices. This can certainly be an advantage, depending on the application.

The foregoing is not to suggest that GaN is a hands-down winner over GaAs; there are some areas where GaAs has the edge. GaAs MMICs have been manufactured far longer than GaN MMICs, meaning they have a clear advantage where cost is concerned. GaN MMICs will ultimately close this gap, but some time will have to pass before such can occur.

GaAs MMICs also have a reliability advantage. Some of this is due to the long experience of the manufacturers—some is also due to the nature of GaN MMICs. Without getting too deeply into semiconductor structure, GaN MMICs are under more mechanical strain than GaAs MMICs and the semiconductor material can crack and degrade if care is not taken during MMIC design. This problem has diminished over time, but is still a consideration. Please refer to Chapter 3 of *GaN RF Technology for Dummies* for more details on this issue.

Likely the biggest advantage for GaAs-based devices today is that they are more linear than GaN-based devices, as the latter are subject to gain expansion, which are non-linearities that occur in gain often most noticeable toward the power saturation point. These non-linearities produce intermodulation distortion (IMD) which can degrade system performance, especially when higher order modulation schemes are used.

High IMD also produces higher spectral regrowth leading to adjacent channel interference. Typically, satisfactory linear performance is achieved by reducing input power, which will reduce IMD, but will also reduce the output power and, thus, reduce the achievable power available.

While a GaN device is more efficient and has more output power than a similarly sized GaAs device, the GaN device output power often needs to be backed off from saturation more than the GaAs device to achieve a linear operating point. Conveniently, running a GaAs-based BUC at P1dB, the point where actual gain is 1 dB below ideal gain, is usually good enough to meet standard linearity requirements, such as spectral regrowth, two tone intermodulation, and so on. This is not true for GaN-based BUCs, so P1dB is generally not a relevant specification for these devices. To compare the output power between different types of devices, use P_{lin} and P_{sat} .

This returns us to the question posed by this article—is GaAs dead? The answer is a firm, "Not quite yet!"

GaN technology has clear advantages some challenges remain to overcome. The day will come when GaN is the clear winner in every category.

For today, GaAs technology can deliver cost, reliability and performance advantages for certain applications. Careful consideration of the pros and cons of each will help to guide users to the device that best meets all needs.

www.norsat.com

Sheri Morita is the Senior Product Manager at Norsat. She is responsible for defining and launching new products to meet the current and future needs of Norsat's customers. Sheri has 15 years of product management experience, and has worked in several segments of the communications industry, including satellite communications, telecommunications and software defined radio. She may be reached at smorita@norsat.com.

Space Tech Expo Launches In Bremen, Germany

After five years on the US West Coast, Space Tech Expo has established itself as one of the leading events on the global space calendar.

The exhibition, which is co-located with Aerospace Electrical Systems Expo, enjoyed a further 45 percent rise in attendance when it ran earlier this year in Long Beach, California. With exhibitor numbers growing by an extra 25 percent the show is an unmissable opportunity for engineers and global decision makers in commercial, government and military space to successfully connect in a focused B2B environment.

Expanding on this success, the launch in Bremen aims to provide the continent's space industry with a purposeful marketplace centered on the design, manufacture and testing of spacecraft, satellite, launch vehicle and space-related technologies. For a full three days in November, thousands of engineers, contractors, system integrators, buyers, manufacturers and industry leaders will converge at the dual exhibitions hosted in Bremen, covering the entire supply chain for space technology and aerospace electrical systems.

As the dynamic and progressive scene in Europe continues to expand, the event signals a recognition of the continuing development of international cooperation and business investment in the sector. Bremen is one of Europe's leading aerospace hubs, with more than 140 companies and 20 research institutions employing 12,000-plus staff with an annual revenue of approximately 2 billion euros.

More than 180 exhibitors are already signed up, among them such industry, research and testing majors as OHB, DLR, Thales Alenia Space, Tesat-Spacecom, W. L. Gore, Zodiac Data Systems, SEA, Olympus, Curtiss-Wright, European Test Services and Fraunhofer Space. It is free for attendees to visit any of the exhibitors, as well as to use many of the other complimentary services during the show, such as the B2B Matchmaking Service, organized in cooperation with Enterprise Europe Network Bremen. Registering for B2B Matchmaking enables connections between businesses on a one-to-one basis. It also guarantees networking prospects before attending the expo, as meetings can be reserved in advance. Participants are able to express their partnership intentions alongside their online profiles, which are then published on a dedicated website accessible to all attendees. Requests for bilateral face-to-face meetings can be both received and given, enabling a head start on networking.

