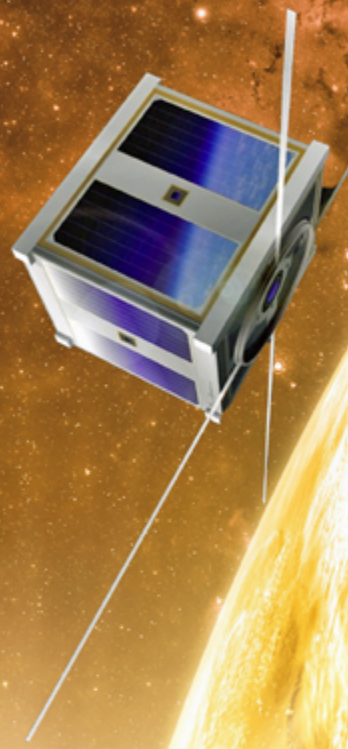
Worldwide Satellite Magazine – February 2017

SatMagazine

The World of Smallsats
Special SmallSat Symposium Issue



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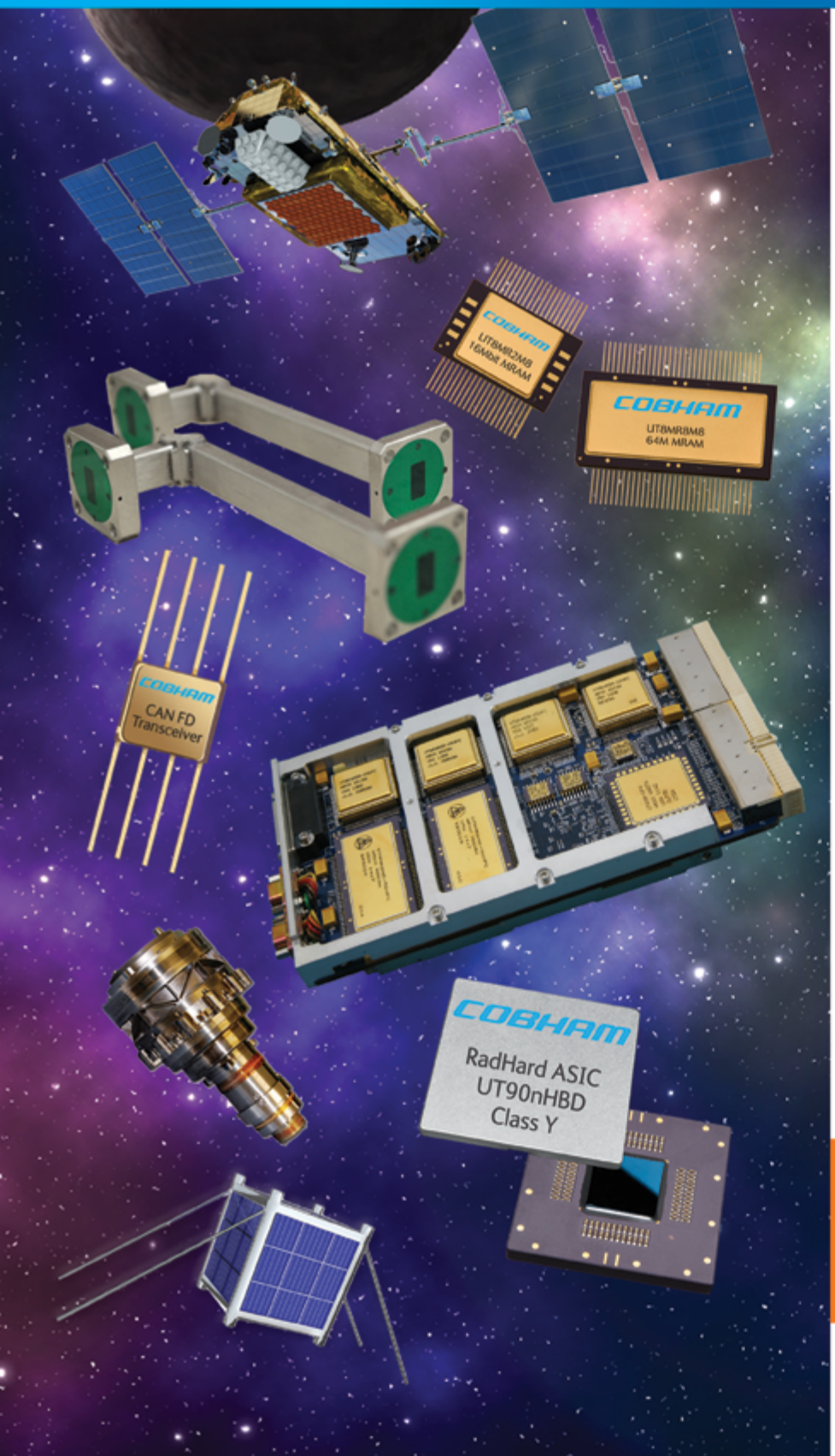

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SatMagazine

February 2017

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SpaceX's Double Successes... Launches Iridum's Satellites—Plus, the Booster Returns To Base

The Satnews team was onsite to witness the doubly successful launch of SpaceX's Falcon 9 soar through the atmosphere to eventually release 10 of Iridium's NEXT satellites.

The team described the sensation as bone shaking even from the distance of three miles. On Earth, the booster successfully descended at sea on the company's automated drone ship aptly named Just Read the Instructions.

The flight took off on schedule at 9:54 a.m. PST (12:54 p.m. EST / 17:54 GMT) Saturday, January 14, 2017, at Space Launch Complex 4 East on Vandenberg Air Force Base in California.

X marks the spot as Spacex's booster slowly descends onto Just Read the Instructions.

As the Falcon 9 rocket soared toward the heavens, the 10 Iridium NEXT satellites, built by Thales Alenia and Orbital ATK, were released into LEO, and are the first members of Iridium Communications' next-generation satellite constellation that will total 72 spacecraft, which will provide communications and data services across the globe.

With each of the 10 satellites weighing approximately 1,874 pounds (850 kilograms) the total payload was within the Falcon 9 Full Thrust's performance capacity.

This is the start of a series of Iridium NEXT launches scheduled over the next 18 months, and marks the beginning of one of the biggest "tech refreshes" in history, completely replacing the only satellite constellation providing 100-percent truly global communications coverage.

Once fully deployed, Iridium NEXT will enable a new broadband multi-service capability called Iridium Certus^{SM}, while providing the technical flexibility to support innovative new services and technologies

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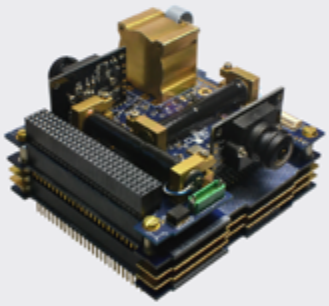

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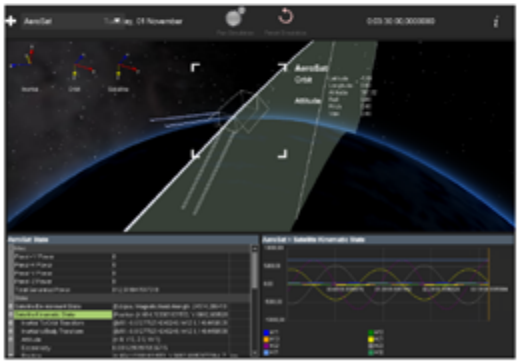

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Successful landing. X most definitely marks the spot.

from Iridium's extensive partner network. Among those technologies is a unique hosted payload from Iridium's partner Aireon, which will provide a real-time global aircraft surveillance service, extending aircraft visibility across the planet.

The first 10 Iridium NEXT satellites were delivered to a 625 kilometer (km) temporary parking orbit where they will be tested and exercised by Iridium over the coming weeks. Upon meeting testing and validation requirements, the satellites will then be moved into their 780km operational orbit and begin providing service to Iridium's customers. One-by-one, the new satellites will be positioned near a current generation satellite, each moving at approximately 17,000 miles per hour as testing begins. Iridium's unique inter-satellite communication links from nearby satellites will be repositioned to point to the new Iridium NEXT satellite as it prepares to take over service. Existing satellites will eventually be de-boosted and de-orbited.

"This is one of the largest commercial satellite systems being built today," said Iridium CEO Matt Desch. When Iridium signed with SpaceX in 2010 to launch 70 Iridium-NEXT satellites, valued at $492 million, it was the largest single launch deal ever engaged in by two companies.

"*Today, Iridium launches a new era in the history of our company and a new era in space as we start to deliver the next-generation of satellite communications,*" said Matt Desch, chief executive officer of Iridium. "*We have been working endless hours for the last eight years to get to this day, and to finally be here with 10 Iridium NEXT satellites successfully launched into low-Earth orbit is a fulfilling moment. We are incredibly thankful for all of the hard work from our team, as well as our partners, to help us achieve this milestone.*"

Both Thales Alenia Space, System Prime Contractor for the program, and their subcontractor for production, Orbital ATK, have been integral in the development of the Iridium NEXT program, from the design and manufacturing of the Iridium NEXT satellite vehicles to managing an 18-station, state-of-the-art assembly line production system.

spacex.com
iridium.com
thalesgroup.com/en/worldwide/space/space
http://orbitalatk.com

InfoBeam

SES Discloses the New Owner of the AMC-3 Satellite

On January 9, *Satnews.com* shared information about Global Eagle Entertainment (GEE) "in discussions with a leading satellite provider to purchase satellite transponders for an estimated price of approximately $50 million," to support a large aviation-connectivity customer.

Since then the curtain has been pulled back, press releases issued and the satellite fleet operator has been identified as SES.

The satellite, AMC-3 renamed Eagle-1 by Global Eagle, carries 24 Ku-band transponders and was launched in September 1997 on an Atlas 2A rocket.

Eagle-1 covers North America, the Gulf of Mexico and the Caribbean.

Lockheed Martin built the satellite, which is now operating nearly five years past its projected design life.

CEO Dave Davis remarked that rather than leasing capacity for a set amount of time, the purchase will prove to be a smarter financial move enabling substantial cost savings, that Global Eagle paid a low enough price for the satellite to outweigh the risk of buying a nearly 20-year-old spacecraft that's drifted into an inclined orbit.

To preserve on-board propellant for contingency operations, operators sometimes forego station-keeping maneuvers for older satellites like Eagle-1.

This allows the spacecraft's position in the sky to gradually shift, which can be an issue for some immobile ground-based antennas and terminals.

However, that is not a serious matter for airplanes and boats equipped with antennas designed to keep satellites in sight while on the go.

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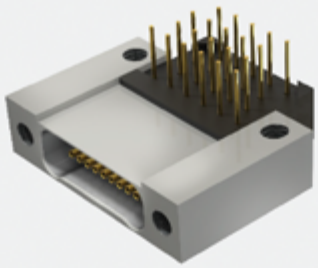

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Japan Suffers a Smallsat Launch Failure

An SS-520 rocket is shown in this undated photo from the Japan Aerospace Exploration Agency.

The rocket was touted as the smallest one capable of launching a satellite; however, something obviously went very wrong.

JAXA terminated a satellite launch in mid-flight after a communications malfunction forced the space agency to abort ignition of the host rocket's second stage.

The No. 4 vehicle of the SS-520 rocket series lifted off at 8:33 a.m. from Uchinoura Space Center in Kagoshima Prefecture carrying a miniature Earth observation satellite, the Japan Aerospace Exploration Agency said.

The agency aborted ignition of the second stage three minutes into the launch after discovering a glitch in the communications system. The rocket and its tiny payload then tumbled into the sea.

"*It's very regrettable. We'd like to determine the cause of the failure*,' said Hiroto Habu, an associate professor at JAXA, later in the day.

The space agency said the rocket stopped sending signals to the operations center just 20 seconds after liftoff. It has no further plans to launch a rocket of this size, it said.

Resembling a utility pole at 10 meters long and 50 cm in diameter, the rocket was developed as a potential vehicle for launching minisatellites, a growing segment of the space industry.

Roughly one-fifth the size of JAXA's mainstay H-IIA rocket, the SS-520 is a three-stage type based on a two-stage model used by JAXA.

The rocket was designed to place a satellite weighing up to 4 kg in orbit at an altitude of up to 2,000 km.

"*The cause of the failure is not known at all yet. All we can do is just analyze the data we got until communications were disrupted*," said Shinya Matsuura, a writer familiar with rocket development. "*I hope they won't be discouraged and will try another launch, because demand for launches of minisatellites is growing worldwide.*"

Matsuura said China has made significant progress in rocket development in recent years and added that Japan should invest more in fundamental research and development so it will not get left behind.

The rocket was carrying Tricom1, a 3 kg satellite developed by the University of Tokyo that measured 10 cm by 10 cm by 35 cm.

The satellite was designed to transmit images of Earth's surface for about a month before re-entering the atmosphere and burning up.

JAXA, which undertook the mission to demonstrate the cost-cutting potential for satellite launches, used commercially available devices found in home electronics and smartphones to inspire private firms keen on entering the space launch business.

It cost an estimated ¥500 million ($4.3 million) to produce and launch the slender rocket.

global.jaxa.jp/

Article source: Kyodo News

Airbus' Invitation... Enter the SpaceDataHighway Challenge

Airbus doesn't want to be the only one having fun... described as 'one of the most ambitious and forward-looking communication systems in operation today', since November 23, Airbus has been transmitting data in near real-time through space at a rate of 1.8 gigabytes per second based on laser technology.

To encourage innovation and enlarge the application portfolio, Airbus has opened the "*Enter the SpaceDataHighway*" challenge for SMEs, start-ups, entrepreneurs and students who would like to participate with their business ideas for using this technology.

The winning project receives a 75,000 euros investment prize, and will be able to draw on the expertise and support of Airbus Bizlab, the Group's innovation powerhouse.

Airbus Bizlab is a business incubator in which entrepreneurs or start-ups participate in a six-month program. Here the winners will be accompanied by engineers, business development experts or even by coaches to support them in the realization of prototypes, market studies or the launch of a product. The project that comes second will receive a prize of 25,000 euros to launch a crowdfunding campaign on the new SpaceStarters platform that enables space related businesses and start-ups to raise money in order to turn their innovative ideas into a business reality.

The SpaceDataHighway is a unique space communication system combining ultra-broadband laser communications in geostationary orbit to deliver a unique, secure, near real-time data transfer service thereby making data latency a thing of the past. It can help revolutionize a number of areas, including the handling of humanitarian crises, maritime security and environmental protection by receiving satellite imagery in near real-time.

The Sentinel satellites of the European Union's Earth observation program, Copernicus, will be the first to benefit from these next-generation services. The SpaceDataHighway will also be able to connect other platforms such as aircraft, UAVs or the International Space Station.

"*The SpaceDataHighway is like the first optical fiber in space, but with the added advantage of mobility. Therefore, the scope of possible applications is vast,*" said Hughes Boulnois, head of the SpaceDataHighway business at Airbus Defence and Space. "Airbus wants this initiative to engage with and listen to the end-users' market needs and to develop ideas to support this extended space ecosystem."

This initiative has been launched with the support of the European Commission and the European Space Agency, which, together with Airbus, developed the SpaceDataHighway program as part of a public–private partnership.

Enter here:

edrs-spacedatahighway.com/challenge

ISRO Aims for Launch of 103 Satellites

Perhaps a surprising statement from India's ISRO... with less than a month left for the proposed launch of 103 satellites at one go, Indian Space Research Organisation (ISRO) has said their aim is to maximize their capability to handle large numbers of satellites with each launch and the agency's aim is *not* to set a record.

After the success of their Mars mission, ISRO, which is currently conducting experiments for its second moon mission, said another mission to Mars, Venus and Jupiter is on the horizon and studies are underway to accomplish these projects.

"*We are not looking at it as a record or anything. We are just trying to maximize our capability with each launch and trying to utilize that launch for the ability it has got and get the maximum in return,*" ISRO Chairman A S Kiran Kumar told reporters.

Of the 103 satellites that ISRO's workhorse PSLV-C37 is expected to carry, 100 are foreign passengers.

"*They are all actually a constellation, they are getting into a constellation of satellites providing observation of Earth,*" Kumar said.

Artistic rendition of Cartosat-2 satellite.

The three Indian satellites are of the Cartosat-2 series, weighing 730 kg as the primary payload, and the INS-IA and INS-1B, weighing 30 kg.

An official from the space agency said it was planned earlier to launch 83 satellites in the last week of January, of which 80 were foreign, but with the addition of 20 more foreign satellites, that launch was delayed by a week and should now occur during the first week of February.

Kumar also said ISRO was working on having more frequent launches. "*The next one is going to carry a number of satellites from various companies along with our own Cartosat-2 series satellite and immediately following that we have GSLV Mark III and Mark II.... In the first three months that's what we are targeting, but beyond that we are trying to work for almost one launch a month,*" he said.

"*The prime driver for all of this is to increase the capacity. Though we have the number of satellites in operation, we require many more for providing the necessary services that is needed,*" he added.

"*As we are progressing, we need to look at long-term. So what we are looking beyond Chandrayan-2, for which we are already working on an approved program,*" Kumar said. "*Beyond that, the Mars second mission and Venus mission are all on the horizon. We have to go through the various studies and then formulate, get the approvals and then move. Right now, [all of these missions] are all in the study phase,*" he added.

ISRO is conducting tests for hazard avoidance for Chandrayaan-2 as the rocket lands at the agency's facility in Challakere in the Chitradurga district of Karnataka, where simulated lunar craters have been created to evaluate the performance of the system.

The ISRO Chairman and French Space agency (CNES) President Jean-Yves Le Gall in the presence of visiting French Minister of Foreign Affairs Jean-Marc Ayrault has signed a partnership agreement regarding the sharing of satellite launch technology.

To a question on the agreement, Kumar said, "*Currently, we are working with them on Oceansat-3... and then we are working for a future payload, on an infrared imaging sensor.*

"*We are also looking at possibilities of working with them in various areas of future developments of satellites, launch vehicles,*" he added.