There will also be ample opportunity to network during the event itself, with networking lunches and receptions held on the show floor. A key element of the program, these introductory gatherings provide visitors with the opportunity to meet hundreds of like-minded industry professionals

in a more informal professional setting, boosting the opportunity to make relevant connections as well as enhancing the show experience.

Conveniently co-located alongside Space Tech Expo Europe, the Aerospace Electrical Systems Expo adds a further dimension to the show. A popular visitor destination in its own right, the show features the components and capabilities that bring aircraft and space vehicles to life, including battery and power systems manufacturing, power distribution and conversion, wire cable and harnesses, electronics, box building, control assemblies, software, data acquisition and testing.

In addition to the exhibit area, a dedicated space is designated for testing technologies, equipment, processes and research. The Aerospace Testing Zone will see testing capabilities for airframes, subsystems, components and electrical power systems for the aerospace and space sectors, presented by a wide range of international companies and organizations. Perhaps one of the greatest features of the Space Tech Expo Europe are the free-to-attend forums, running alongside the program for the full duration of the event. Over the course of three days, two concurrent forums will provide insights from key contributors such as NASA, DLR, ESA, ULA, OHB, Thales, Airbus and many others.

The **Industry Forum** starts with a full day committed to markets, business models and cross-sector collaboration, with key themes including launch services, ESA technology roadmaps, advanced propulsion technologies and future fuels. The second day will concentrate on trending technologies and growth opportunities, including space station utilization, the space logistics market, on-orbit servicing and exploration technologies. The final day will focus on the small-satellites market in terms of economics, applications, launch capabilities and enabling technologies.

The **Technology Forum** will showcase the latest R&D findings, technical innovations and product development methodologies from a set of carefully selected exhibitors.

Day One is themed on lunar exploration technologies, the use of advanced composites on satellites, reducing the cost of manufacturing and opto-mechanical design and integration.

Day Two covers areas such as managing the growth of spacecraft data, avionics testing technologies and compliance testing. The forum will conclude with a continuation of the testing theme, focusing on optimizing system integrity and test efficiency, automation technologies for testing, robotic systems for non-destructive testing and model-based testing for embedded systems.

Speakers at the forums will include:

- **Dr.-Ing. Johann-Dietrich Wörner, Director General, ESA**
- **Dr. Pascale Ehrenfreund, Chairwoman of the Executive Board, DLR**
- **Guy Perez, CTO, OHB**
- **Bart Reijnen, Head of Orbital Systems and Space Exploration & Head of Site Bremen, Airbus Defence and Space**
- **Frank Salzgeber, Head of Technology Transfer Program Office, ESA**
- **Daniel Lockney, Technology Transfer Program Executive, NASA**
- **Mark Sirangelo, Corporate Vice President, SNC Space Systems**
- **Dan Lopez, VP Technology, Urthecast**
- **Alex da Silva Curiel, Head of International Business, Surrey Satellite**
- **Dr. John Horack, Vice President Global Commercial Space, Teledyne Brown Engineering**
- **Johannes Mattes, Head of Key Applications, Hottinger Baldwin Messtechnik GmbH**
- **Bob Metz, Director Aerospace and Defense, PCB Piezotronics Inc**
- **Arne Brehmer, Manager Aviation, Vector Informatik GmbH**
- **Juergen Bosse, Managing Director, Robo-Technology GmbH**

The **Space Tech Expo Industry Forum** runs for one day on November 17—areas of concentration will include *Markets, Business Models and Cross-Sector Collaboration*.

The key themes include...

- **Launch services**
- **ESA Technology roadmaps**
- **Collaboration, business models and partnerships**
- **Advanced propulsion technologies and future fuels**

- **Technology Transfer**
- **Reusability and affordability**
- **Space logistics market**
- **On orbit servicing**
- **Exploration technologies**
- **Space station utilization**

Day 3 of the Industry Forum, November 19, will spotlight *Enabling the Smallsats Market*

The key themes include...

- **Economics of smallsats**
- **Earth observation and remote sensing**
- **Next gen applications**
- **Smallsat launch capabilities**
- **Enabling technologies**

The event's **Technology Forum** will offer...

On Day 1, November 17...

- **Lunar exploration technologies**
- **Advanced composite use in satellites**
- **Reducing the cost of manufacturing**
- **Opto-mechanical design and integration**

On Day 2, November 18

- **Managing the growth of spacecraft data**
- **Avionic testing technologies**
- **Compliance testing**
- **Technology management**

And on Day 3, November 19...

- **Optimizing system integrity and test efficiency**
- **Automation technologies for testing**
- **Robotic systems for non-destructive testing**
- **Model-based testing for embedded systems**

To register for a free pass, please visit the websites:

www.spacetechempo.eu
www.aesexpo.eu



Executive Spotlight: Rick Goerner, Executive Vice President, Worldwide Sales + Marketing, Microsemi Corporation



SatMagazine (SM)

Good day, Mr. Goerner. You have been involved in the semiconductor and embedded systems environment for many years with several leading firms... what drew you to Microsemi?

Rick Goerner

When I came to Microsemi in early 2011, the company had just closed the acquisition of a field programmable gate array (FPGA) company, expanding its product offerings to include FPGAs and system-on-chip (SoC) solutions. It was clear to me Microsemi embarked on a course to reinvent itself. This strategic move expanded the company's ability to position itself in other key markets such as communications, industrial, security and, especially, space.

Microsemi has a strong, experienced management team and an aggressive growth model to outpace the semiconductor industry's growth rate. We are accomplishing this through organic progression, such as internal research and development project funding, as well as via the strategic acquisition of new products and technologies. In fact, Microsemi has completed nearly \$1 billion in acquisitions just since I joined the company.

During my career, I have been on both sides of the integration process post-acquisition—as the company bought and as the company buying—and feel I have something to “bring to the party” during these essential integrations.

Lastly, the sales positioning with key OEM customers and global and regional channel partners represented a significant challenge for me, as I

had to create a channel structure capable of supporting Microsemi's aggressive growth plans and align it with the company's unique and strategic acquisition process.

SM

With your 40+ year career, what project or projects truly bring a sense of satisfaction to you?

Rick Goerner

Seeing business plans come to fruition is always gratifying. With that said, recognizing our company's success in “public-eye” programs is particularly satisfying. As a recent example of this, Microsemi's space solutions are onboard NASA's New Horizons spacecraft supporting its successful exploration mission to Pluto.

The high-reliability Microsemi products on the spacecraft include electronic content used in imaging cameras to transmit stunning images of Jupiter and Pluto back to Earth, as well as in the communications systems and other avionics and payload systems.

SM

The role of silicon in the success of space missions is often overlooked by the general SATCOM industry... until the time arrives to build craft and operating environments and, suddenly, the role of space tolerant semiconductors becomes totally relevant. How does Microsemi make its presence known to current and potential clients as to the silicon necessities?



Artistic rendition of NASA's New Horizon spacecraft. Image is courtesy of NASA.

Rick Goerner

Microsemi has a strong leadership position in space electronics from both a product breadth and revenue perspective, and also has broad recognition in this market segment with our more than 55 year commitment to the space industry. Microsemi is one of the few suppliers actively defining product roadmaps to address the unique, and certainly challenging, environmental needs of space applications.

Microsemi is constantly addressing the space industry's ever-evolving needs for decreased size, weight and power (SWaP) with higher levels of integration and radiation-tolerant (RT) performance in FPGAs, ASICs and ASSPs, hybrids, JANS-level [discretes](#), isolated DC-DC converters and space grade oscillators. By working closely with our customers and partners, Microsemi is able to develop the most in-demand solutions addressing the most difficult challenges in the industry.

Microsemi conducts Space Forums in key markets to ensure key customers are aware of, and have early access to, our next generation technology solutions. We recently completed a global Space Forum series in North America, Europe and India which attracted more than 500 attendees.

SM

What are some of the biggest changes you've seen in the space business over the years?

Rick Goerner

A major development in space electronics over the past two decades has been the adoption of FPGAs, initially in command, control and interfacing functions, and more recently in high speed signal processing applications. RTG4 is an incremental step along this path as it provides programmable high speed signal processing capability without sacrificing radiation tolerance.

SM

Any predictions for the space business?