ISRO, in the past, has worked with CNES on sounding rockets, the SARAL satellites program and had also launched satellites for them.

isro.gov.in/

Article source: India Times

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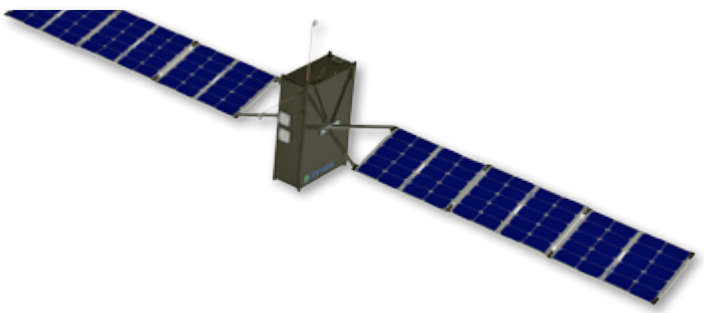
Pathfinders For NASA



Artistic rendition of Tyvak's six-unit (6U) Pathfinder Technology Demonstrator CubeSat design. Image is courtesy of Tyvak Nanosatellite Systems.

Tyvak NanoSatellite Systems Inc., a wholly-owned subsidiary of Terran Orbital, provides turnkey nanosatellite solutions for civil and commercial customers around the world—and now the company has been awarded a contract by NASA's Small Spacecraft Technology Program to provide a series of CubeSats for the agency's upcoming Pathfinder Technology Demonstrator (PTD) missions.

Through this contract, Tyvak will handle the design, integration, testing and operations support of up to four different payloads, selected by NASA for four separate missions. Tyvak was awarded this contract based on excellence in technical design, proven company past performance, mission assurance processes, and budget.

The 6U CubeSat being built for this mission utilizes the Tyvak Endeavour Platform and is equipped with solar arrays that will provide at least 45 watts average power while in-orbit and allocate at least one-third of its volume for a technology payload.

Tyvak also will ensure thermal management for the payload and precision pointing for propulsive maneuvers. Beyond the spacecraft design, Tyvak is also establishing the ground network to support operations for each satellite.

The PTD program was created to benefit future NASA missions by demonstrating the operation of new subsystem technologies on orbit.

Payloads scheduled to fly on these missions include propulsion systems that will provide the capability to maneuver small science platforms and send small spacecraft to deep space, as well as novel technologies to stabilize spacecraft, and laser communication systems that will greatly increase the amount of data that can be transmitted from spacecraft to the ground.

tyvak.com/

nasa.gov/mission_pages/cubesats/index.html

Interorbital Systems on a TubeSat Roll

Interorbital Systems (IOS) watched their first TubeSats reach orbit, courtesy of the Japanese HTV-6 rocket and sat-kit builders: an Ubatuba, Brazil Middle School with its Tancredo Sat-1 and OSNSAT from California start-up Open Space Network.

These picosats were derived from the IOS TubeSat Personal Satellite Kit, the ultimate hands-on academic space science tool designed to support STEM and STEAM curricula in US and over 20 countries worldwide.

"These are the first spacecraft elements designed and made in Mojave to go to orbit. The TubeSat kit is one of IOS' inventions and one of our best–selling products—a teaching tool that instructs the builder to create the world's least expensive, fully functional satellite," said IOS Co/Founder and CTO Roderick Milliron.

One of the IOS TubeSats launched to the ISS, Tancredo-1, was built by the Tancredo Middle School, with the mentorship of INPE, and the Brazilian Space Agency. The Ubatuba, Brazil program, is led by educator Candido Moura, an early adopter of Interorbital's satellite 'maker' program.

The TubeSats flew on December 9th, 2016, aboard the Japanese HTV-6 cargo rocket to the International Space Station where it now awaits deployment and activation. The GAUSS organization facilitated the payload placement, and provided the 3-Unit TuPOD, a 3-D-printed deployer, designed as a kind of P-POD specifically for TubeSats.

The TuPOD was first created as part of a Morehead State University smallsat team led by Professor Bob Twiggs.

Interorbital also offers CubeSat kits, which are equally popular and affordable at a special academic price. The first TubeSat kits hit the market in 2009, and were sold with a launch on a future mission of Interorbital's NEPTUNE rockets.

The ultra-low cost was offered because Interorbital considered the first of its rocket launches to be high-risk and experimental, but offered a ride-share payload space to LEO, something in short supply to the smallsat community. With 137 small satellites--most of them built from IOS' own TubeSat and CubeSat kits--on its launch manifest the company anticipates beginning its own orbital launch services when testing and FAA/AST licensing is complete, projected for mid-summer 2017.

The HTV-6 TubeSat mission capped off an eventful 2016 for IOS. In August, Interorbital's launch contract with Google Lunar X PRIZE Team SYNERGY MOON was verified, sending the team and launch-provider one step closer toward the Moon launch they hope will win the $30 million dollar prize. IOS will fly a super-variant of it NEPTUNE rocket series, the NEPTUNE 8 (N8) LUNA, an eight-module rocket with enhanced performance engines, to launch SYNERGY MOON's Lunar Lander and Rover at year's end.

Current lead-up development and testing for the big event includes field testing of all rocket systems and the guidance and control system for the NEPTUNE rocket series.

Upon completion of these final ground tests, IOS will conduct a full-scale vehicle flight test of a guided CPM, as one of the milestones in IOS' busy launch schedule for 2017. Planned events include a space-altitude suborbital flight of a full-performance CPM, the core module of all its NEPTUNE rockets, followed by its first orbital satellite mission with an N3 (3-module) carrying 15 currently manifested small sats to a 310-km circular polar orbit from an ocean-base off the coast of Southern California.

As 2017 continues, the excitement builds with a lunar-impact mission, designated "Lunar Bullet," that will feature a lunar-direct trajectory ending with a hard impact on the Moon's surface, similar to the NASA 'Ranger' mission from the 1960s. Not only will the Lunar Bullet be the first payload launched by a commercial rocket company to the surface of the Moon, the IOS/Innovative Orbital Design mission will also serve as a precursor to Interorbital/SYNERGY MOON's GLXP prize-attempt launch by verifying IOS' launch and interplanetary navigation technology.

Interorbital's message for 2017: Moonward!

For more about Interorbital Systems and its program, please see:

Launching Into Space 3.0... An Interorbital Systems Perspective: ***milsatmagazine.com/story.php?number=1512656321***

Randa Milliron, Planetary Society 2017 interview: ***planetary.org/multimedia/planetary-radio/show/2017/0102-randa-milliron-interorbital.html***

InfoBeam

AMERGINT Increases Their Capabilities

Eight years ago, AMERGINT began to transform the satellite ground systems market by moving SATCOM processing into software applications.

This objective quickly spread to transforming the spacecraft test, real-time data acquisition and spacelift range markets with the same software application approach. AMERGINT's SOFTLINK architecture is the single unifying technology that makes this a reality.

The transformative capability and dramatically lower cost of ownership of SOFTLINK applications is driving AMERGINT's growth and facility expansion needs.

"*Four years ago we doubled the size of our facility when we moved to our current location*," noted Sean Conway, AMERGINT's Chief Operating Officer. "*With the completion of our expansion, we are doubling that space yet again to more than thirty thousand square feet.*"

The latest addition includes lab space for additional development, integration, test, and support for large projects.

The new facility also includes offices for new employees, as well as facilities to support a broader range of programs and customers in house.

"*Customer adoption of our softFEP and satTRAC products has really accelerated in the past few years,*" said Rob Andzik, AMERGINT's President. "*Our products are used on many mission critical systems. We understand the importance of the trust placed in us and we are committed to providing the best talent, products, and customer support possible. As a result, we are strategically seeking both experienced engineers and recent college graduates to add to our team. This new expansion gives us the high quality work environment and needed lab space to support our projected growth.*"

"*As we begin our ninth year, we are tactically focused on delivering technology and managing our growth in a way that allows us to continue our exceptional support for all of our customers*, "said Sean Conway.

AMERGINT Technologies, Inc. is an employee-owned company delivering signal and protocol processing software applications to the satellite ground, test, and data acquisition markets. For more information or to arrange an onsite or web demonstration, contact the firm at **719-522-2800**.

amergint.com/

A Metallic Mission for SSL and NASA

Artistic rendition of the Psyche spacecraft. Image is courtesy of SSL/ASU/P. Rubin/NASA JPL-Caltech.

The metallic asteroid 16 Psyche, as of yet unidentified with any asteroid family, is one of the most massive asteroids within the asteroid belt and is now the focus of Space Systems Loral (SSL), as that firm is going to be providing the spacecraft platform for a NASA Discovery Mission to explore this spatial concern, which is believed to be a stripped planetary core.

SSL will work for NASA's Jet Propulsion Laboratory (JPL) to support Principal Investigator Dr. Lindy Elkins-Tanton, director of Arizona State University's (ASU) School of Earth and Space Exploration, in a mission to research the 210 km diameter asteroid, which is believed to be the only place in the solar system where a metal planetary core can be studied.

As the industrial partner, SSL will provide the "power-propulsion chassis," a highly capable composite structure spacecraft platform equipped with a high-power solar electric propulsion (SEP) system.

The NASA Discovery Program goal is to deepen the knowledge of our solar system by launching modest cost-capped missions on a routine cadence.

Scheduled to launch in the 2020s, the Psyche mission was selected for flight out of five Discovery Mission candidates.

The spacecraft design is based on the SSL 1300 platform, which has been proven on more than 100 missions, and has the flexibility to serve a broad range of applications, ranging from space exploration and remote sensing, to commercial communications.

SSL is also contributing to a variety of other next generation US government missions, including the Restore-L mission for NASA's Goddard Space Flight Center, which will demonstrate the ability to extend the life of a satellite in Low Earth Orbit (LEO), and the Dragonfly program for NASA and DARPA, which will demonstrate on orbit satellite assembly.

"Our many years of experience and success in building state of the art spacecraft, position us well to support NASA programs and to contribute to this NASA Discovery Mission," said John Celli, president of SSL.

He added that the firm's partnership with ASU and JPL will enable this ground breaking research, which will help with a better understand of the early days of the solar system and the formation of terrestrial planets.

According to the JPL infosite, 16 Psyche is about three times farther away from the sun than is the Earth. This asteroid measures some 130 miles (210 kilometers) in diameter and, unlike most other asteroids that are rocky or icy bodies, is thought to be comprised mostly of metallic iron and nickel, similar to Earth's core.

Scientists wonder whether Psyche could be an exposed core of an early planet that could have been as large as Mars, but which lost its rocky outer layers due to a number of violent collisions billions of years ago.

The mission will help scientists understand how planets and other bodies separated into their layers—including cores, mantles and crusts—early in their histories.

"*This is an opportunity to explore a new type of world - not one of rock or ice, but of metal*," said Psyche Principal Investigator Lindy Elkins-Tanton of Arizona State University in Tempe. "*16 Psyche is the only known object of its kind in the solar system, and this is the only way humans will ever visit a core. We learn about inner space by visiting outer space.*"

Psyche, also a robotic mission, is targeted to launch in October of 2023, arriving at the asteroid in 2030, following an Earth gravity assist spacecraft maneuver in 2024 and a Mars flyby in 2025.

sslmda.com/

jpl.nasa.gov/

Multi-Band Comms For Stena Line from Marlink

Marlink has added the first out of four additional Stena Line ships to the firm's multi-band communications network.

Marlink now serves the entire fleet of Stena Line vessels, ensuring high levels of connectivity for passengers and crew, in addition to operational applications and commercial businesses on board. Marlink will also further increase available capacity to Stena Line vessels with an additional 10 to 15 percent, following the tripled bandwidth increase in June 2016. As one of the largest ferry operators in Europe and the world, more than 7 million people a year travel to their destination with Stena Line.

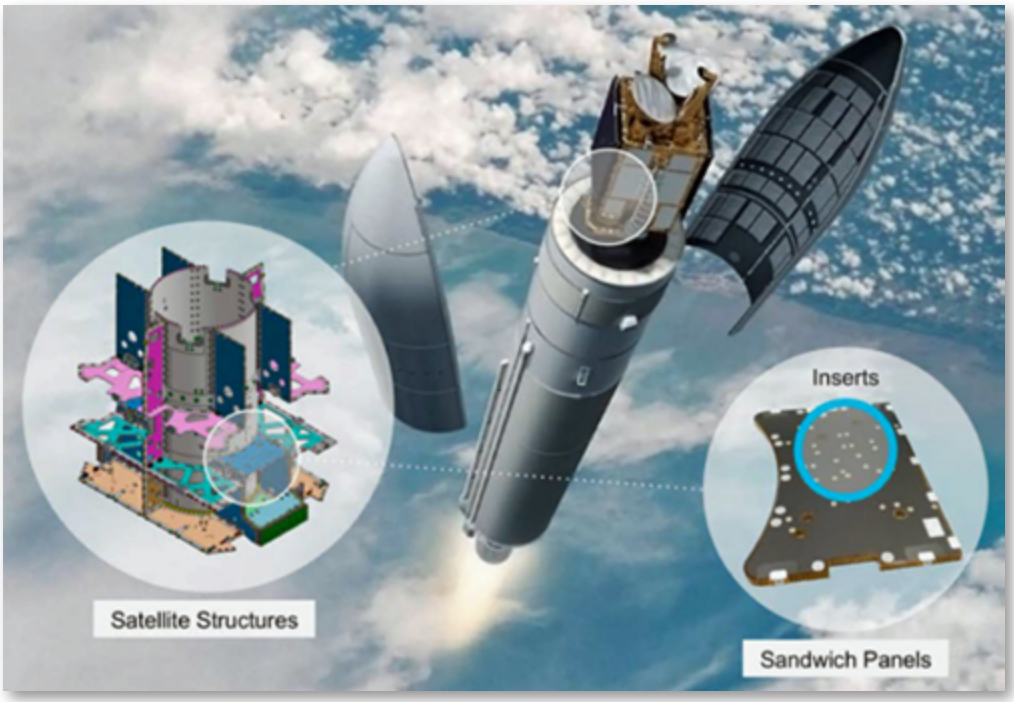
The company defines on board communications as a critical passenger satisfaction indicator so it is committed to offering the best available technology and services for its customers. Stena Line is today well recognized as an early adopter of new communication services, having worked closely with Marlink since the mid-nineties to introduce several 'firsts' in the world of maritime communication; including paving the way for multi-band networks that deliver high availability, redundancy and value for money.

Marlink has developed one of the most advanced multi-band networks for the Stena Line fleet, based on seamless integration of VSAT and GSM 3/4G services for connectivity during voyages in addition to in-port Internet Wi-Fi networks. The service was upgraded this summer, with three times more bandwidth added to the Stena-Line 'Closed User Group' (CUG), which guarantees bandwidth availability and flexibility for all vessels in the network.

The capacity in Stena Line's dedicated CUG will be increased by a further 10 to 15 percent early in 2017. Stena Line's industry leading multi-band solution enables high availability of voice and Internet, serving hundreds of passengers simultaneously. With a pool of bandwidth reserved just for the Stena Line fleet, the CUG also provides the flexibility to optimize connectivity based on current demands of the fleet. Stena Line vessels receiving connectivity within 3/4G coverage areas or Wi-Fi while in port will require less from the VSAT CUG capacity, allowing even more satellite bandwidth to be available for other vessels and passengers at sea. Switching between VSAT, 3/4G and port Wi-Fi services when docked is seamless, allowing passengers and businesses on board to benefit from reliable multi-band Internet connectivity that can be relied upon throughout a voyage.

marlink.com/
stenaline.com/

GreDom-Insert from RUAG Space is a Real Winner



Sandwich panel with inserts as part of a satellite structure. Image is courtesy of RUAG Space.

An invention in the area of satellite construction by the University of Applied Sciences and Arts, Northwestern Switzerland FHNW, with support from its industrial partner, RUAG Space, has been awarded the 2016 YPSOMED Innovation Prize—the automation process subsequently developed on the basis of this invention contributed to RUAG Space acquiring a major project.

The 2016 YPSOMED Innovation Prize went to the development of the "*GreDom-Insert*." This is a novel kind of insert that is installed and bonded in satellite panels fully automatically.

These are special thread inserts which allow instruments, assemblies and sensors to be attached to the load-bearing structure of a satellite. An average communications satellite has between 5,000 and 10,000 inserts, which have had to be installed manually up to now.

When presenting the 2016 YPSOMED innovation prize, Professor Peter Mulˆrner, Trustee of the YPSOMED Innovation Fund, summed up the jury's decision as follows: "*This invention produced at FHNW is a perfect example of targeted, innovative and forward-looking collaboration between research and business.*"

Based on the "GreDom" insert developed at FHNW, and on the findings of this research project funded by the Commission for Technology and Innovation (CTI), RUAG Space then designed and built the "Automated Potting Machine."

This automatically cuts panels to size, drills holes, applies adhesive and places the inserts into the panel with a high degree of precision.

The manufacturing time for satellite structures can thus be significantly reduced, enabling considerable cost savings.

This revolutionary invention provides an instant benefit for the industrial partner RUAG Space.

"*The fact that we have been awarded the contract to construct the OneWeb satellite structure is partly due to this automated manufacturing process. Our efficiency means we stand out from the competition*," according to Urs Breitmeier, CEO of RUAG.

For this major project, a total of 900 satellites should provide blanket broadband Internet by the end of 2020 and this is the largest series production in the history of satellite construction.

Product development for the space industry is one of the FHNW School of Engineering's focus areas.

The School's 14 institutes work closely together with the business sector on applied research and development.

The inventors of the revolutionary "GreDom" insert are Prof. Gregor Burkhard (FHNW) and Dominik Nägeli (previously FHNW, now RUAG Space).

Their invention was developed further by the project team with FHNW researchers Laurent Repond, Marcel Gloor and Stefan Kobler, under the leadership of Prof. Hans-Peter Gröbelbauer (FHNW) and Stefan Kögl (previously RUAG Space).

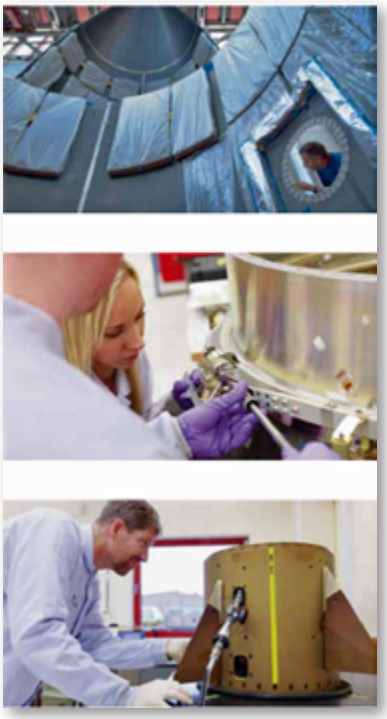
The research project was funded by the Commission for Technology and Innovation CTI.