Rick Goerner

We see increasingly complex satellite payload instruments, as the satellite operators seek greater information from the satellite including higher resolution imaging, and more channels of spectrometry to name a few. These applications require more sophisticated payload processing electronics performing complex on-board processing. High-density, high-performance FPGAs are an enabling technology, since the flexibility of programmable logic enables faster time to launch.

Satellite developers are also facing increasing pressure

to develop systems faster and at lower cost. Product innovations from semiconductor suppliers can dramatically shorten development times for satellites, and in addition significantly reduce cost, and save weight and power. For example, Microsemi's LX7730 Telemetry System Manager provides acquisition and control of up to 64 telemetry channels, integrating an entire I/O card into a single 132-pin CQFP package.

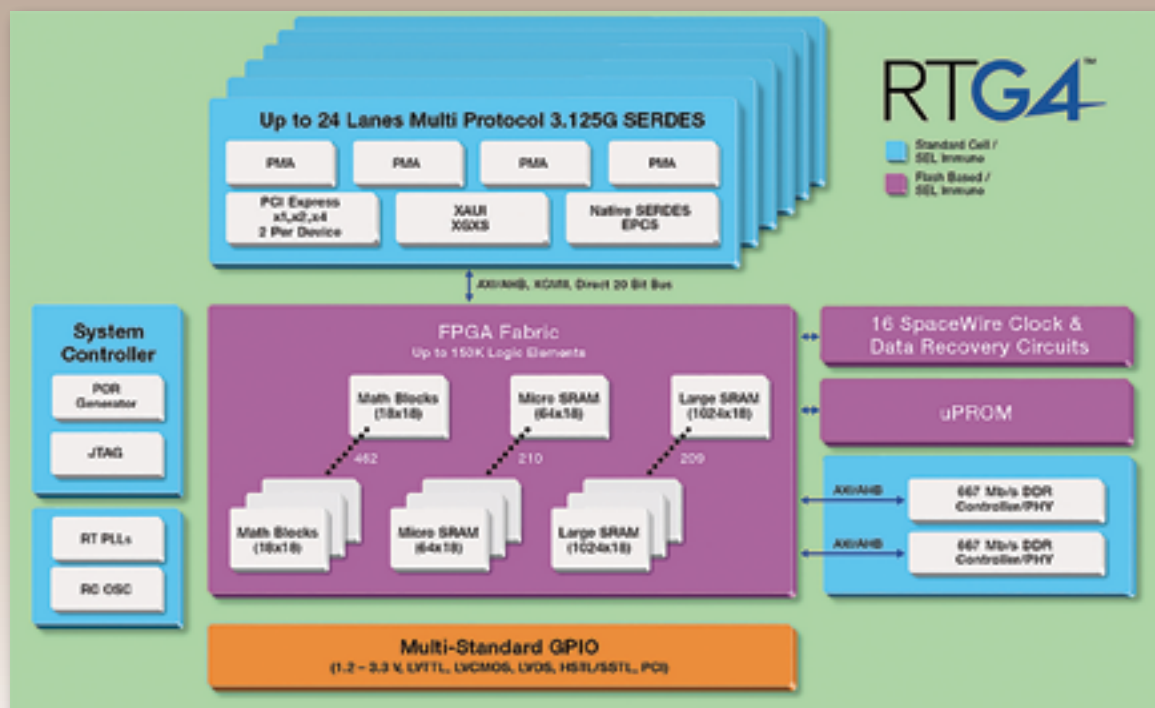
The space environment is very unforgiving with measures protecting against radiation effects top of mind for developers. What technology advancements have you seen in recent years that are helping to ensure satellites and other space applications function properly while in orbit?

For CMOS integrated circuits, advancing semiconductor processing technology leads to a natural improvement in resistance to total ionizing dose radiation, which is the gradual accumulation of radiation effects in space. Specialized technologies such as Flash require extra design steps to mitigate total dose effects. Microsemi's RTG4 Flash-based FPGAs include radiation-hardening-by-design (RHBD) techniques to provide total dose mitigation sufficient for the vast majority of Earth orbit and deep space applications.

While advancing processing technologies are good news for total dose effects, they are bad news for single event upsets (SEUs) and transients. SEUs are instantaneous upsets and transients caused by high energy sub-atomic particles in space. This form of radiation can cause storage elements (flip-flops, SRAM cells) to erroneously change state. Sub-atomic particles can also cause combinatorial logic to glitch, which becomes problematic if the glitch occurs within the set-up and hold time window of a downstream flip-flop. Modern integrated circuits such as Microsemi's RTG4 FPGAs have design features which mitigate single event upsets and single event transients.