The YPSOMED Innovation Fund Foundation aims to motivate creative and innovative teams or individuals to incorporate the needs of industry and services in their academic work.

The projects presented should therefore contain innovative, financially feasible ideas, products, procedures, methods or services.

Together with the award, the winner of the YPSOMED Innovation Prize receives CHF 30,000 in prize money.

ruag.com



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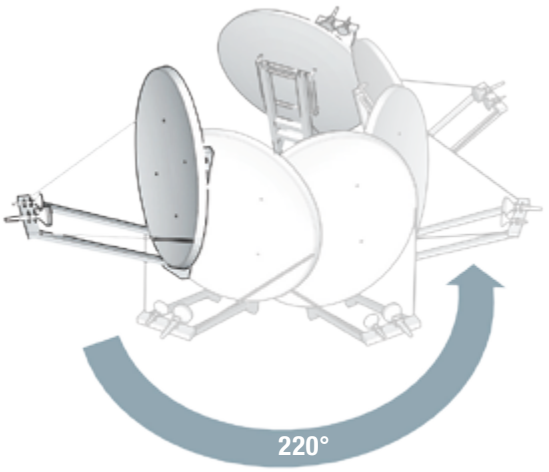

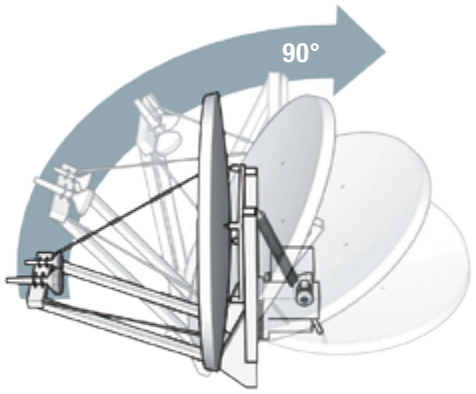

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KVH Upgrades and Plans to Include IoT and OneWeb

At the 19th Annual Needham Growth Conference in New York, KVH CEO Martin Kits van Heyningen announced that his company is initiating an upgrade to mix high-throughput capacity from geostationary and LEO satellites into its network that will triple current speeds.

He added that they will launch a new high-capacity network using Ku-band spot beam satellites that have a capacity up to 60 gigabits per second, which is a huge improvement over the technology that was available before.

KVH CEO
Martin Kits van Heyningen

This has been his ambition for a number of years, offering higher speeds at approximately the same current price for his customers when factoring in the additional pricing pressure exerted by oversupply.

KVH uses 19 satellites and 12 teleports to support a global C- and Ku-band network for maritime vessels.

Kits van Heyningen estimated the company's addressable market at about 250,000 vessels, of which he estimated less than 10 percent use Very Small Aperture Terminals, or VSATs, currently for connectivity, which will be changing.

"*We are at the beginning of a major upgrade cycle in this market. The technology that has been used is over 10 years old now,*" he said. "*L-band satphone-type technology is really no longer adequate for modern operations, but about 40,000 vessels are still using that, and those are getting speeds that are in kilobits per second, not in megabits per second. We see a lot of those customers upgrading to VSAT over the next few years.*"

KVH manufactures satellite terminals and other equipment and currently is preparing new terminals simultaneously with the planned network upgrade so users can tap into geostationary HTS this year.

Kits van Heyningen said there will be an easy upgrade path for existing customers to tap into the higher speed services, but that it will not be mandated.

"*It is a little bit like 3G, if you want to stick to that network, you're fine, but if you want the higher speeds, there is an upgrade path both for the install base as well as for new customers*," he said.

Beyond geostationary-HTS the company is developing antennas to link with LEO systems especially OneWeb as well as for cellular backhaul systems.

He said maritime antennas already have traits needed to connect with LEO systems because they are designed to track with a satellite while in motion.

Other projects include developing an Internet of Things (IoT) product to optimize maritime operations, to assist with new regulations that require carbon dioxide emissions reporting from maritime vessels, that entails operators tracking new data.

kvh.com

New AMC-3 Owner

On January 9, *Satnews.com* shared information about Global Eagle Entertainment (GEE) "in discussions with a leading satellite provider to purchase satellite transponders for an estimated price of approximately $50 million," to support a large aviation-connectivity customer.

Artistic rendition of the "newly named" Eagle-1 satellite.

Since then, the curtain has been pulled back, press releases issued and the satellite fleet operator has been identified as SES.

The satellite, AMC-3 now renamed Eagle-1 by Global Eagle, carries 24 Ku-band transponders and was launched in September of 1997 on an Atlas 2A rocket.

Eagle-1 covers North America, the Gulf of Mexico and the Caribbean. Lockheed Martin built the satellite, which is now operating nearly five years past its design life.

CEO Dave Davis remarked that rather than leasing capacity for a set amount of time, the purchase will prove to be a smarter financial move enabling substantial cost savings, that Global Eagle paid a low enough price for the satellite to outweigh the risk of buying a nearly 20-year-old spacecraft that's drifted into an inclined orbit.

To preserve on-board propellant for contingency operations, operators sometimes forego station-keeping maneuvers for older satellites like Eagle-1, allowing the spacecraft's position in the sky to gradually shift that can be an issue for some immobile ground-based antennas and terminals, it's not a serious matter for airplanes and boats equipped with antennas designed to keep satellites in sight while on the go.

geemedia.com

PanGeo Alliance Obtains PCI Geomatics Support

PCI Geomatics is going to be collaborating closely with Deimos Imaging to support the PanGeo Alliance.

Deimos Imaging is a founding member of the PanGeo Alliance, which is the first global alliance of Earth Observation (EO) sensors operators.

The PanGeo Alliance is made up of eight member companies, and a fleet of 15 operational EO sensors, providing multispectral imagery in a wide range of resolutions (from 20 m to 75 cm per pixel), 4k full-color videos, and AIS data.

PCI Geomatics is working closely with teams from Deimos Imaging to ensure support for pansharpening, atmospheric correction orthorectification, Digital Elevation Model (DEM) extraction and automatic mosaicking and color balancing operations.

Support for many of the sensors has already been implemented by PCI Geomatics, including Deimos-1, KazEOSat,-1, Theia, Dubaisat-1, TH-1, Deimos-2, Dubaisat-2, and other sensors that make up the PanGeo Alliance fleet.

PCI Geomatics will be preparing instructional videos and webinars, and provide documentation on the firm's dedicated customer portal, ***support.pcigeomatics.com***, to provide helpful information on working with the imagery from the PanGeo Alliance fleet over the coming months.

According to Arnold Hougham, Vice President, Sales and Marketing at PCI Geomatics, providing support for the PanGeo sensors is of critical importance to the Earth Observation community, who make operational use of geospatial imagery to deliver products and services to their customers on a daily basis.

PCI Geomatics develops software that is modular, scalable and flexible.

Not only will the company provide access to operations for essential image processing steps (ortho-mosaic, DEM extraction), PC Geomatics also plans to deliver application based demonstrations through the marketing channels to help educate customers on what analysis and information can be performed on such a rich multi-sensor data source, which is offered through the PanGeo constellation.

pcigeomatics.com/

pangeo-alliance.com/

O3b's Debt Disappears

The last of O3b's debt has been taken care of by SES S.A. (Euronext Paris and Luxembourg Stock Exchange: SESG).

SES has announced the refinancing of the remaining O3b debt.

Since acquiring the remaining O3b shares, SES has refinanced the entire $1.4 billion of gross debt at a materially lower average funding rate.

This will deliver a total of approximately 60 million euros of annual finance cost savings, starting in 2017.

The refinancing was funded using cash that was available at Group level, which included the proceeds of the hybrid bond issued by SES S.A. in November 2016.

SES's weighted average cost of funding is around 4 percent, which is significantly lower than the average cost of the previous O3b debt.

Padraig McCarthy, CFO of SES said, "*The early completion of the O3b debt refinancing is an important source of value creation for shareholders and enhances SES's overall return on its investment in O3b. O3b's unique global solution represents an important growth accelerator for SES. The annual financing synergies will allow SES to maximize profitability and drive long-term returns.*"

ses.com

o3bnetworks.com/

Take One Tablet and Feel Better About Global Comms

Xplore Technologies Corp. and CLS America take it to the tablets with the Thorium X, a satellite communications tablet system built on the Xplore XSLATE D10 Android™ rugged tablet PC.

Xplore received an initial order from OEM customer CLS for 1,000 XSLATE D10 units and is prepared to fulfill follow-on orders as needed over the next three years to support rising production and sales of the CLS-branded system.

The Xplore XSLATE D10 rugged tablet was selected to serve as the underlying platform for the Thorium X rugged satellite tablet and software solution, which is now available to customers worldwide.

Mark Holleran, president and COO of Xplore, remarked, "*One of Xplore's strengths is the ability to engineer flexible rugged tablet technologies that allow OEMs such as CLS to customize and implement future-proof mobility solutions based on our industry leading platforms. By adding satellite data communications capabilities to the best Android rugged tablet on the market—the Xplore XSLATE D10—CLS both expands the addressable market and enables increased ROI for customers with 'off the grid' mobile workforces.*"

The Intel®-powered Thorium X features an integrated Iridium Short Burst Data (SBD) modem and flexible satellite antenna that increases the reliability, speed, and cost-effectiveness of mobile communications.

As a result, users will be able to maintain continuity in their professional activities from any remote location around the globe, and probably at a lower cost than most cellular data plans.

"*We know that communications challenges in places or during times when no cellular or WiFi is available costs global industries and governments millions of dollars,*" explained Michael Kelly, vice president of CLS America. "*Thorium X now allows people to stay connected via satellite 100 percent of the time, and at a fraction of the cost of satellite phones.*"

Thorium X users will have the ability to access email, view statistical reports of missions, engage in M2M communication and monitoring, and send electronic forms, among other critical tasks, via satellite in real-time.

A bright, 10.1" outdoor viewable screen and Glove Touch capabilities make it easy to conduct secure, TPM 1.2-protected transactions day or night, even in inclement weather.

Thorium X software solutions are also available as a tablet app and desktop platform to securely facilitate mapping functions, deliver weather reports, and perform data compilation and transmissions in real-time via the rugged satellite tablet.

"*The launch of Thorium X means that users no longer have to rely solely on WiFi or cellular network connections. This is a huge win for people and teams who work in remote areas, or during times that other communications have been compromised, especially those supporting global operations related to emergency management, military, environmental monitoring, government, fisheries, and other field-centric industries,*" Kelly added.

xploretech.com/D10

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Drilling with Expertise

Signalhorn's hybrid network solutions have been awarded an extended contract by major drilling contractors for its multi-site operations within the Middle East (Oman) and North Africa (Algeria).

The contractors work in 12 remote rig sites that are located in some of the harshest and most remote locations, which will benefit from Signalhorn's ability to deliver a reliable, competitive service with consistent service level agreements (SLAs).

Signalhorn provides the customer with best-in-class support both on the ground and from its state-of-the-art 24/7/365 Network Operation, Technical and Data Centers, along with local knowledge and the flexibility to respond quickly to the customers' requirements.

By deploying their SCPC and iDirect platforms, Signalhorn will continue to provide the mission critical communications from its self-owned and self-operated European facilities.

Gary Bray, Vice President Energy at Signalhorn, said, "*This extended contract award from a major drilling company demonstrates Signalhorn's commitment of renewed growth in the energy sector that has been consistently built throughout Signalhorn's 44 year experience. With a wide portfolio of trusted solutions and highly trained, local personnel on the ground throughout the Middle East and African continent we can ensure that our customers receive outstanding service and support regardless of where they operate.*"

signalhorn.com

The Incredible Shrinking Forests of Cambodia

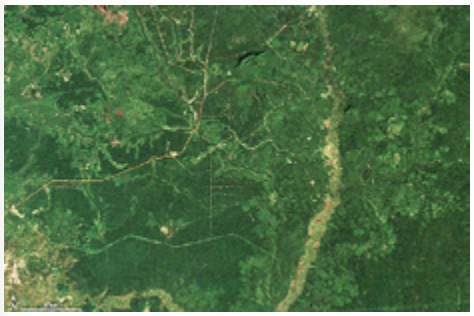

Image acquired in December of 2000.

Image acquired October 30, 2015.

Cambodia has one of the fastest rates of forest loss in the world. In broad swaths of the country, densely forested landscapes—even those in protected areas—have been clear-cut over the past decade—much of the forest has been cleared for rubber plantations and timber.

Scientists from the University of Maryland and the World Resources Institute's Global Forest Watch have been using Landsat satellite data to track the rate of forest loss on a global scale.

Though other countries have lost more acres in recent years, Cambodia stands out for how rapidly its forests are being cleared.

Between 2001 and 2014, the annual forest loss rate in Cambodia increased by 14.4 percent. Put another way, the country lost a total of 1.44 million hectares—or 5,560 square miles—of forest.

Other countries with accelerating rates of forest loss include Sierra Leone (12.6 percent), Madagascar (8.3 percent), Uruguay (8.1 percent), and Paraguay (7.7 percent).

The transformation of Cambodia's landscape has been profound, as revealed by this pair of Landsat images.

The first image, captured by Landsat 7's Enhanced Thematic Mapper Plus on December 31, 2000, shows intact forest near the border of the Kampong Thom and Kampong Cham provinces.

On October 30, 2015, the Operational Land Imager (OLI) on Landsat 8 captured the second image, in which much of the forest has been replaced by a grid-like pattern of roads and fields and by large-scale rubber plantations.

Clear-cutting has also chewed away at the edges of densely forested areas (dark green) and replaced them with exposed soil, croplands, and mixed forests (brown and light green).

Researchers working with Landsat data and other economic datasets have demonstrated that changes in global rubber prices and a surge of land-concession deals have played key roles in accelerating Cambodia's rate of deforestation.

Concession lands are leased by the Cambodian government to domestic and foreign investors for agriculture, timber production, and other uses. Researchers found that the rate of forest loss within concession lands was anywhere from 29 to 105 percent higher than in comparable lands outside the concessions.

Work by Matthew Hansen and his University of Maryland Global Land Analysis and Discovery (GLAD) lab has played a key role in revealing the scope of deforestation.

In 2013, the group published their first global map of forest change. The map above, based on Hansen's work, depicts the extent of forest loss throughout Cambodia between 2000 and 2014. Much of it has occurred in the past five years.

In conjunction with the World Resources Institute, GLAD has developed a new weekly alert system: deforestation is detected by satellites with each new Landsat image, and users can subscribe for email updates.

The freely available alert system is already operating for Congo, Uganda, Indonesia, Peru, and Brazil. The researchers hope to have the system operating for Cambodia and the rest of the tropics in 2017.

More information can be found at:
earthobservatory.nasa.gov/IOTD/view.php?id=89413

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WORKSHOPS: FEBRUARY 6th

CONFERENCE: FEBRUARY 7th - 8th

WORKSHOPS

Monday, February 6th, 2017

9:00 am — 12:00 pm	Lovelace Room	Legal and Regulatory Roadmap
9:00 am — 12:00 pm	Boole Room	Earth Observation – Market Trends
2:00 pm - 5:00 pm	Lovelace Room	Earth Observation - Remote Sensing and Geospatial Data
2:00 pm - 5:00 pm	Boole Room	The Use of COTS Products in Small Satellites

CONFERENCE

Day 1 — Tuesday February 7th, 2017

7:00 am	Registration Opens
Breakfast	Sponsored by: Mitsubishi Heavy Industries, Ltd
8:15 am	The State of the Small Satellite Industry
9:30 am	Financing Small Satellite Operations
10:45 pm	Networking & Refreshment Break — Sponsored by: Orbital Systems
11:15 am	Keynote Roundtable — SmallSat Market Inflection Points
12:30 am	Lunch — Sponsored by: Ball Aerospace
2:00 pm	Launch Provider Roundtable – Efficiency, Risk & Trends
3:15 am	Ground Systems Economics & Architecture
4:30 pm	Networking & Refreshment Break — Sponsored by: Orbital Systems
5:00 pm	Pricing and Marketing SmallSat Services
6:15 pm	Wine & Hors d'Oeuvres Reception — Sponsored by: Kratos Defense & Security Solutions

Day 2 — Wednesday February 8th, 2017

7:00 am	Registration
Breakfast	Sponsored by: DHV Technology
7:30 am	Small Satellite Constellation Dynamics
8:45 am	Earth Observation
10:00 am	Networking & Refreshment Break — Sponsored by: JSC Glavkosmos
10:30 am	Securing Capital In New Small Satellite Ventures
11:45 am	Traditional Large Integrators – What is their Role in the SmallSat Industry?
1:00 pm	Lunch — Sponsored by: Boeing Satellite
2:30 pm	Next Generation Technology
3:45 pm	Networking & Refreshment Break — Sponsored by: JSC Glavkosmos
4:00 pm	Cost Savings in Small Satellite Alternatives
5:15 pm	Defense and Government Applications
6:30 pm	Concluding Remarks
7:00 pm	SmallSat Symposium After Dark (Hosted by SSL)

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SmallSat Symposium Keynote Speakers

By Silvano Payne

Steve Jurvetson, Partner
DFJ

Steve Jurvetson is a partner at the venture capital firm DFJ. His current board responsibilities include Planet Labs, SpaceX, Synthetic Genomics, and Tesla Motors (TSLA).

He was the founding VC investor in Hotmail, Interwoven (IWOV), Kana (KANA), and NeoPhotonics (NPTN). He also led DFJ's investments in other companies that were acquired for $12 billion in aggregate.

Previously, Steve was an R&D Engineer at Hewlett-Packard, where seven of his communications chip designs were fabricated. He also worked in product marketing at Apple and NeXT Software and management consulting with Bain and Company.

At Stanford University, he finished his BSEE in 2.5 years and graduated first in his class, as the Henry Ford Scholar. Steve also holds an MS in electrical engineering and MBA from Stanford.

Steve was selected by Deloitte as "Venture Capitalist of the Year", by *Forbes* as one of "Tech's Best Venture Investors", by the *VC Journal* as one of the "Ten Most Influential VCs", by *Fortune* as part of their "Brain Trust of Top Ten Minds" and "The Valley's Sharpest VC" on the cover of *Business 2.0.*

Professor Sir Martin Sweeting, Founder and Executive Chairman
Surrey Satellite Technology Ltd.