SM

Would you explain more about the RTG4 radiation-tolerant FPGA and application in the space market? What advantages does the RTG4 provide compared to other FPGAs?



Rick Goerner

The RTG4 addresses the growing need for high-performance signal processing requirements of complex instruments and systems in satellites and other space vehicles as demand for images, scientific data and other information increases. Unfortunately, downlink bandwidth is not growing fast enough to satisfy demand for this information. The limited downlink bandwidth must be used for processed information rather than raw data, so satellites must perform more processing in space using high-density, high-performance payload processing electronics.

Solutions such as Microsemi's RTG4 FPGAs enable designers to achieve high rates of signal processing without sacrificing radiation hardness. Our FPGAs are more flexible than radiation-hardened ASICs, have more signal processing features than any other radiation-tolerant FPGA, and have complete immunity to configuration upsets.

RTG4 uses a low-power 65nm Flash technology with established reliability heritage, combined with a high-performance architecture featuring many enhancements for high-performance signal processing applications, to provide a leading radiation-tolerant programmable solution for space applications. It features more radiation-protected registers, combinatorial logic cells, multipliers, and serial transceivers than any other radiation tolerant FPGA. In addition it features some unique enhancements specifically for space applications—such as 16 hardwired SpaceWire clock and data recovery circuits.

SM

Microsemi has announced its Space System Manager (SSM) for Satellite sensor monitoring, attitude and payload control, etc. Can you describe Microsemi's overall space solution offerings?

Rick Goerner

Microsemi has been developing space solutions for almost six decades and has played an important role in a wide variety of space programs globally. The company has a proven track record for innovation, quality and reliability, and continues to build on that legacy with an impressive portfolio of industry-leading new product and technology introductions.

Microsemi's high-reliability products and solutions have been used in applications that require high levels of radiation hardness for trips to the moon, Mars and beyond. Microsemi has always responded to the specific needs of space applications and has a long standing commitment to the space market.

Microsemi's heritage in space started with the Atlas launch vehicles in 1957. The first space flight using Microsemi FPGAs was in 1991 using an 883B military part. Then in 1992 we sold our first parts with production screening specifically intended to meet the needs of space customers. This was to support the GOES-2000, SILEX and Cassini missions.

The first parts with deliberate radiation hardening (in this case, hardening by process) were available in 1996. The current generation of RT FPGAs (hardening by design) started with the introduction of the RTSX-SU FPGAs in 2004. Since then we have been on multiple space projects with our RT FPGAs, such as the Mars Reconnaissance Orbiter with an RTSX-SU in 2005 as well as the Curiosity Rover in 2011 with RTAX™ and RTSX-SU FPGAs. Currently we have over 80 percent of the space FPGA market.

With one of the industry's most comprehensive portfolios of space products, Microsemi provides radiation-hardened and radiation-tolerant solutions including high performance FPGAs, precise frequency and timing solutions with space-grade oscillators, mixed signal ICs, isolated DC-DC converter modules, custom power supplies, hybrid solutions, MOSFETs, diodes, transistors, RF components and custom solutions.

We are committed to supporting our products throughout the lifetime of our customer programs. We continue to innovate in areas such as semiconductor materials, advanced packaging technologies and high density integrated circuits. Our products are qualified to the highest government, DLA, NASA and ESA standards, and their reliability has been independently verified by multiple agencies.

As our customer's supply partner for electronic systems in space, Microsemi can solve problems at all stages of design and implementation, including power conversion and distribution, radio and radar signal processing, system telemetry and control, digital logic integration, and semiconductor packaging.

SM

Accurate timing plays a critical role for satellites when communicating with the ground station. How do you ensure timing accuracy when a satellite is in orbit?

Rick Goerner

Accuracy on-orbit is established using crystal oscillators or in some cases atomic clocks. These devices are controlled by the ground stations and adjusted to a system or Universal Time Coordinated (UTC) timescale.

The best examples of on-orbit timing are the Global Navigation System Satellites (GNSS), in particular the US GPS system. GPS satellites have onboard Cesium or Rubidium atomic clocks which are adjusted from the ground to be as close to the US Naval Observatory's time scale as possible. By using the highly accurate clocks in orbit, GPS users can establish their time and position.