Professor Sir Martin Sweeting pioneered rapid-response, low-cost and highly capable small satellites using modern consumer (COTS) electronics devices to change the economics of space.

In 1985, he founded a spin-off University company (SSTL), which has now designed, built, launched and operated in orbit 49 nano-, micro- and mini-satellites. These smallsats include the international Disaster Monitoring Constellation (DMC). SSTL also built all of the 22 navigation payloads for the European Galileo operational constellation and a low-cost, medium-resolution SAR minisatellite (NovaSAR).

SSTL has grown to 500 staff in number, with annual revenues of $150 million—total export sales to 24 countries have approached $1 billion.

As Chairman of the Surrey Space Centre as well as being a distinguished professor at the University of Surrey, Sir Martin heads a team of 90 faculty and doctoral researchers investigating advanced smallsat concepts and techniques, acting as the research laboratory for SSTL – a true example of real academic-commercial synergy.

Sir Martin has been appointed OBE and knighted by HM The Queen, elected a Fellow of the Royal Society and a Fellow of the Royal Academy of Engineering, and he has received the prestigious von Karman Wings Award from CalTech/JPL.

In 2016, Sir Martin was identified by *The Sunday Times* as one of the UK's 20 most influential engineers, confirmed again in Debrett's 2017 list of the 500 most influential people in the UK.

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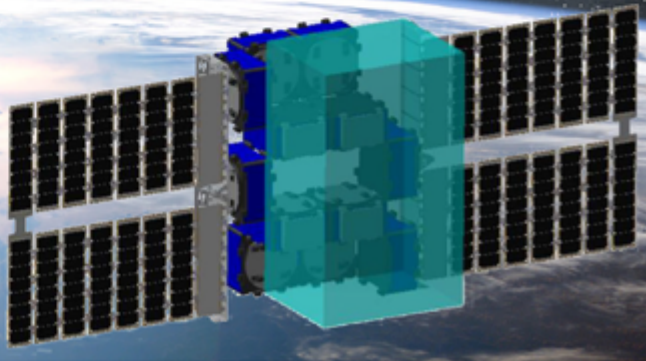

PTB SATELLITE
with primary Payload volume shown

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SmallSat Symposium Speakers

By Jill Durfee, Associate Editor

Chad Anderson, Managing Director
Space Angels Network

Chad has facilitated millions of dollars of private investment into new commercial space ventures. He is also Non-Executive Director of the UK Space Catapult, where he supports the national strategy to grow the space sector in the country, and is Board Director of WayPaver Foundation, where he forwards the goal of sustainable lunar settlement. Prior to his current roles, Anderson enjoyed a successful career at JP Morgan Chase where he managed a $50 billion real estate portfolio through the Great Recession. He is a prominent advocate of the entrepreneurial space industry with numerous public speaking appearances, interviews, and papers on the subject, including publications in *Space Policy Journal*, the first-ever market assessment for commercial lunar services, and the economic case for a UK spaceport. Anderson holds an MBA from the University of Oxford.

Dr. Eric Anderson, President
And One Technologies

Eric is a Senior Advisor at Silicon Valley Space Center and an angel investor in emerging space and IOT. He has contributed to dozens of space products, missions and programs within small and large companies, government and academia. He directly supports DoD customers by identifying and evaluating promising technologies and new industrial partners who have small satellite based capabilities in Earth observation, communications and space situational awareness. As Chief Technologist for Space at Moog, he helped lead the space business and collaborated with worldwide colleagues on business strategy, technology and innovation across multiple markets. Eric earned his B.S., M.S. and Ph.D. degrees in Aeronautics and Astronautics at MIT. At JPL, he researched space structures and control systems for future large optical observatories. At Sikorsky he evaluated composite structures and performed structural, life extension and certification analyses for commercial and military helicopters.

Rob Andzik, President
AMERGINT Technologies

Rob attended the University of Colorado obtaining degrees in Aerospace Engineering and Computer Science. He has over 22 years experience in the space industry working for Lockheed Martin, RT Logic and now AMERGINT Technologies. As an engineer he has designed, implemented, and maintained satellite communication systems for programs including the International Space Station, GPS, AFSCN, MMSOC, and recently launch systems for Atlas and Delta rockets. Rob was previously a co-chair of the OMG Space Domain Task Force, and author of OMG's GEMS specification.

Jason Andrews, CEO
Spaceflight Industries

Spaceflight Industries (Spaceflight) is a next-generation space products and services company. Through its wholly owned subsidiaries and service lines Spaceflight Systems, Spaceflight Services and Spaceflight Networks, Spaceflight streamlines the process and reduces the cost to access and operate in space. Andrews co-founded Spaceflight Systems in 1999 as Andrews Space with the mission of being a catalyst in the commercialization, exploration and development of space. Andrews then founded Spaceflight Services, the "space logistics company," in 2010 to provide cost-effective, commercial "rideshare" launch services. In 2014, Andrews announced Spaceflight Networks, a business dedicated to cost-effective spacecraft communications and operations for small-satellite customers. Under Andrews' direction, all of these companies were combined and rebranded under the Spaceflight name in 2015 to form Spaceflight Industries. Prior to Spaceflight, Andrews served at Kistler Aerospace Corporation. He holds a bachelor's degree in aerospace engineering from the University of Washington.

David A. Anhalt, President
Blue Residuum

David joined Iridium in 2013 as Vice President and General Manager of Iridium PRIMESM, a hosted payload accommodation service that will utilize the Iridium inter-satellite communication network, ground infrastructure, and flexible spacecraft bus design. He spearheads business development for Iridium PRIME, focusing on customer acquisition and technology partnerships. Prior to joining commercial industry, Mr. Anhalt served in the Air Force for 28 years and graduated from its Test Pilot School. He has played key roles in a broad array of USAF research and development, test operations and program management responsibilities in both the air and space sectors. Mr. Anhalt earned a BSEE degree in electrical engineering from the US Air Force Academy. He holds an MSE in Aerospace and Mechanical Sciences from Princeton University and is an Associate Fellow in the American Institution of Aeronautics and Astronautics.

Jenny Barna, Launch Manager
Spire Global, Inc

Jenny is the Launch Manager at Spire Global, Inc., a satellite powered data company headquartered in San Francisco, California. Jenny spent about 10 years as a launch vehicle propulsion engineer at Orbital Sciences, supporting and ultimately leading the propulsion team on successful Orbital Boost Vehicle (OBV) launch campaigns out of Vandenberg. Jenny then took a role at SSL in Palo Alto, focusing not on GEO satellites, but shifting to business pursuits in emerging markets like smallsats and hosted payloads. Coming from an 'Old Space' background on a missile defense program, Jenny got her first real taste of 'NewSpace' during an SSL visit to Skybox Imaging in Mountain View and was immediately inspired to be part of it. Jenny has a degree in Aerospace Engineering from Arizona State University.

Chris Baugh, President
NSR - Northern Sky Research

Chris serves as the President and Founder of Northern Sky Research (NSR), which he created in 2000 to provide independent, actionable market research and consulting services to the satellite industry. Chris directs all NSR multi-client research reports and single-client consulting projects, and manages a global team of analysts. Before forming NSR, Mr. Baugh served as Senior Analyst for Pioneer Consulting where he covered all aspects of the satellite market. Prior to Pioneer, Mr. Baugh was an International Trade Specialist and Economist for the US Department of Commerce. While at the Department of Commerce where he had extensive legislative and analytical experience from his work for the Committee on International Relations and the Permanent Select Committee on Intelligence, both in the US House of Representatives. Mr. Baugh holds a Bachelor's Degree from Westminster College and a Master's Degree in International Affairs from The George Washington University.

Natalie Bednar, Director of Business Development
Swedish Space Corporation (SSC)

SSC is a leading company in providing ground station services to commercial and government customers worldwide. Natalie is focused on the new space community and finding solutions to support their ground system needs. Natalie has over 11 years of experience in the aerospace industry. Prior to SSC, Natalie worked at Boeing's Satellite Development Center where she was a member of the engineering, executive office, and business development teams. Natalie took on and transitioned to the role of Chief of Staff to the VP of Boeing's Commercial Satellite Systems and to the VP of Business Development for Boeing's Network and Space Systems. Natalie received her BS in mechanical engineering at Purdue University, Indianapolis, where she played division-I tennis on an athletic scholarship. She obtained her MS in mechanical engineering from the University of Wisconsin, Madison. Natalie is in her final year of the MBA program at UCLA Anderson School of Management.

Robert Bell, Executive Director
Society of Satellite Professionals International (SSPI)

Robert is responsible for the programs, finances and operations of the Society. Under his leadership, SSPI has introduced new programs focusing on advancing satellite industry workforce practices and promoting enormous contributions of satellite to the world economy, governance, human welfare, peace and security. His team has also established effective partnerships with educational institutions and associations to attract young people to careers in the first and most successful business operating in space today. A frequent speaker and writer on satellite topics, Robert has contributed content to *Satellite News*, Asia-Pacific Satellite, Satellite Executive Briefing and Telecommunications, and has appeared in segments of ABC World News and The Discovery Channel.

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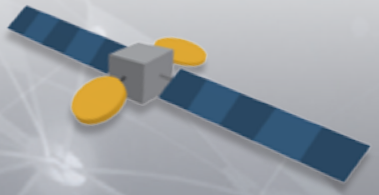

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SmallSat Symposium Speakers

Dr. Sami BenAmor, Director of Marketing
Thales Alenia Space

After Engineering studies and a PhD in Physics, Sami BenAmor held different research and teaching positions in France and the USA. He eventually left Academia and joined Thales Alenia Space (then Alcatel) more than 20 years ago. There he held various technical positions from hardware design to system engineering to program management. He transferred to marketing functions in the early 2000's. In that role, he moved to Asia during several years and became APAC VP. Upon his return to Europe, he led the advanced project teams for the system division during several years. He is presently leading the R&D and product policy activities within Thales Alenia Space.

John Booher, Partner
Hogan Lovells

John Booher is a partner in the Silicon Valley office of the international law firm Hogan Lovells. John has over 16 years' experience as an attorney representing clients on a wide range of corporate and commercial matters. John has extensive experience representing clients in several industries, including the aerospace and satellite industries. His clients include multinational corporations, private equity and venture capital firms, start-ups and emerging growth companies. John received his J.D., cum laude, from Harvard Law School in 1998 and his B.A., summa cum laude, in Economics from The College of William and Mary in 1995.

Dr. Chris Boshuizen, Entrepreneur in Residence
Data Collective VC

Data Collective VC, is a boutique investment firm specializing in hard, data-driven science and engineering companies. Chris is the co-founder of Planet Labs. As the company's CTO for five years he took the company from the drawing board to having launched more satellites into space than any other company in history. Chris was previously a Space Mission Architect at NASA Ames Research Center. While also at NASA, he established Singularity University, a school for studying the consequences of accelerating technological development. Initially fulfilling the role of Interim Director, Chris helped raise over $2.5 million to establish the university, assembling the faculty and serving as co-chair for the University's Department of Space and Sciences. Chris received his Ph.D. in Physics and BSc. with honors from the University of Sydney.

Phil Carrai, President
Kratos Technology and Training Division

Phil is responsible for all aspects of business operations, sales, mergers and acquisitions. Kratos Defense is an approximately $650 million public company focusing in Areospace and Defense products and services. He is a former Managing Director for the Morino Group and Special Advisor to General Atlantic, Inc. During that period, he served as the Executive Chairman for US mobile media leader Ztango until its sale to Widerthan.com (now part of Real Networks), and an active board member for Internosis, a commercial and federal services provider, until its sale to EMC. Phil began his career as a systems analyst/programmer for Alcoa and currently serves as a board member for Network Alliance, and is the President of the Alumni Board for Indiana University of Pennsylvania. He graduated from IUP in 1983 where he is a University Distinguished Alumni and a member of the Eberly Business Hall of Distinction, and received his MBA from Carnegie Mellon University in 1989.

Dr. Sean Casey, Managing Director
Silicon Valley Space Center

Dr. Sean Casey is Co-Founder and Managing Director of the Silicon Valley Space Center, a business accelerator for NewSpace entrepreneurs in Silicon Valley. He is a member of the Suborbital Applications Researchers Group of the Commercial Spaceflight Federation and has over two decades of experience as an airborne astronomer. Dr. Casey's work has been recognized as an example of NASA's goal for "more efficient and cost effective methodologies to instrument design and construction…". He served as a Senior Scientist with the NASA/DLR SOFIA program as management and technical lead for SOFIA's science instrument development program, lead for science instrument integration and commissioning, and science liaison for the review of system level requirements for SOFIA's final operating capability. He is an author and co-author on several dozen science publications and has a Ph.D. in Astrophysics from the University of Chicago and dual MBAs from the Berkeley Haas and Columbia Schools of Business.

Dr. Bruce Chesley, VP, Global Broadband Network & Space Systems Defense, Space and Security
Boeing

Bruce leads the design, development, deployment and operation of a satellite-based system to provide very high data rate connectivity to support a wide range of Internet and communication services. Prior to his latest position, Dr. Chesley served in several leadership roles in business development for N&SS starting in December 2013. Previously, he served as the director of Advanced Space & Intelligence Systems (S&IS), part of the Phantom Works business unit. He led a Phantom Works team that developed next-generation satellites and advanced mission capabilities for the S&IS business. Dr. Chesley joined Boeing in 2000 after serving in the US Air Force included positions at Air Force Space Command, the NRO and the Department of Astronautics at the US Air Force Academy. He earned a doctorate in aerospace engineering at the University of Colorado, Boulder. He also holds a Master of Science degree in aerospace engineering from the University of Texas at Austin and a Bachelor of Science in aerospace engineering from the University of Notre Dame. An author of more than 20 technical articles and book chapters on space systems engineering and satellite design, Chesley is a senior member of the American Institute of Aeronautics and Astronautics and a member of the American Astronautical Society.

Satish Chetty, Co-Founder and VP of Software Systems
Hera Systems

At Hera Systems, Satish is responsible for all phases of software development, including software platform architecture, technical strategies, and roadmaps. His team designs and develops flight software, mission operation software, cloud solutions and on-board & on-the-ground real-time analytics solutions. He has built extreme-environment technology solutions, including polar instrumentation and field-tested hardware that operate at very low polar temperatures. He co-authored "Preserving and Rebuilding Reflective Ice" paper, which he presented at the 2014 American Geophysical Union. He has also authored papers on several topics at the Polar Technology Conference , and contributed to "Sensor System Tests Efforts to Artificially Boost Polar Ice Formation, Albedo," which was published in *Environmental Monitor*. Satish has a Bachelor of Science in electrical and electronics engineering and a Master of Science in information systems.

Carissa Christensen, Managing Partner
The Tauri Group

Ms. Christensen is a Managing Partner of The Tauri Group, an analytic consulting firm serving science and technology clients that she cofounded in 2001. Tauri serves NASA, the FAA, Department of Defense agencies and services, the Department of Homeland Security, as well as space and defense firms. She was a partner in CenTauri Solutions, a Tauri spin-out sold to CSC in 2010. She is an active investor in technology-focused startups and advises several companies she has helped seed. She chairs the Board of QxBranch, and early stage quantum computing firm. Carissa holds a Master of Public Policy degree from Harvard University's Kennedy School of Government, where she specialized in science and technology policy. She also completed the General Course in Government at the London School of Economics, and was a Douglass Scholar at Rutgers University. She is an Associate Fellow of the American Institute of Aeronautics and Astronautics.

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SmallSat Symposium Speakers

Craig Clark, Founder
Clyde Space Ltd.

Craig has a BEng in Electrical Power Engineering from the University of Glasgow and an MSc in Satellite Engineering from the University of Surrey. Clyde Space is now one of the most successful suppliers of small satellites in the world, becoming a 'household name' in the space industry. The company continues to grow and develop cutting-edge products for the space market, in particular in the area of tiny satellites called 'CubeSats'. Presently in its 11th year of trading, Clyde Space has over 70 highly skilled, full-time staff. Clyde Space launched Scotland's first satellite in July 2014. In June 2013, Craig was awarded an MBE in the Queen's birthday Honors list for his services to Innovation and Technology.

Robert R. Cleave, Director, Vice President, Commercial Space
Lockheed Martin

Robert has experience in the entire space-related value chain, including payload engineering, satellite design and launch vehicle management, as well as financing and licensing. He currently manages Advanced Programs and Investments. His credits include winning the largest commercial satellite contract in corporate history, which also was the first ever negotiated under Shari'ah law. Previously, Mr. Cleave worked at Space Systems/Loral and Rockwell International, contributing to flight hardware in nearly every obit around Earth, including the surface of Mars. He founded two different companies, one of which became the first to commercially lease military frequencies to government agencies, along with innovative use of operationally hosted payloads (www.xtar.com). Robert is an active author and speaker, publishing more than 25 technical and business papers, and owns one patent.

Mike Collett, Founder and Managing Partner
Promus Ventures

Mike previously was Founder and Managing Partner of Masters Capital Nanotechnology Fund and also on the Technology Equity team with Masters Capital, a hedge fund. Mike was Vice President at Merrill Lynch in the M&A Group as well as an Associate in M&A Division with Duff & Phelps. Mike has invested in over 60 software/hardware startups, and is currently on the board of Spire, Layer, Kurbo Health, Gauss Surgical, Dispatch, Enview, FirstLine, and Daylight Solutions. Mike received his BS in Math and BA in English from Vanderbilt University and MBA from Washington University in St. Louis.

James Crawford, Founder and CEO
Orbital Insight

Orbital Insight is a geospatial big data company using computer vision and data science to process satellite and drone imagery at a global scale. He has two decades of experience leading innovative software projects: empowering farmers with climate data at the Climate Corporation, working to a commercial robot on the moon at Moon Express, making the world's books searchable at Google, and managing autonomy and robotics at NASA Ames Research Center. At Orbital Insight, he's using software expertise to create a new level of understanding of socio-economic trends and objective insights for multiple industries.