Microsemi delivered the first production atomic clocks for the GPS program and continues to provide its Ultra-Stable Oscillator for the future GPS III satellites. The GPS satellites have revolutionized many aspects of our lives. Microsemi is now developing clocks that can be steered on-board by GPS receivers, reducing or eliminating the requirements for ground station support. Microsemi has an extensive legacy of crystal oscillators and atomic clocks for space for numerous scientific, commercial and military missions.

SM

What can we expect to see being developed and arriving from Microsemi over the next few quarters?

Rick Goerner

Microsemi continues to develop the most innovative space-related products, capabilities, and technology to combat the effects of radiation. Expect to see new developments with our rad-tolerant FPGAs and controllers, and products that provide accurate frequency and time required for timing, radar and communication functions.

www.microsemi.com/

European EO Industry Survey Is Examined By EARSC



The European Association of Remote Sensing Companies (EARSC) is the European organization which—on a non-profit basis—promotes the use of Earth Observation (EO) technology and, especially, the companies in Europe which offer EO-related products and services. This is a membership based organization whose mission is to foster the development of the European EO geo-information service industries.

The EARSC has published their latest survey of the EO services industry in Europe and Canada. This is the second survey the organization has completed and follows their first survey two years ago. The survey provides a detailed perspective on how the industry is developing and what the key issues are which must be addressed.

This is a critical time with enormous changes occurring in the EO sector. In the last few months, two European satellite operators have acquired by North American companies. This caps a significant two year period when many new companies emerged with new and innovative business models.

This change moves remote sensing out of the government sector and into commercial ones. Nevertheless, government is still, and will remain, a key player and a major influence over the EO industry.

The EARSC survey reveals that the EO services industry continues to expand in Europe, with an estimated 450 companies generating revenues of over 900 million euros and employing some 6,800 highly skilled persons. This represents an average growth of around 8 percent per annum since the last survey, which is a little lower than the longer term growth rate over the last 10 years.

New companies are constantly being formed and policy should encourage this as much as possible. Most of the innovation emerges from the newer and smaller companies as well as where almost all the growth in revenues and employment is derived.

New companies have many options to generate capital through acquisition or by continuing to grow and sell equity. Policy should be and is geared to helping this process. Nevertheless, there seems to be a problem in Europe with access to risk capital—such is not so readily available as opposed to the US, where many more private, young entrepreneurs have made money on technology companies and are now looking around for other opportunities within which to invest. According to the economist, there are around 1,000 of these new-money private investors.

Chart 1 below reveals the growth in revenues over the last nine years from just over 400 million euros in 2006 to the 910 million euros last year. This includes EO service companies in Europe and Canada.

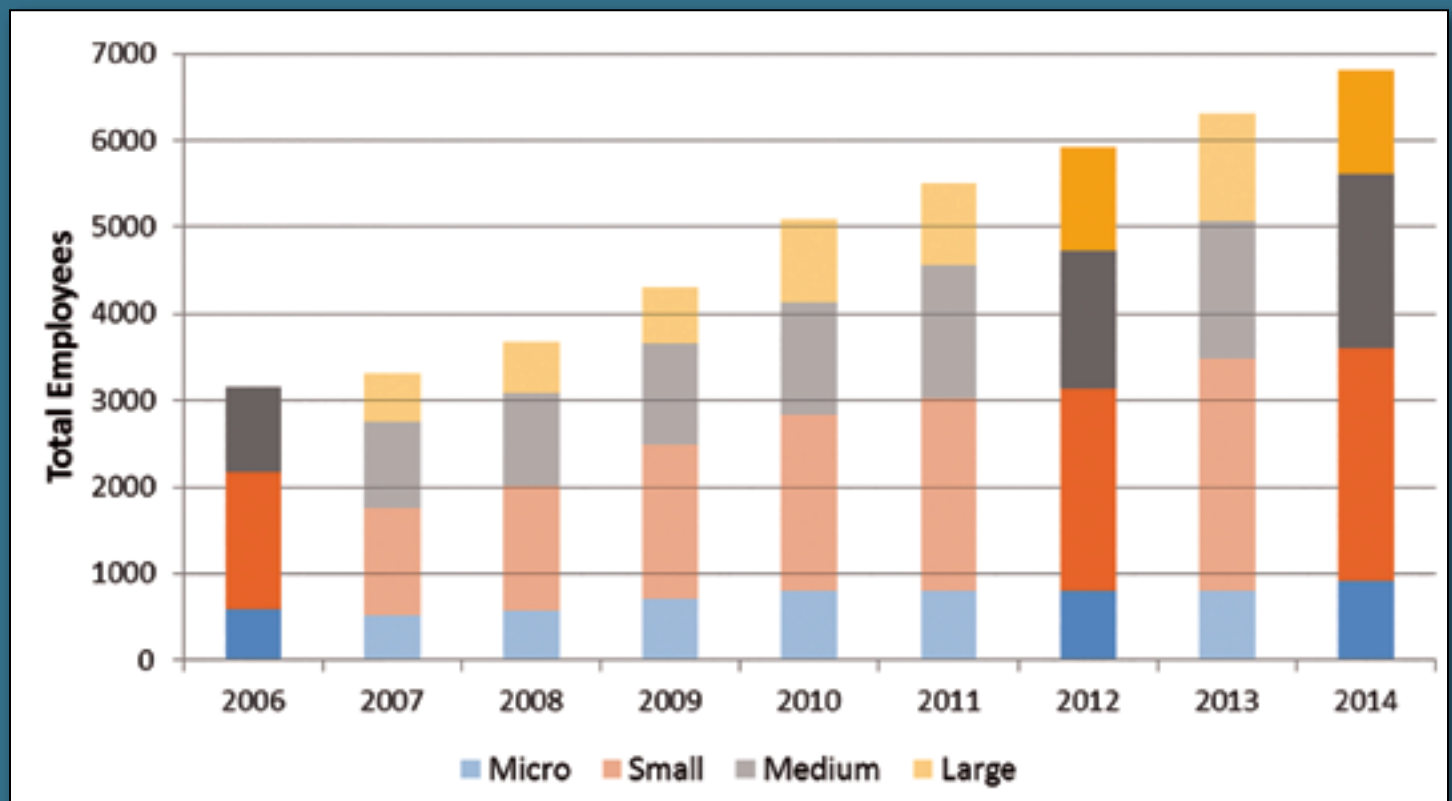


Chart 1. Total Industry Employment

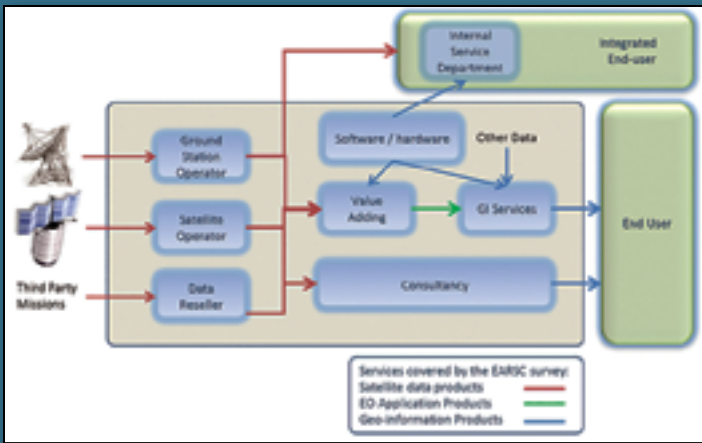


Chart 2. EO Services Value Chain.

Our definition of an EO service company is any profit-making, legal entity which is selling products based on some element of data from Earth Observation satellites. This includes satellite operators, data distributors, value-adding, GI and consulting companies and ranges from a satellite operator who earns all of its revenue from selling imagery to a GI company which perhaps uses one part of an image combined with many other types of data to generate a GI product. The value-chain which we use in our survey is that shown in *Chart 2*.

Chart 3 shows similarly the growth in the number of employees working in the sector. From a total of around 3,100 in 2006, this has grown to 6,800 in 2014. The numbers have grown steadily and, whereas most of the revenue growth has come from the large companies (>250 employees), the majority of the employee growth has been witnessed in the small and medium sized ones.

In the chart figures, EARSC makes the distinction between micro companies (<10 employees), small companies (<50 employees) and medium-sized companies (<250 employees).

Copernicus is seen as being a major stimulus for growth in the European EO sector. However, with the launch of Sentinel 1 in April of 2014, it is too early to see much impact. Nevertheless, the figures provide a reference for future years when some impact should be experienced.