Kara Cunzeman, Strategic and Global Awareness Directorate
The Aerospace Corporation

Aerospace prides itself on solving the "hard problems" and brings innovative solutions to problems of national significance. Over the past 55 years, Aerospace has developed unique laboratory capabilities and analytical tools that provide its customers with world-class problem-solving expertise and services. Aerospace is now engaging commercial space companies and offering core services across the entire systems development and operations lifecycle. Ms. Cunzeman received her B.S. in Multidisciplinary Engineering and M.S. in Aeronautics and Astronautics Engineering from Purdue University in West Lafayette, Indiana. In her current role at Aerospace, Ms. Cunzeman provides thought-leadership and strategic insight into global space advancements, technology development, and space futures to a variety of customers within national security and civil space.

Stuart Daughtridge, Vice President of Advance Technology
Kratos Technology and Training Solutions

Mr. Daughtridge has been with Kratos-Integral Systems since 1999, and in the satellite and aerospace industry since 1986. Prior to his current role, he held several senior management positions, including SVP and GM of the Integral Systems Products Group, SVP and GM of the Integral Systems Commercial Group, as well as Program Manager of several major commercial programs. Before joining the Company, Mr. Daughtridge held various management and engineering positions with Orion Satellite Corporation, Intelsat, and Spacecom. Mr. Daughtridge holds a Bachelor of Science from Lafayette College.

Tahara Dawkins, Director, Commercial Remote Sensing Regulatory Affairs Office
NOAA - National Oceanic and Atmospheric Administration

Tahara Dawkins is the Director of NOAA's Commercial Remote Sensing Regulatory Affairs Office and has been in her current role since 2011. For over 10 years, Tahara has been intimately involved in space policy and the policy, security, and market issues related to commercial remote sensing. Ms. Dawkins first joined NOAA in 2001 where she was a Senior Licensing Officer in the Commercial Remote Sensing Licensing Regulatory Affairs Office. From 2008-2011, Tahara worked for NGA where she focused on the security and counterintelligence implications of the Government's use of commercial satellite imagery.

Chris DeMay, Founder and COO
HawkEye 360

Mr. Chris DeMay spent 14 years at the National Security Agency with his last five years detailed to the National Reconnaissance Office (NRO). His final tour at NRO was as Director of the Non-Traditional SIGINT Program Office (NSPO), where he was responsible for the execution of an appropriated portfolio of over 25 space-based intelligence technology development projects and programs totaling more than $500M. Mr. DeMay is a recipient of the NRO Gold Medal of Distinguished Performance and the Frank Beamer Award for Exceptional Service. Mr. DeMay holds an MS in Systems Engineering and a BS in Business Information Technology, both from Virginia Tech.

Dr. Lars Dyrud, CEO
OmniEarth

Dr. Dyrud received a BA in Physics from Augsburg College conducting research on ultra-low frequency geomagnetic pulsations. He was a Fulbright Scholar in space and plasma physics at the University of Oslo and received a Ph.D. from Boston University conducting doctoral research on plasma turbulence using theory and super-computer simulations and observations. He was also a Senior Scientist, Johns Hopkins University Applied Physics Laboratory. As a professional, Dr. Dyrud has served as PI on R&D grants and contracts from NSF, DOE, NASA, AFOSR, Air Force SMC and Industry and is involved in basic and applied research in plasma physics, applications and techniques of tomography, software radio, GPS, inertial navigation and radar. He was previously senior scientist and section lead at the Johns Hopkins University Applied Physics Laboratory in the areas of space physics, GPS tomography, Novel Earth observation missions, and mobile applications.

Jaime Estela, CEO
Spectrum Aerospace Research Corporation

Mr. Jaime Estela born in Lima-Peru he worked at the German Space Operations Center of DLR in Oberpfaffenhofen for 11 years. In this period he gathered experience in satellite operations and systems engineering and supported several LEO orbit satellite missions like Terrasar-X, Tandem-X, Prisma A & B, Grace 1 & 2, CHAMP, BIRD, TET and was also involved, as Ground Segment Engineer, in the ESA project Columbus, space laboratory onboard the ISS,. In 2010 he founded Spectrum ARC GmbH and served as CEO/CTO. He is currently managing the company Spectrum Aerospace Technologies UG (Munich-Germany) and Spectrum Aerospace Research Corporation S.A.C. (Lima-Peru). Both companies belong to the Spectrum Aerospace Group.


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SmallSat Symposium Speakers

Liz Evans, Partner
Dentons US LLP

Liz Evans concentrates her practice in aviation, project and satellite finance, as well as in equipment leasing and related transactional work, including private placements of debt and equity, structured finance arrangements, asset-based financing and leveraged leasing. She has represented a variety of domestic and foreign passenger and cargo airlines in a wide range of areas, including aircraft sales and leasing matters, Federal Aviation Administration (FAA) and Department of Transportation (DOT) compliance, equipment financings, bankruptcy matters and privatizations. Liz has represented Fortune 500 corporations in the purchase of business aircraft for their fleets and in their participation in fractional interest aircraft ownership programs.

Debra Facktor Lepore, VP and GM of Strategic Operations
Ball Aerospace & Technologies Corp

Prior to joining Ball in 2013, Debra served as the president of DFL Space LLC. As an industry professor at Stevens Institute of Technology, she led its Master's of Engineering in Technical Leadership program and served as Director of Strategic Programs. Lepore was also President and an owner of AirLaunch LLC, a small business which won funding from the Defense Advanced Research Projects Agency (DARPA) and the US Air Force to develop an operationally responsive small launch vehicle. She previously served as VP of Business Development and Strategic Planning for Kistler Aerospace Corp. Earlier in her career, she was Chief of Moscow Operations for ANSER's Center for International Aerospace Cooperation. Among other distinctions, Lepore was honored with the University of Michigan 2014 Alumni Merit Award for Aerospace Engineering and as the Women in Aerospace (WIA) "Most Outstanding Member" for 2012. She is also an appointed member of the FAA's Commercial Space Transportation Advisory Committee (COMSTAC). Lepore is a fellow of the American Institute of Aeronautics and Astronautics (AIAA) and an Academician of the International Academy of Astronautics (IAA). She holds a B.S.E. (magna cum laude) and M.S.E. in aerospace engineering, both from the University of Michigan.

Dr. Shahin Farshchi, Partner
Lux Capital

Shahin is a Partner at Lux Capital. He has a passion for cars, aircraft, space, robots, and computers. He started his career as a C and ColdFusion developer for a number of startups in Silicon Valley before heading to Detroit to design hybrids at General Motors. He started a company doing wireless health monitoring based on his research on brain-computer interfaces before joining Lux in 2007. He sourced Lux's investments in Silicon Clocks (NASDAQ:SLAB), SiBeam (NASDAQ:SIMG), Planet Labs, Plethora, Scaled Interface, and works closely with Nervana. Shahin completed his undergraduate degree in Electrical Engineering Computer Science at UC Berkeley with Honors, and his Master's and Ph.D. at UCLA. He is based in Palo Alto, California.

Allen Griser, Business Manager
General Dynamics Mission Systems
SATCOM Technologies

As Business Manager for the SATCOM-on-the-Move product line for General Dynamics Mission Systems SATCOM Technologies business, Mr Griser provides the strategic leadership and overall management of business operations. Prior to his current position, he was the Sr. Operations Manager of Integration and Production for General Dynamics Mission Systems' SATCOM Technologies business. Mr. Griser joined General Dynamics Mission Systems after 20 years in the telecommunications industry where he held multiple leadership positions leading the sales and marketing teams for Megladon Manufacturing, Draka Comteq Americas Inc, and Alcatel telecommunications Cable Inc. Mr. Griser received his Bachelor of Science in engineering technology from the University of North Carolina in Charlotte, North Carolina and an Associate of Applied Science in electrical engineering from Catawba Valley Technical College in Hickory, North Carolina. He currently holds two US patents.

Dr. Shay Har-Noy, VP and General Manager
DigitalGlobe

Shay serves as VP and General Manager of the company's Platform business—the fast pace, high growth effort to get DigitalGlobe's 15 year digital library in the cloud and available for processing. Before joining DigitalGlobe, Shay (Shy) was founder and CEO of Tomnod, an innovative company combining crowdsourcing and machine learning to create new applications for satellite imagery. Tomnod was acquired by DigitalGlobe in early 2013 and is now a critical component of their Platform initiative. Shay was previously at ViaSat where he worked on the deployment and market positioning of satellite communication systems around the globe. Dr. Har-Noy graduated summa cum laude from Rice University with degrees in Economics and Electrical Engineering and received a Ph.D in Electrical Engineering with research in image processing from UC-San Diego, California.

David Hartshorn, Secretary General
GVF - Global VSAT Forum

David Hartshorn is Secretary General of the GVF, the London-based non-profit international association of the satellite industry. Mr. Hartshorn leads the Forum's global efforts to facilitate the provision of satellite-based communications solutions throughout all nations of the world. Mr. Hartshorn works closely to support national, regional and global-level policy makers as they formulate state-of-the-art satellite regulatory, policy and spectrum-management frameworks. He is also responsible for creating greater awareness of the commercial, economic, political and technological advantages that satellite-based communications provide. GVF's training, product quality assurance, network validation, and other programs are an important means by which these aims are achieved.

Jonathan Hofeller, Vice President of Commercial Sales
SpaceX

Mr. Hofeller's primary responsibility is for commercial business development efforts across the globe. He is also responsible for developing SpaceX's approach to meet the growing demand of the secondary and small payload market. Mr. Hofeller joined SpaceX in 2007 and previously headed the company's business development efforts in North America, Middle East and Asia. Mr. Hofeller received his Bachelor of Science in Mechanical Engineering from the Johns Hopkins University, a Master's of Science in Mechanical Engineering from the University of Southern California, and a degree in Technology Commercialization from USC's Marshall School of Business. He is also a graduate of the International Space University's Space Studies Program. Prior to joining SpaceX, Mr. Hofeller worked at The Raytheon Company as a Senior Mechanical Engineer and designer on several optical satellite programs.

Susan J. Irwin, President
Irwin Communications, Inc.

Irwin Communcations has provided strategic consulting services to hundreds of major corporations worldwide, including satellite operators, manufacturers, broadcasters, government agencies and telecommunications companies. Ms. Irwin also heads the US Office of Euroconsult. She was a telecommunications policy analyst for the National Telecommunications and Information Administration of the U.S. Department of Commerce, where she managed the Satellite Applications Program. Ms. Irwin then joined the start-up team of Private Satellite Network, a company that pioneered the use of satellites for training and corporate communications. Ms. Irwin is on the Advisory Board of Kymeta Corporation, co-founder and Director Emeritus of the Society of Satellite Professionals International, a Director Emeritus of the Arthur C. Clarke Foundation and Vice President and a Director of the American Astronautical Society. In 2013, Ms. Irwin was inducted into the Society of Satellite Professionals International (SSPI) Satellite Hall of Fame for her outstanding achievements in the industry. She holds a Masters of Arts degree from San Francisco State University.

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SmallSat Symposium Speakers

Talbot Jaeger, Founder & Chief Technologist
NovaWurks™

Jaeger leads the NovaWurks team and is responsible for business development and all projects at the company. With more than 30 years of experience in the aerospace industry, Jaeger has managed and directed project concepts, systems engineering, ground and 10 spaceflight operations. In addition, he led the development of the Mayflower CubeSat, a highly-integrated building block, delivering product from initial design to the launch integrator in just six months. Jaeger began his career at TRW as an electrical engineer. TRW then became Northrop Grumman where he held increasingly complex positions within the company, including Director of Novaworks, a sub-division of Northrop Grumman. Jaeger has bachelor degrees in biochemistry and information computer science from the University of California, Irvine. He also holds a professional graduate certificate in optical sciences from the University of Arizona.

John P. Janka, Partner
Latham & Watkins LLP

John's clients include investors, banks and companies from start-up entities to global leaders. He has negotiated a wide variety of business transactions, including buying, selling and financing satellite companies, procuring satellite networks, and leasing and selling satellite capacity. Mr. Janka has been consistently recognized as a leading communications lawyer in publications such as *The Legal 500 US*, *Euromoney's Expert Guides to the World's Leading TMT Lawyers, Euromoney's The Best of The Best USA-Telecoms, The International Who's Who of Telecoms & Media Lawyers and Super Lawyers*. Mr. Janka has served as a US delegate to an ITU World Radiocommunication Conference in Geneva. Mr. Janka holds a JD degree from the UCLA School of Law, where he graduated Order of the Coif, and an AB degree from Duke University, where he graduated magna cum laude. His book, *The Technology, Media and Telecommunications Review*, is in its sixth edition.

Dr. Andrew E. Kalman, is Founder, President and Chief Technologist
Pumpkin

Pumpkin is the parent of Pumpkin Space Systems, which designs and builds turn-key spacecraft buses for the most sophisticated NanoSat missions. Pumpkin is also the owner of CubeSat Kit ™ the internationally adopted family of COTS components for orbit. Pumpkin was founded in 1995 and has flight heritage on countless missions. Dr. Kalman is Director of Stanford's Space and Systems Development Laboratory (SSDL), which created the CubeSat standard and is a Consulting Professor in the Aero/Astro Department at Stanford University. He earned his doctorate in Electrical Engineering at The University of Florida and BS at Stanford.

Dr. Gareth Keane, Senior Investment Manager
Qualcomm Ventures

Gareth helped define the Qualcomm Ventures investment thesis around UAVs and robotics, and led the Qualcomm Ventures investments in companies like 3-D Robotics and Spire. He started his professional career as an engineer, and spent many years in engineering roles. He graduated from the National University of Ireland with a Bachelor's degree in Electronic Engineering in 1994, and followed this up with a Ph.D. in Electronic Engineering from The Queen's University of Belfast in 1999. His first job was for Cadence, and he continued working on methodologies and design flows as an engineer and manager at PMC-Sierra. After eight years of solving technology challenges in successively smaller silicon geometries he decided it was time for Business School and spent two years in the MBA program at UPenn/Wharton in Philadelphia, graduating in 2010.

Adam Keith, Managing Director
Euroconsult Canada

Adam has advised a wide range of clients including space agencies, government organizations and commercial actors along the value chain. Leading to 2015 he was the Director of Euroconsult's Space and Earth observation practice. When joining the firm in 2006, Adam initiated Euroconsult's research and consulting activity in the EO sector. Adam leads the firm's EO research reports, including the flagship *Earth Observation: Market Prospects*, now in its 7th edition (2014). Starting in Euroconsult's Paris office, he helped establish the firm's North American offices in 2008. His previous experience includes working for the European Space Agency (ESA-ESRIN). The early part of his career was spent working for the UK National Remote Sensing Center (now Airbus Defence & Space). Adam holds a Masters in GIS and Remote Sensing from Cambridge University and a B.Sc. in Geology from the University of London.

Karl A. Kensinger, Deputy Chief, Satellite Division
FCC International Bureau

Karl began his career at the FCC in 1987 in the FCC's Mass Media Bureau, regulating radio and television. In 1994, he joined the FCC's, then newly formed, International Bureau where he served as an attorney, as the Chief of the Satellite Division's Satellite Engineering Branch, and as a Special Advisor and then Associate Chief of the Satellite Division, before assuming his current position. He has been the primary FCC point of contact on orbital debris matters since 1995, and was instrumental in the FCC's adoption of orbital debris mitigation rules in 2004. Mr. Kensinger is an attorney by training. He is a 1985 graduate of the University of Michigan Law School and a 1982 graduate of the University of Chicago.

Dr. Josef Koller, Senior Advisor
Office of the Secretary of Defense for Space Policy

Josef is a senior staff analyst responsible for providing technical advice and analyzing space-related United States Government and DoD policy matters. He directly supports key international strategy efforts to implement the President's National Space Policy and the Secretary's National Security Space. His portfolio includes space traffic management, space situational awareness, Congressional engagements, and public affairs related issues. Prior to this assignment, Dr. Koller was co-leading the Space Science and Applications Development Group at Los Alamos National Laboratory, founder of the Los Alamos Space Weather Summer School, and project lead for a number of satellite conjunction analysis and space weather projects. Dr. Koller is an author and co-author of over 40 referenced publications with 500 citations. He is a topical editor for the *Journal of Geoscientific Model Development* and received his Ph.D. in Astrophysics from Rice University in 2004.

Andrew M. Kwas, Engineering and Technology Strategist
Northrop Grumman Corp.

Andrew graduated from the University of Michigan in 1980 with a Masters degree in Aerospace Engineering. He has 37 years with TRW/NGC working in advanced space projects, specializing in satellite development, astrophysics projects and missile systems. In Mr. Kwas' role as a manager in Engineering and Technology, he supports NASA, AFRL, NRO, DARPA, SMDC, ORSO and the Navy on space related programs. Mr. Kwas is on the Technical Advisory Board for Cornell, University of Michigan, Georgia Tech and University of New Mexico. Mr. Kwas is considered one of the prominent small satellite experts in the country and has produced numerous papers on advanced satellite technology, in-space manufacturing using advanced additive manufacturing techniques, and miniaturization of components. He was appointed as a Research Professor at the University of New Mexico in satellite research.

Wade Larson, President and Chief Executive Officer
UrtheCast

Mr. Larson has over 20 years of space sector experience with the Canadian Space Agency, MacDonald, Dettwiler and Associates (MDA), and most recently as President and COO of UrtheCast. He also has extensive experience in space-related strategy formulation, business development, government relations, corporate development, and operations. UrtheCast is an international technology company that serves the rapidly evolving geospatial and geoanalytics markets with a wide range of information-rich products and services.

Wallis Laughrey, Vice President, Space Systems
Raytheon

As a member of the SAS leadership team Wallis oversees all Space Systems programs, developing the organization's vision, strategy and plans. He also has direct responsibility for the precision clock and high energy laser campaigns and programs. Before joining Space Systems, Laughrey was SAS VP and deputy in Advanced Concepts and Technology. Laughrey came to Raytheon from Northrop Grumman Aerospace Systems where he was director of Strike Systems Advanced Development. Prior to Northrop, Laughrey was with Raytheon SAS as program manager for a family of products employed on the E2D Advanced Hawkeye aircraft. After graduating from the United States Air Force Academy, Laughrey served in a number of different roles and organizations within Air Force Space Command and Air Force Materiel Command. Laughrey holds a bachelor's degree from the Air Force Academy, a master's degree in public administration from the University of Colorado and a master's degree in product development engineering from USC. He has also earned a certificate in advanced project management from Stanford University. Laughrey holds memberships in the Air Force Association, American Institute of Aeronautics and Astronautics, and National Defense Industrial Association professional organizations.


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SmallSat Symposium Speakers

Johanne Lecomte, Vice-President
Thales Alenia Space

Johanne is responsible for increasing business in North America in all five space segments, Telecom, Observation, Exploration, Earth Sciences and Navigation. She has more than 25 years of experience in the telecommunication and satellite industry. She was VP of Sales and Marketing in North America for almost a decade at EADS Astrium (now Airbus Defense and Space) and VP Sales, Marketing and Communications at International Launch Services (ILS). She also occupied various leadership positions at Telesat, Amos by Spacecom, Dynegy, Teleglobe International and Bell Canada. Johanne holds a BSEE, from Ecole Polytechnique and an MBA/MSEE, from Sherbrooke University in Canada. She is fluent in English, French and Spanish.

Chris Lewicki , President and CEO
Planetary Resources, Inc.

Mr. Lewicki has been intimately involved with the lifecycle of NASA's Mars Exploration Rovers and the Phoenix Mars Lander. Lewicki performed system engineering development and participated in assembly, test and launch operations for both Mars missions. He was Flight Director for the rovers Spirit and Opportunity, and the Surface Mission Manager for Phoenix. The recipient of two NASA Exceptional Achievement Medals, Lewicki has an asteroid named in his honor: 13609 Lewicki. Chris holds bachelor's and master's degrees in Aerospace Engineering from the University of Arizona. At Planetary Resources, Mr. Lewicki is responsible for the strategic development of the company's mission and vision, engagement with customers and the scientific community, and serves as technical compass, and leads day to day operations.

Daniel Lim, President & CEO
Xtenti, LLC

Xtenti is a new solutions provider that brings disruptive enablers for the space industry and creates tangible solution sets that intersect the space industry with other non-space industries. Daniel has over fifteen years of experience in systems engineering and design on major Government and commercial programs, including mission integration for numerous Government space missions. Mr. Lim received a MS in Mechanical Engineering from Georgia Tech and a BS in Mechanical Engineering from the University of Illinois at Urbana/Champaign. He also has served on Active Duty service in the Air Force in flight test, launch vehicle systems, and mission integration, and continues to serve as a Reservist for the Air Force.

Dr. Tony Lin, Counsel, Washington, DC
Hogan Lovells

Tony has extensive experience in international satellite and communications regulatory matters and advises clients on such matters before international organizations and federal and state agencies, including the International Telecommunication Union (ITU), the Federal Communications Commission (FCC), the National Oceanic and Atmospheric Administration (NOAA), and state public utility commissions. His satellite transactional experience includes negotiating and drafting orbital use agreements (with both foreign administrations and satellite operators), frequency coordination agreements, non-disclosure agreements, satellite transfer of control and assignment agreements, satellite manufacturing agreements, and other commercial satellite arrangements. Prior to joining Hogan Lovells, Tony concentrated on communications law matters. Tony also holds a Ph.D. in economics, and prior to entering the practice of law, he taught economics at Southern Illinois University.

Christopher Loghry, Business Development Manager
Moog

Christopher is currently focused on supporting Moog's Orbital Maneuvering Vehicle (OMV) program aimed at low-cost space access for a wide variety of customers. He joined Moog in 2012 as part of the AMPAC In-Space Propulsion (ISP) acquisition. He currently works the Space Access and Integrated Systems business unit in a business development role in addition to a supporting engineering role for propulsion, launch vehicle, and spacecraft missions. Prior to joining Moog, he worked for Lockheed Martin for seven years performing spacecraft propulsion system integration and test (I&T) operations including launch site propellant loading. This included many unique, or first of their kind, programs like AEHF, SBIRS, MUOS, JUNO, GRAIL, and several other commerical and military spaceraft. He received his Bachelor's of Science in Engineering (BsE) from Purdue University with a major focus in Aerospace Propulsion and a minor in Nuclear Engineering.

Adam Maher, Founder and President
Ursa Space Systems Inc.

Adam has 10 years of experience in the satellite industry. Prior to founding Ursa, he worked at Space Systems Loral, serving in technical and business roles. He was lead systems engineer for two complete satellite builds and satellite lead for four successful commercial satellite proposals. Mr. Maher managed three major IR&D efforts, each resulting in multiple satellite awards, and was program manager and capture lead for five US government programs. He helped establish a new subsidiary of the parent company and as new business lead, worked closely with three venture capital backed start-ups and was the primary contact for a major Silicon Valley company. Mr. Maher holds a Bachelor of Mechanical Engineering and Master of Engineering, Mechanical Engineering, from Cornell University.

Dr. Clare Martin, Vice President of Programs
Surrey Satellite Technology US

Clare leads the Surrey project management and engineering teams to ensure that Surrey's low-cost methods, and the benefits they bring, are applied to the execution of programs. Clare joined the Surrey US team after serving more than seven years with Surrey Satellite Technology Ltd. in the United Kingdom. She brings a thorough knowledge of all Surrey spacecraft and systems and ethos and culture to the US team. She held several positions there including head of telecommunications and navigation and senior project manager. Prior to Surrey, Clare worked at QinetiQ, formerly the Defense Evaluation & Research Agency (DERA), as a project manager and scientist. She earned an M.Sci. in astrophysics and Ph.D. in mathematics and computational sciences, both from the University of St. Andrews, Scotland.

Attila Matas, Head of the Space Publications and Registration Division
International Telecommunication Union (ITU)

Mr. Matas is responsible for the processing and publication of GSO and non-GSO space systems and Earth stations submitted by administrations for inclusion in the formal coordination procedures or recording in the Space Master International Frequency Register (SMIFR). Mr. Matas has been deeply involved in the ITU since 1993 in the development and efforts to treat the space notices using computer tools for data capture, validation and publishing, resulting in the adoption of electronic International Frequency Information Circular. Mr. Matas representing the ITU at the UN COPUOS and ICG and he is active participant on all World Radiocommunication Conferences (WRC) since 1992. Mr. Matas holds Radio Engineering degree from the Czech Technical University of Prague.

Barry A. Matsumori, Senior Vice President – Business Development & Advanced Concepts
Virgin Galactic

Barry brings over 25 years of experience in technology and business. He is responsible for the development of next generation products as well as long-term product roadmap. Prior to Virgin Galactic, Barry was senior vice president at SpaceX, responsible for all sales and business development. During his tenure, he oversaw the significant expansion of SpaceX's launch service business base. Prior to SpaceX, Matsumori worked for several telecom companies, primarily at Qualcomm, in developing mobile communications technologies and products lines. Matsumori holds a BS in business from Arizona State University and an MS in electrical engineering from the University of Arizona.

Paul Murray, Director, Reconfigurable Processing Programs
SEAKR

Mr. Murray has been instrumental in SEAKR's expansion and evolution into the processing system business area and continues planning the future generation of space processing technology at SEAKR. He is currently spearheading the development and production of the On-Board Processor for the Iridium NEXT constellation of satellites; SEAKR's largest contract to date. In his portfolio are several other processing system applications ranging from experimental payloads such as AFRL's TacSat-3 Hyper-Spectral Image Processor to large GEOSATCOM communication processors.

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SmallSat Symposium Speakers

Sunil Nagaraj, Vice President,
Bessemer Venture Partners

Sunil serves as a Board Director for Auth0, Nitrous.IO and Zoosk. He is a board observer at GetInsured, Rocket Lab, Spire and Virtru. Sunil is also closely involved with Bessemer's investments in Box, DocuSign, Simply Measured, Tile and Zapier. His past investments include Twitch (acquired by Amazon), Defense.net (acquired by F5 Networks) and Grow Mobile (acquired by Perion). Prior to joining Bessemer, Sunil was the founder and CEO of Triangulate, a venture-backed online dating startup. Previously, Sunil worked in consulting at Bain & Company, in Cisco's Corporate Development group, and in product management at Microsoft. He has also worked at several early-stage startups (Sendio, ZeeWise, Celito) as a software engineer and in business development. Sunil holds an MBA from Harvard Business School and a BS in Computer Science from the University of North Carolina at Chapel Hill, where he graduated with honors. Sunil is Co-Founder/Co-Chair of the NextGen Board of the Computer History Museum and is Co-Chair of NextGen Partners, the largest pre-partner VC networking group in the Bay Area. He also serves on the board of the San Francisco Amateur Astronomers.

Ryo Nakamura, Director,
Business Development Department
Mitsubishi Heavy Industries

Ryo Nakamura is Director, Deputy General Manager, Business Development Department, Space Systems Division, Mitsubishi Heavy Industries. He is fully responsible for sales and marketing of the current H-IIA Launch Services, including next generation Launch vehicles. He also engaged in H-IIA and H-IIB development projects in Japan mainly as a rocket propulsion system engineer. Mr. Nakamura holds an honorary Master Degree in Aeronautics and Astronautics from Tokyo University

Carlos Niederstrasser, Business Development and Special Initiatives
Orbital ATK

Some of the programs Carlos has supported at Orbital ATK include the Dawn interplanetary spacecraft, the OrbView remote sensing system, and the Cygnus CRS resupply mission. He leads a number of cross-group activities and outreach efforts. Carlos conceived and leads the Orbital Academy—a series of professional development courses taught by and for Orbital ATK employees. He is responsible for Orbital ATK's Warp 10 program, an innovation incubator established for the development of new employee-driven ideas. Prior to joining Orbital ATK, Carlos served as program manager for Stanford's student, built, and managed satellite—OPAL. OPAL's primary mission demonstrated the feasibility of launching multiple picosatellites from a mothership satellite, and served as the direct predecessor to the CubeSat standard. Carlos earned a BSE in Mechanical and Aerospace Engineering from Princeton University, an MS in Aeronautics and Astronautics from Stanford University, and an EAA from Stanford University where he was a National Science Foundation Fellow. He is also a graduate of the International Space University.

Steve Oldham, Vice President,
Strategic Business Development
Space Systems Loral (SSL)

Mr. Oldham leads the business development team, with a focus on small satellites, US government work, and New Space ventures. He played a critical role in establishing SSL's partnership with Google's Terra Bella, formerly Skybox Imaging, and has also driven the company's activity in complex technology demonstrations and LEO satellite programs. Mr. Oldham has been with SSL's parent company MDA for over 20 years, holding a variety of positions in systems engineering, program management, and business development. He was appointed VP and General Manager for Satellite Missions and Robotics in 2007 before moving to focus on mergers and acquisitions in 2011, and he was part of the MDA team that worked on the purchase of SSL in 2012. Mr. Oldham's responsibilities have included major Earth observation programs such as RADARSAT-2, RADARSAT Constellation Mission, and RapidEye. He has also overseen flagship programs such as the Canadarms on the Space Shuttle and the International Space Station. Mr. Oldham holds a bachelor of science degree in mathematics and computer science from the University of Birmingham in England.

Dara A. Panahy, Partner
Milbank, Tweed, Hadley & McCloy

Dara has been a partner since 2007 and joined Milbank in 1999. His practice focuses on representing clients involved in the aerospace and communications industries. His experience includes representing satellite operators, aerospace manufacturers, launch services providers, communications companies, banks, private equity firms and hedge funds in numerous financings involving public offerings, high yield debt, investment grade bonds, project and vendor financings, mergers and acquisitions, financial restructuring and reorganizations and in negotiating project contracts. His recent representations include numerous commercial satellite and launch services procurements for clients in North America, Europe, the Middle East and Asia. He has been recognized as a leading lawyer in Telecom, Broadcast and Satellite Financing in Chambers USA and The Legal 500. Mr. Panahy speaks fluent Spanish and Farsi.

Andrew Petro, Program Executive for Solar Electric Propulsion and Small Spacecraft Technology
NASA

Before coming to NASA Headquarters Andrew worked at the Johnson Space Center in Space Shuttle mission operations and then in Engineering on human space vehicles, orbital debris control, advanced space propulsion, lunar transportation, lunar bases, and Mars exploration. He worked with Russian engineers to adapt the Soyuz spacecraft for use with the International Space Station. As a project manager in the NASA Advanced Space Propulsion Laboratory, he led superconducting magnet and cryocooler technology projects and other efforts supporting demonstration of a plasma rocket engine. While at the Johnson Space Center he also served as Deputy Manager of the In-Situ Resource Utilization Program and as Launch Vehicle Integration Manger for the Mission Operations Directorate.

Bruce Pittman, Chief System Engineer
NASA Ames Research Center

Mr. Pittman supports the Emerging Space Office at NASA Headquarters on programs ranging from orbital applications of the International Space Station and other orbiting commercial facilities; low cost, reliable access to space, reusable space infrastructure as well as cis-lunar commercialization. He has been involved in high technology project management and system engineering in a variety of industries for over 30 years. Mr. Pittman has also been a founder and member of the startup team in a number of early growth companies including SpaceHab, Kistler Aerospace, New Focus, Product Factory, Prometheus II Ltd. and Industrial Sound and Motion. Mr. Pittman has a BS in Mechanical/Aerospace Engineering from U. C. Davis and a MS in Engineering Management from Santa Clara University. Mr. Pittman is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and is the chairman of the AIAA Commercial Space Group.

Chris Quilty, President
Quilty Analytics LLC

Quilty Analytics is an independent research and consulting firm that provides strategy, competitive benchmarking, financial analysis, and investment diligence on all aspects of the Satellite and Space industry. Prior to establishing Quilty Analytics in 2016, Chris served as a sell side research analyst with Raymond James for 20 years, publishing hundreds of company-specific, macro, sector, and thematic research reports on the industrial, defense, space, wireless, and communications industries. Chris is widely-acknowledged as the leading Wall Street analyst on the Satellite & Space sector, and has participated in 30 capital markets transactions over the past five years valued at over $2.5 billion. Chris received a BS degree in Systems Engineering from the United States Naval Academy in 1989 and an MBA from the University of Chicago in 1994.

Christopher Richins, Cofounder & CEO
RBC Signals

RBC Signals, a provider of global satellite communication "infrastructure as a service." Richins began his career as an RF Communications Engineer at Boeing Sea Launch, where he supported multiple launch campaigns from the shipbased equatorial launch site. After business school, he completed an internship with SpaceX before joining Bain & Company as a management consultant. Post Bain, Richins held management roles at Arkyd Astronautics (Planetary Resources), Space Angels Network, Expedia, and Applause. Richins earned an MBA from the Darden Graduate School of Business at the University of Virginia as a Jefferson Fellow, a master's degree in Astronautics from the USC, and a bachelor's degree in Electrical Engineering from Brigham Young University.

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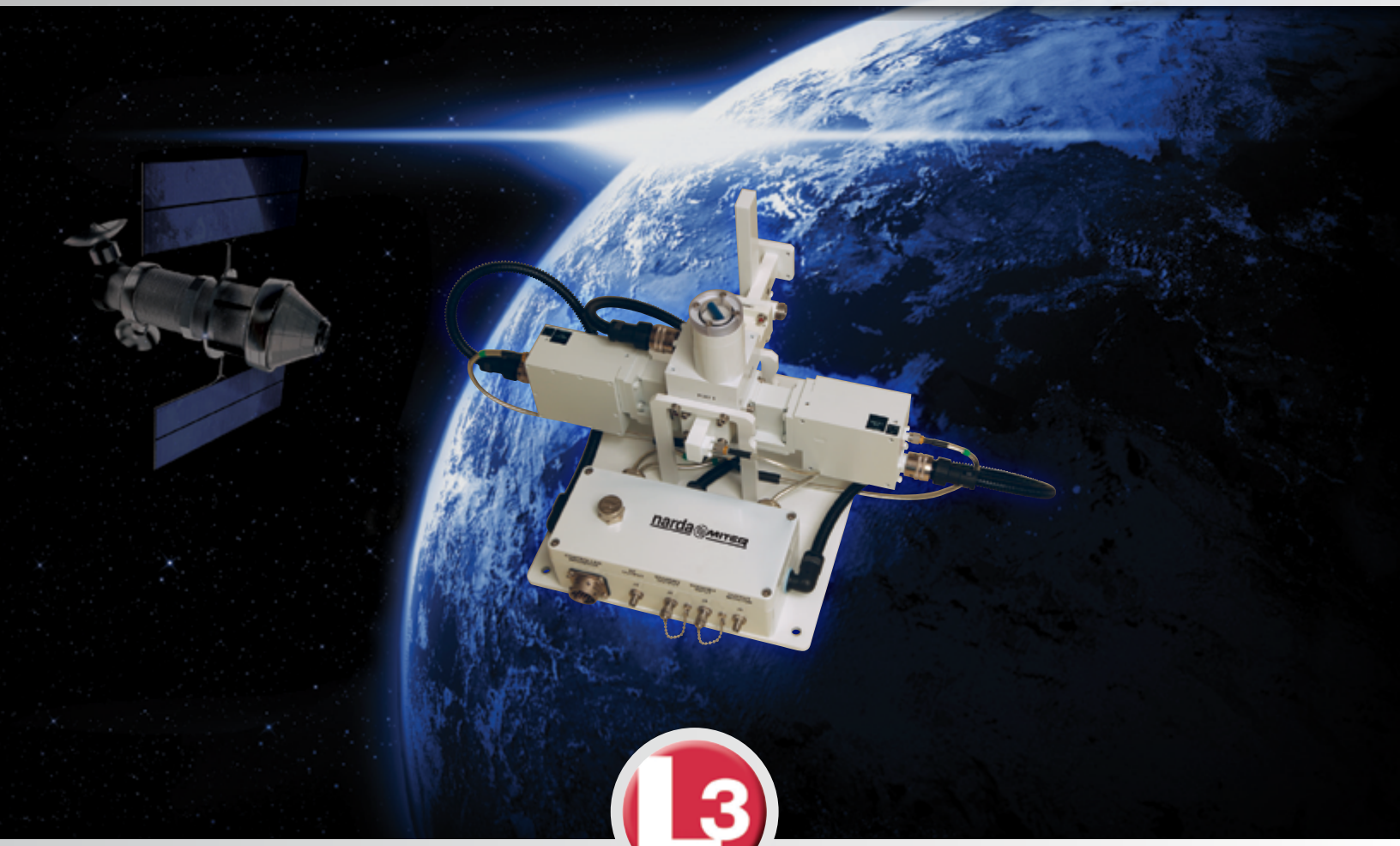

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George Romaniuk, Product Line Manager, Space Sector
Aitech Defense Systems, Inc.