Companies are optimistic and a majority expect to increase their business based on Copernicus products, mostly through the use of the satellite data coming from the Sentinels.

A summary of the survey results and a full and detailed report are both available on the EARSC infosite: www.earsc.org.

EARSC has 75 members from more than 22 European countries and is a recognised association both in Europe and worldwide and represents the European providers of geo-information services creating a network between industry, decision-makers and users. The organization considers that the market is at a crucial stage of development as Earth Observation becomes more frequently used by society and adds positive value to our daily lives. Nevertheless, there are many issues, opportunities and threats facing industrial actors. Supported by a small secretariat, EARSC informs and involves its members through its website and newsletters, through the provision of web-tools, as well as organizing events.

EARSC provides tools for its members to promote themselves and their services. As well as the afore listed EARSC infosite, the organization offers a portal (www.earsc-portal.eu) which promotes links between EARSC members and other communities such as the Oil & Gas industry, and a brokerage site (www.eopages.eu) for customers to find the services which they require and where companies can offer solutions.

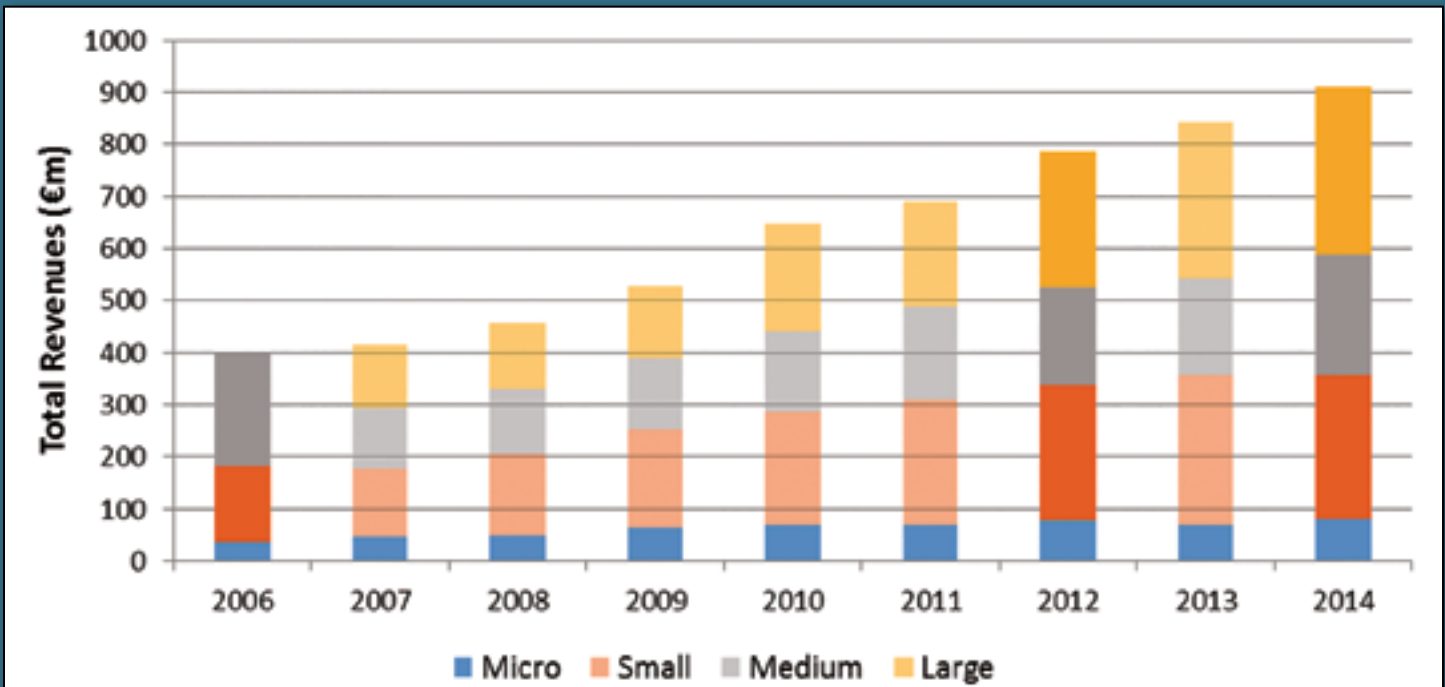


Chart 3. Total Industry Revenues.