During the last three years Mr. Romaniuk was involved mainly in the following programs: Orbcomm Og2, CTS-100 CIS, Orion (two subsystems) working on architecture, parts selection and radiation testing. Previously Mr. Romaniuk was the Director of Research and Development for Music Telecom. In 2006 Mr. Romaniuk joined a start-up Advanced Platform Design. Mr. Romaniuk also worked for Polish Academy of Sciences. In 1993 Mr. Romaniuk started his company Digisys, Inc. and developed a line of UHF and MMDS TV transmitters. Later he joined startup Subspace Communications Inc. as a President and was involved in speech compression using DSP for Voice over Packet applications.

Martin Canales Romero
Consultant

Mr. Martin Canales served as Operations Coordinator of the ESA ISS Columbus Project at the German Space Operation Center (DLR). He has held management positions at start-ups Spectrum SAC and Spectrum ARC GmbH, and has a master degree in aeronautical engineering (former USSR) and postgraduate studies in space engineering (Germany). In 2010 he co-founded "Spectrum ARC GmbH", a start up and small size company, spin-off of the German Aerospace Center and the ESA Business Incubator Center in South Germany. He acts as CEO supporting in project management and being responsible for project acquisition, procurement planning and technical coordination and implementation. Between 2010 and 2013 he worked as project manager for the Peruvian University Consortium on the design and development of a CubeSat as contribution to the QB50 program.

Dr. Alex Saltman, Chief Operating Officer
GeoOptics

Alex oversees operations, business development, marketing and public affairs. Before joining GeoOptics, Alex was the Executive Director of the Commercial Spaceflight Federation, a trade association that represents the dozens of companies that are reinventing the space industry. At CSF he led policy development, lobbying and business operations and spoke to many audiences about the benefits of commercial space. Prior to joining CSF, he was Legislative Director to Congressman Adam Schiff, where he advised on a wide variety of issues, taking a leading role in advancing a NASA Authorization bill as well measures on energy research and development, space exploration funding and nuclear forensics. Alex has a BA from Harvard and a Ph.D. from Stanford, both in Physics.

Emmanuel Sauzay, Director, Commercial Space
Airbus Defense and Space, Inc

Emmanuel graduated as an Aerospace Engineer from the Ecole Nationale Superieure de l'Aeronautique et de l'Espace (Toulouse, France) and also holds a master's degree in business administration from Toulouse University. Emmanuel spent most of his career in the Space Systems division of Airbus (formerly Astrium), occupying various positions in spacecraft design and engineering, spacecraft flight operations, program management, business development and sales. Emmanuel is now in charge of commercial space activities for Airbus Defense and Space Inc, the US affiliate of Airbus Defence and Space. He is based in the San Francisco Bay area since August 2015.

Randy S. Segal, Partner, Co-Lead Satellite Practice
Hogan Lovells

Randy Segal is a global satellite and "frontier technology" transactional lawyer, representing clients in space, UAS (drone), wireless and other disruptive technologies. The scope of representation includes financing, joint ventures, system procurement, technology development, mergers and acquisitions, and international cross-border transactions. Prior to joining the firm, Randy served as general counsel and/or a member of the Board of Directors of a variety of telecommunications and media companies. Randy is a frequent speaker and has written widely on the practical logistics of doing transactions, including a "How To" Guide with respect to Satellite and Hosted Payload Procurements. Randy received her B.S. and M.S. from Cornell University, and her J.D. from Columbia Law School. She is recognized as a top Satellite, Technology, Telecoms and M&A lawyer by Chambers, Legal 100, Legal 500 and Who's Who Legal 100.

John Serafini, Chief Executive Officer
HawkEye 360

HawkEye 360 is a developer of space-based radio frequency (RF) mapping and analytics capabilities. He previously served as Senior VP of Allied Minds where he led the formation of and the investment into HawkEye 360, along with other Allied Minds companies such as BridgeSat, Federated Wireless, Optio Labs, Percipient Networks, and Whitewood Encryption Systems. John's investment activities and management expertise center upon the intersection of profit-maximizing private capital and the unique requirements and R&D capabilities of the U.S. government. A former Airborne Ranger-qualified US Army infantry officer with duty stations at the 82d Airborne Division & UNCSB-JSA of the Korean DMZ, John holds a BS from the United States Military Academy at West Point, and a MBA and MPA from Harvard University.

Dr. George F. Sowers, Director, Vice President, Advanced Programs & Chief Scientist
United Launch Alliance (ULA)

Sowers is responsible for assessing product offerings, technology roadmaps, operations concepts, and business models that meet various potential customer future space architecture needs and buying approaches. Prior to this position, Sowers was the VP of Human Launch Services. Before joining ULA, Sowers was director of Business Development for Lockheed Martin Space Systems Company. Sowers previously served as director of Mission Integration for the Atlas program and Chief Systems Engineer and director of the Systems Engineering and Integration Team (SEIT) for Atlas V development. Sowers began his career with Martin Marietta in 1981 as a flight design engineer on the Titan program. Sowers received his Bachelor of Science degree in physics from Georgia Tech in 1980 and his PhD in physics from the University of Colorado in 1988.

John Stack, Managing Director, Aerospace Leader
The McLean Group Advisory Team

John Stack has 25 years' global strategy, business development and M&A experience focusing on publicly-held and private companies. He previously was VP, Strategy and Business Development and a member of the Senior Leadership Team at Cessna Aircraft Company, where he led the Columbia Aircraft acquisition. Prior to that, he was Director, Strategy Development and International at Textron. During his career, he has led project, M&A and joint venture teams in more than 15 countries in Europe, the Middle East, Africa and Asia, and he lived in Switzerland for more than four years. Mr. Stack holds a degree in Business Administration from Bryant University and an MBA from Fordham University.

Leon Stepan, Lead Mission Operations Analyst
Planet Labs

Leon leads a team responsible for mission performance and analysis, automating satellite operations, satellite orbit determination and conjunction response. Planet's mission is to image the entire Earth every day, using a large constellation of cubesats in Sun-Synchronous Orbit. Since joining Planet in 2014 he has been involved in the launch and operations of over 50 spacecraft. With 10 years experience in satellite system engineering, he previously worked on simulations and modeling for surveillance systems and cubesat collaborations for Defense and universities in Australia and United States, with applications in space situational awareness. Leon Stepan graduated from University of Sydney with a Bachelor of Aerospace Engineering and Bachelor of Science majoring in Physics. He is also an alumni of the International Space University.

Sid Stewart, Portfolio Manager Satellite Solutions
Harris Corporation

The Satellite Solutions group at Harris provides affordable remote sensing mission solutions to commercial and government customers worldwide. Mr. Stewart joined Harris in 1985 as an electrical engineer. Sid is a recipient of numerous awards including the NASA Space Flight Awareness Award. Mr. Stewart earned a Bachelor of Science degree in Electrical Engineering from Auburn University, a Master of Science degree in Electrical Engineering from the University of Florida, and a Master of Business Administration degree from the Florida Institute of Technology. Mr. Stewart is also a graduate of the Harris Leadership Directions Program at the University of Virginia's Darden School of Business. He is an instructor for numerous Harris internal training programs including Project Engineering, Program Management, Earned Value Management Systems, and Subcontract Program Management.

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SmallSat Symposium Speakers

Chris Stott, Founder, Chair & CEO
ManSat

ManSat is the world's first, and now largest, commercial satellite spectrum firm and was also key in founding the multi billion dollar space and satellite industry on the Isle of Man. A founder of the International Institute of Space Commerce, he is also a passionate activist for STEM & STEAM education serving as faculty at the ISU and on the University's Main Board and with the Conrad Foundation, Challenger Centers, and the United Space School. At ISU he teaches entrepreneurialism, networking, and other business topics and is a past Co-Chair of the School of Management and Business. A fellow of the Royal Astronomical Society, Member of the Reform Club, and the International Institute of Space Law, Chris is also a TED'ster and TEDx Curator (ISU, Douglas, and Sugarland). After working in executive positions with Boeing and Lockheed Martin, Chris left Lockheed Martin in 2000 to become an entrepreneur in the space industry before it was trendy.

David Strobel, CEO
Space Micro

Mr. Strobel has an MBA from Claremont Graduate School, a BS Systems Management from the University of Southern California, a BS Nuclear Engineering, Cornell University; a BS Astronautical Engineering, US Air Force Academy. Mr. Strobel adds his expertise in technical management of complex technologies for space and space market penetration experience. This was gained during his seven years as President of Space Electronics Inc (SEi) and 18 years at SAIC and Northrop Electronics. He built SEi from a small R&D startup company to over $13M in annual space sales with 125 employees before Maxwell Technologies acquired SEi. He also won the SBA Tibbetts Award, for SBIR excellence; with a focus on rapidly commercializing technologies initiated under SBIR. At Space Electronics Inc Mr. Strobel led four Phase I and two Phase II contracts from NASA, Air Force, and BMDO. He holds six US patents for space radiation shielding and microelectronics, including versions of RADPAK and RADCOAT.

Tom Stroup, President
SIA—Satellite Industry Association

Tom manages the day-to-day operations of SIA, including member communications, staff leadership and organization of SIA sponsored events. Prior to joining SIA, Mr. Stroup was with Shared Spectrum Company (SSC), a leading developer of spectrum intelligence technologies, where he served as CEO. For more than a decade, he served as the President of the Personal Communications Industry Association (PCIA). Previous to his position at SSC, he founded and ran several companies in the technology industry, including Columbia Spectrum Management, P-Com Network Services, CSM Wireless, and SquareLoop. Mr. Stroup holds a BS, summa cum laude, in Public Administration from the University of North Dakota. He is also a graduate of Georgetown University Law Center where he served as Editor of the Georgetown Law Journal.

Stig-Are Thrana, US Sales Director and Head of Kongsberg Silicon Valley Office
Kongsberg Satellite Services

Stig-Are Thrana holds a Bachelor degree in Entrepreneurship and Innovation and has been working with professional radio and satellite communication for over 10 years, despite his age. Stig has been one of the intrapreneurs and pioneers of the KSAT lite network—the world largest NewSpace network. Kongsberg Satellite Services is a world leading provider of ground station services for polar orbiting satellites from their uniquely located global ground network, and has over 20 ground stations distributed on all the continents.

Dr. Joe Thurgood, Vice President, Corporate Development and Marketing
Hera Systems

Dr. Joe Thurgood is responsible for guiding business development and marketing strategies in preparation for the launch of the company's first micro-satellites in 2017. In his position at Hera Systems, Joe brings over two decades of experience in the field of high-resolution commercial satellite imaging and its application in government and the private sector, with additional expertise in geographic information systems, geospatial imaging and supporting operations. Joe served as vice president of marketing for DigitalGlobe, where he managed marketing communications and PR, and directed programs for all channel and vertical marketing. At Space Imaging, the world's first commercial high-resolution satellite imagery provider, Joe was responsible for product marketing and international market rollout programs. Joe holds a BSc from the University of Glasgow, and a Masters and Ph.D. in remote sensing and image processing from Purdue University.

Alexander Tokarev, Deputy General Director, International Affairs
Glavkosmos

Alexander Tokarev is responsible for Glavkosmos development in the international arena bringing more than 25 years' experience of cooperation with foreign partners. Mr Tokarev plays a key role in establishing the position of Glavkosmos as a single point of contact for international cooperation development of the leading space scientific centers of Russia. Previously Alexander occupied different positions at the Ministry for Foreign Affairs of the USSR and Russian Federation.

Dr. Miguel A. Vazquez,Managing Director & Co-Founder
DHV Technology

Miguel has been involved in more than 15 projects or missions for small satellites from the foundation of the company in November 2013. DHV Technology has manufactured the solar panels for the Italian satellite UNISAT-6 that was launched from Yasni (Russia) on June 19th 2014. DHV Technology has participated as well in several projects for PocketQubes, 1U, 2U, 3U, 6U and 12U. Miguel is an expert on photovoltaic technology at mass production level, he is Doctor on Physics by Seville University, Master in Renewable Energy by Andalusia International University and Master in Energy Engineering by Seville University. Prior to DHV Technology, Miguel served at Isofoton, S. A. from 2000 to 2013, in different positions. He has developed more than 30 R&D projects funded by the European Commission and Spanish Government and he published over 20 scientific publications at international journals and conferences about industrial photovoltaic technology.

Dr. Marco Villa, President & COO
Tyvak Nano-Satellite Systems

Dr. Villa received his Bachelor's Degree in Aerospace Engineering in 1999 from Politecnico di Milano, Italy. Following a brief stint as a structural analysis at Carlo Gavazzi Space in Milano, Italy, he moved to the United States and earned his Doctoral Degree in Aerospace Engineering in 2005 while also leading a small satellite development project. Dr. Villa also earned his Master's Degree in Engineering Management while working as system engineer and project manager for Swales Aerospace and as a contractor for NASA and the Air Force. In 2007, Dr. Villa joined SpaceX, where he served as Director of Mission Operations. In 2010 Dr. Villa and Max Vozoff founded mv2space LLC, a Business Development, Strategy formulation and support services consultancy. With mv2space, Mr. Villa brings deep experience in strategy formulation and implementation, program management and systems engineering, and has developed advanced financial modeling and analysis tools that, when customized for each client, form the basis for their business plans, strategies and priorities.

Dirk Wallinger, Chairman & CEO
York Space Systems

Mr. Wallinger leads York's continued focus on delivering ultra-low cost access to Space, and enabling the harnessing of the Space Data Frontier. Mr. Wallinger has successfully executed across a wide range of commercial and Government customers including NASA, USAF, DoD, NRL, NGA, ORS, and DigitalGlobe. During employment with industry leaders including Orbital Sciences, General Dynamics, and Lockheed Martin he led Senior Management market assessments, evaluated new market entrance opportunities, set system pricing, and coordinated proposal strategy and messaging for company critical proposals. Mr. Wallinger's extensive experience includes roles as the Principal Lead System & Subsystem Engineer on multiple space vehicles, including GeoEye1, ORS-1, Fermi Gamma Ray Observatory, NFIRE, and numerous classified programs. Mr. Wallinger holds a Mechanical Engineering degree from the University of Arizona, Summa Cum Laude.

Tony Wilkey, Senior Vice President
AvL Technologies

Tony has the responsibility for US Sales, Marketing and Customer Service. He has 30 years of experience in satellite communications in engineering, sales, program management and general management roles. He began his career at Ford Aerospace in Palo Alto, California (1981-1983) before joining RSI SatCom Technologies (1983-1987, 1992-1995), Georgia Tech Research Institute (1987-1992), COMSAT RSI (1995-1998), and TriPoint Global (1998-2000). Most recently he served as Director of Antenna Systems Business Development for ViaSat (2000-2008) before joining AvL Technologies in 2008.

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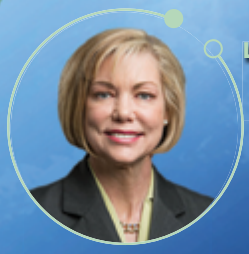

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The Forrester Report: Smallsats—Do They Have a Future in Video?

By Chris Forrester, Senior Contributor

The world has grown to understand the role of geostationary DTH/DBS satellites: whether in a 'wide-beam' role covering vast swathes of the planet, or highly-focused spot beams, we know how broadcasters (and point-to-point usage for video contribution and distribution) can tap into this coverage.

Ever since SES placed two satellites in the same orbital position (at 19.2 degrees East) back in 1991, the industry has had the ability to make use of a craft's movable spot-beam technology, now a model for orbital efficiency.

However, over the past few years, a new and extremely exciting satellite sector has sprung up, notably in the use of smaller MEO satellites—and now with a cluster of super-constellations under development.

These MEO (even LEO) satellites have as their primary role the delivery of data and telephony and few anticipated their use for video—even in the contribution side of the business. After all, they travel though their journeys at one heck of a speed, and tracking—it has been assumed—would be an expensive task for any but the most adventurous—or those desperate for a signal.

Worth remembering is that there was a time when giant, steerable dishes were the norm. Indeed, the very earliest trans-Atlantic signals came from the tiny Telstar and Early Bird satellites. Telstar, built by Bell Labs, was launched in 1962 as part of a j-v between AT&T, NASA, the UK's GP and France's PTT.

Telstar weighed 77 kgs (170 lbs) and operated in a geocentric, somewhat unusual LEO orbit (952 kms at closest, 5933 kms at apogee). The satellite carried one transponder capable of a single monochrome TV channel, but its high-speed, 2 hours 37 minutes circumnavigation, meant it was good for only 20 minutes of TV when over the Atlantic and to provide connectivity between Andover, Maine, and Goonhilly in the UK. Early Bird (more correctly, Intelsat-1) weighed just 34 kgs (76 lbs) and launched in 1965 and was built by the then Hughes Aircraft. Incidentally, it is still orbiting at a mere 3.12 degrees inclination.

The 'new' LEO and MEO operators, while frequently talking of 'broadband' and other data-related tasks for their smallsats, often mention video as part of their offerings. Jersey, Channel Islands-based OneWeb and their LEO constellation moved a major step closer to a 2020 availability when the firm announced a $1.2 billion funding injection from Japan's Softbank on December 19, 2016. Softbank will hold a nominal 40 percent stake in Greg Wyler's business, with other stakes held by Richard Branson's Virgin Group, telco giant Qualcomm, Indian media giant Bharti Enterprises, Coca-Cola, Hughes Network Services and Intelsat.

Indeed, the Intelsat "strategic" investment seeks to link OneWeb with Intelsat's fleet in a "complementary" "collaboration to develop hybrid LEO/GEO end-user access terminals, furthering Intelsat's vision to "*lower the cost and accessibility of satellite-based broadband and unlock new markets for satellite broadband.*"

Intelsat, in a press statement of their OneWeb participation, quoted NSR's forecasts of "*over $7 billion of incremental revenue industry-wide through 2024 from demand for satellite-based broadband connectivity services for aircraft, ships, connected devices, cars and remote villages. These applications are currently, or planned to be, served by Intelsat's global fleet of approximately 50 C-band and Ku-band GEO satellites.*"

Another set of aggressive mentions comes within SpaceX's 'catch all' filings with the FCC (made in November of 2016). SpaceX talks about their LEO "high capacity" orbiters that will provide aggregate downlink capacity to users ranging from 17 to 23 Gbps, depending on the gain of the user terminal involved. Assuming an average of 20 Gbps, the 1,600 satellites in the Initial Deployment would have a total aggregate capacity of 32 Tbps. SpaceX says the firm will periodically improve the satellites over the course of the multi-year deployment of the system, which is likely to further increase capacity. The final deployment will comprise 2,825 satellites.

SpaceX says this "high adaptability" is key to their mission. "*The system leverages phased array technology to dynamically steer a large pool of beams to focus capacity where it is needed. Optical inter-satellite links permit flexible routing of traffic on-orbit. Further, the constellation ensures that frequencies can be reused effectively across different satellites to enhance the flexibility and capacity and robustness of the overall system.*"

The Elon Musk-backed company is specific about its broadband services: "*The system will be able to provide broadband service at speeds of up to 1 Gb/s per end user. The system's use of low-Earth orbits will allow it to target latencies of approximately 25-35 ms.*"

And, of course, there's worldwide coverage: "*With deployment of the first 800 satellites, the system will be able to provide US and international broadband connectivity; when fully deployed, the system will add capacity and availability at the equator and poles for truly global coverage.*

Specifically for the US (and the FCC application), SpaceX stated, "*the proposed system is capable of providing Fixed-Satellite Service on a continuous basis throughout the fifty states, Puerto Rico and the US Virgin Islands.*"

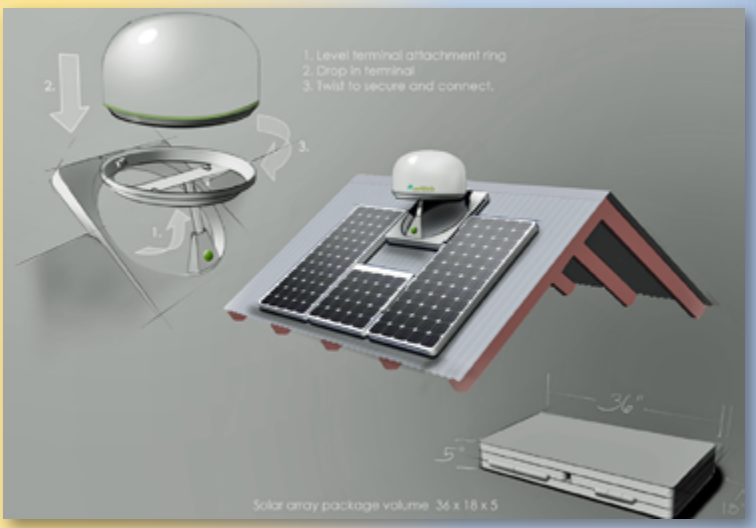
SpaceX adds that low cost satellite manufacturing (and subsequent launch) is a key part of the firm's strategy. "*SpaceX is designing the overall system from the ground up with cost effectiveness and reliability in mind, from the design and manufacturing of the space and ground-based elements, to the launch and deployment of the system using SpaceX launch services, development of the user terminals, and end-user subscription rates.*" SpaceX stresses that its phased-array user antenna design "*will allow for a low-profile user terminal that is easy to mount and operate on walls or roofs.*"

Before pondering the technical challenges for SpaceX and other LEO operators, who are the potential users of video, certainly, there are plenty of news gatherers who might find existing cellular/terrestrial connectivity inadequate, whether in times of catastrophic emergencies or war zones and conflict. However, these are simply extensions of existing 'occasional use' demands and well-served by conventional geostationary operators.

TMF Associates recently conducted a detailed—and excellent—examination regarding the types of dishes needed to collect SpaceX's signals and those of its rivals (in particular, OneWeb) and the technical plausibility of the proposals.

TMF said, "*One hint that the user terminals are likely to be large and expensive is that SpaceX assures the FCC that "the Earth stations used to communicate with the SpaceX System will operate with aperture sizes that enable narrow, highly-directional beams with strong sidelobe suppression". TMF says "the supposed user downlink capacity of 17 to 23 Gbps per satellite assumes a very large user terminal antenna diameter, because there are only 8 Ku-band user downlink beams of 250 MHz each per satellite, and thus a total of only 2 GHz of user downlink spectrum per satellite.*"

OneWeb's receiver.



Greg Wyler's OneWeb plan for a rooftop solar powered receiver.

TMF then added, "*In other words, this calculation implies a link efficiency of somewhere between 8.5 and 11.5bps/Hz. For comparison, OneWeb has 4 GHz of user downlink spectrum per satellite and is estimated to achieve a forward link efficiency of 0.55bps/Hz with a 30 cm antenna and up to 2.73bps/Hz with a 70 cm antenna. Put another way, OneWeb is intending to operate with twice as much forward bandwidth as SpaceX, but with only half as much forward capacity per satellite.*"

However, TMF suggests that SpaceX's system appears much more focused on large expensive terminals, similar to those used by O3b, which can cost $100K or more and are used to connect large cruise ships or even an entire Pacific Island to the Internet with hundreds of Mb/s of capacity. While this has proven to be a good market for O3b, TMF said, "*it is far from clear that this market could generate enough revenue to pay for a $10 billion SpaceX system.*"

TMF suggests that SpaceX could replicate ViaSat's 'beam-hopping' technology although, interestingly, this is *not* mentioned in SpaceX's FCC filing.

SpaceX's ambitions are immense. Their FCC filing says they could potentially reduce "or eliminate" the need to impose strict limits on consumers. Moreover—and notwithstanding its critics—SpaceX stated their phased array 'dish' antennas will mean flexibility and ease-of-use as well as installation.

However, some existing geostationary operators (although perhaps not Intelsat) are concerned about interference, especially for the likes of SpaceX which will use both Ka- and Ku-band in its systems.

SpaceX told the FCC in its November 2016 filing, "*These techniques are used to protect GSO satellite networks from interference from the SpaceX System and have the effect also of protecting the SpaceX System from GSO interference, as they are based on the principle of avoiding inline and near-inline events. In addition, SpaceX has begun to provide initial briefings on the operational parameters of its system to GSO satellite operators whose systems use the same Ku- and Ka-band frequency ranges as the SpaceX System, and is confident that compatibility with all GSO satellite networks in these bands can be achieved.*" SpaceX says it is confident that there will be no cross-satellite interference with OneWeb.

Most insiders do not see these future LEO and MEO smallsats as being a direct threat to satellite broadcasting in a DTH/DBS-dominated world. But there are considerable opportunities for them to deliver content, whether by simple broadband supply or enhanced 4G-type services.

For example, O3b is already busy linking clients and their broadband demands and makes no secret of their wish to use its MEO satellites to bridge the "digital divide" and deliver fiber-like connectivity to its customers.

Rajab Moussa, CEO at Presta Bist Telecom in Chad, a landlocked central African country, said, "*With the launch of O3b's satellite services we have been able to provide residents with clear sound, live High Definition (HD) video and high-speed downloads. For the first time ever, we are able to provide residents with connectivity that they thought only existed in large and fully development countries.*"

O3b's initial 12 satellites are up and running and the SES-owned operator states that just about every client has boosted their demand over the past year. This demand occurred whether in land-locked Chad, remote Pacific islands, or passengers on the spectacular fleet of Royal Caribbean floating hotels. They want high-speed broadband, and that definitely includes video.

O3b has to use middle men' as its primary customer/client. As mentioned, O3b has itemized its successes in winning broadband clients in Central America and the Pacific Islands, Africa and elsewhere.

The company also secured a fascinating outlet with the Royal Caribbean Cruises shipping line. The vessels are simply huge, carrying around 6,300 passengers on each voyage. Royal Caribbean's Quantum of the Seas is the most technologically advanced passenger ship on the oceans and its passengers (and crew) can browse, stream, game and download to their "hearts content."

As the cruise ship owners explain, "*our on-board Wi-Fi is fast and it's everywhere.*"

Passengers and crew have taken up the ship's offering and the direct result is extra demand from O3b—and a happy client! O3b is being added to the other Royal Caribbean 'Quantum' vessels as they go to sea. By mid-2016, there were three 'Quantum' vessels on the water, with another expected by 2019 and a fifth vessel in 2020.

At sea, O3b has already revolutionized the connected cruise ship passenger experience with its fiber-in-the-sky offering that delivers up to 1.6 Gb/s of throughput per beam at a low latency (tiny delay) of less than 150 milliseconds—another eight satellites are scheduled to join the scalable O3b constellation in 2018.

There can be little doubt that MEO and LEO satellites have an important role to play in the future—and video is expected to participate in the expansion plans of each of the new, planned constellations. Customers will expect nothing less!

Senior Contributor Chris Forrester is a well-known broadcast journalist and industry consultant. He reports on all aspects of broadcasting with special emphasis on content, the business of television and emerging applications. He founded Rapid TV News and has edited Interspace and its successor, Inside Satellite TV since 1996.

Chris also files for Advanced-Television.com. In November of 1998, Chris was appointed an Associate (professor) of the prestigious Adham Center for Television Journalism, part of the American University in Cairo (AUC), in recognition of his extensive coverage of the Arab media market.

Electrospray—A Powerful Third Option for Electric Satellite Propulsion
An Accion Systems Perspective

By Natalya Bailey and Raleigh Werner

Electric propulsion systems for satellites have been in commercial use for decades—primarily Hall-effect thrusters and gridded ion engines—but their adoption in the market has been constrained on account of their high costs, inability to scale down to smaller designs, and performance limitations.

However, a third approach—electrospray technology—could put electric propulsion on a much more competitive footing for a wide variety of space applications, from constellations of small satellites to manned interplanetary missions.

Electric Propulsion 101

Electric propulsion works on the same Newtonian principle as more familiar chemical rockets. A thruster accelerates matter and ejects it into space, thereby generating force in the opposite direction. While traditional rockets produce force through explosive chemical reactions, electric thrusters do so with electromagnetic fields acting on ionized particles.

It's not currently feasible for electric propulsion to generate the intense levels of force needed for launching rockets into orbit, but once in space, they have distinct advantages. Chief among these advantages are increased propellant efficiency (less propellant is needed) and the ability to derive power from batteries or solar panels instead of explosives.

Hall thrusters and gridded ion engines have been the dominant forms of electric propulsion, used extensively in geostationary orbiters and other large satellites. These technologies rely on compressed gas propellants, requiring heavy pressurized containers for storage. They need to draw electric power for two stages: first, to ionize the gas so a magnetic or electric field can act on it, and then to accelerate that ionized gas. And they require an external neutralizing cathode to de-ionize the ejected thrust particles, adding bulk and complexity. However, the fundamental physics that make these systems work restrict their ability to scale down to smaller systems.

Though similarly accelerating charged particles to produce thrust, electrospray propulsion works somewhat differently. Exposing a conductive liquid to a strong electric field causes that liquid to deform, creating "*peaks*" in the liquid. The peaks extend the liquid into stronger areas of the electric field, deforming it still further. Eventually the peaks become extremely attenuated, and the field pulls a tiny droplet (which may even be as small as a single ion) from the tip and away from the rest of the liquid, accelerating it out and away.

Accion Systems has developed an approach that moves electrospray propulsion technology out of the research lab and into application. By using a conductive liquid that already contains positive and negative ions, it's not necessary to ionize the propellant before accelerating it. Additionally, this propellant is liquid at room temperature and is non-volatile, even in a vacuum. This eliminates the need to compress it and store it in bulky, massive tanks.

Additionally, Accion thrust emitters are made using reliable, inexpensive MEMS manufacturing techniques—the same used to create many smartphone components—enabling the placement of large numbers of extremely small emitters in a small space. Each emitter need only be a few nanometers across, so hundreds or thousands together in a thruster "chip" about the size of a penny can generate a meaningful amount of thrust.

If more thrust is needed, multiple thruster chips can be grouped together to create almost any desired level of force. No external neutralizing cathode is needed, because the thruster emits both positive and negative ions.

Hall thrusters and gridded ion engines have demonstrated thrust densities on the order of 1-2 N/m² in practice. Higher thrust densities are difficult if not impossible to achieve: In the case of gridded ion engines, the thrust density is limited by space charge. The theoretical limits of electrospray propulsion are much greater; densities as high as 10,000 N/m² can be achieved by decreasing the spacing between emitters.

Accion has demonstrated a four-fold increase in thrust density over the current electrospray state of the art, to 2 N/m², making current electrospray technology competitive with Hall thrusters and ion engines. And we anticipate that the technology will achieve a 100x improvement within the next three years.

Bringing Electric Propulsion to Smallsats

Increasing thrust densities, combined with the ability to cluster many small thruster units together, means that electrospray is suited for a wider variety of commercial applications today than other types of electric propulsion.

It is more propellant-efficient than chemical thrusters and avoids the need for heavy, pressurized storage containers, reducing the mass of the thruster itself and the amount of propellant that must be carried onboard. The less mass required for propulsion, the more value in the satellite itself.

Additionally, because these thruster units can be created in bulk using batch manufacturing techniques, there is enormous potential to reduce the cost of this type of propulsion. Across the whole mission lifecycle from shipping to fueling, the non-volatile, handleable propellants used in electrospray reduce safety hazards and costs.

At 2 N/m² of thrust density, electrospray is one of the first viable options for small, low orbit satellites typically weighing 100-400 kg--a market that until now has had to rely on chemical thrusters or no propulsion at all. Two current examples include satellite "constellations" and synthetic aperture radar imaging satellites.

Several companies, including OneWeb, Boeing, and SpaceX, are currently seeking regulatory approval to launch large constellations of hundreds to thousands of communications satellites. In SpaceX's case, the plan calls for 4,425 satellites. These satellites would orbit the Earth at altitudes of several hundred miles, above the orbit of the International Space Station but well below that of geostationary satellites, with the aim of providing global broadband communications coverage. Such satellites range in size from 150 kg to nearly 400 kg, with mission profiles easily accommodated by electrospray propulsion.

Synthetic aperture radar imaging missions use several small satellites operating in concert to increase the effective aperture of the radar imaging system onboard, which increases its visual resolution. Using signal processing algorithms, the radar system can stitch together and synthesize adjacent radar pulses from neighboring satellites to create an image with a "virtual aperture" much larger than is physically possible with a single satellite.

Useful composite images often require satellites to maintain non-Keplerian orbits, meaning they need a constant application of force in order to maintain their position. Electrospray thrusters are well suited to provide such positioning.

Future Breakthrough Applications

With future improvements to thrust density, an even wider range of applications become feasible. At 100-200 N/m² of thrust, electrospray propulsion will be a powerful alternative for even the largest missions within several years.

For example, exploratory work is underway by several governments as well as private companies to develop manned missions to Mars. One of the design requirements for such a mission is an efficient propulsion system that can operate reliably for months if not years.

A well-known tradeoff: the longer the mission, the more propellant is needed. This increases the mass of the overall vehicle, which increases propellant requirements, and so on. Electrospray propulsion offers one way to increase the efficiency of that tradeoff.

In the case of a Mars mission, a 1U electrospray propulsion system operating at the theoretical thrust density limit (10,000 N/m²) could provide the same performance, use the same amount of propellant and operate on the same power as roughly 4,000 Hall-effect thrusters.

The difference: The electrospray propulsion system would be the size of a shoebox and the 4,000 Hall thrusters would be the size of the International Space Station. Considering the pace of advancement in the electrospray propulsion field, reaching that theoretical limit may only be 10 or 15 years away.

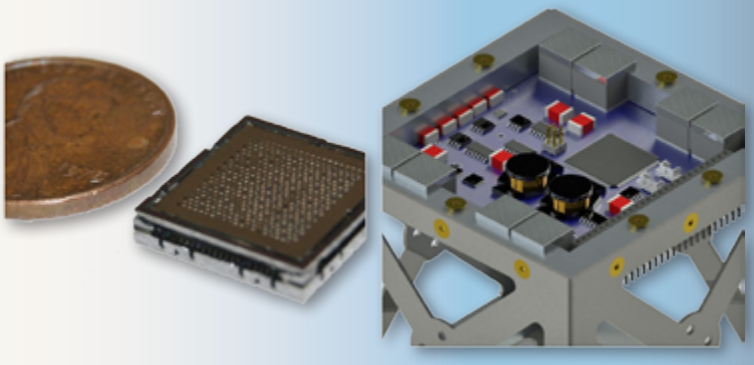
While electric propulsion systems have traditionally been reserved for the largest, most expensive missions, the theoretical limits of electrospray and its declining cost will open doors for a far wider range of applications and ultimately new markets.

Accion Systems is developing new configurations of its electrospray emitters that will be suited to small- and medium-size satellites in the near term, and possibly enormous, manned interplanetary missions in the long term. With further development, the potential for electrospray propulsion is astronomical.

accion-systems.com/

Natalya Bailey is the CEO and founder of Accion Systems. Natalya earned her doctorate from MIT where she helped invent the core technology that would become the company's first product line. Prior to MIT, she pioneered a new chemical rocket technology that she also spun into a space startup. Recently she was named to Forbes' 30 Under 30 list. Outside of academia, Natalya mentors entrepreneurs in the Boston community and youth interested in pursuing STEM careers.

Raleigh Werner is a member of the Accion Systems team, focusing on business development and product commercialization. He is also the creator and host of Space Ventures Radio, a podcast dedicated to exploring innovation in the commercial space sector. Raleigh has an entrepreneurial background and continues to serve as a mentor, advisor and coach to aspiring startup founders in the Boston area.



Ground Segment Considerations for LEO and MEO Satellites: An AvL Technologies Perspective

By Tony Wilkey, Senior Vice President, AvL Technologies

With the growing popularity of small satellites (smallsats) positioned in LEO and MEO altitudes, the opportunity is now available for small organizations, educational institutions and even individuals to, quite literally, reach into space.

Several concepts exist for large constellations of smallsats, commonly known as CubeSats, operating at LEO altitudes, and new high-throughput constellations such as O3b are already positioned in MEO.

As one considers putting his or her mark in space, there are the obvious considerations of funding, design, cost, schedule, launch and insurance that are all involved in getting a spacecraft into orbit. However, the most important considerations are concerned with how to monitor the health of the spacecraft and how to command it— neither is possible without Earth terminal operations.

CubeSats in LEO

One of the most critical elements for any satellite is the Telemetry, Tracking and Control (TTandC) System, which provides a basic information lifeline between the spacecraft and its operators. As with all systems onboard a satellite, the TTandC system expends already limited power resources, and for smallsats, their power resources are even more limited.

It is not uncommon for the solar-generated power of a CubeSat to be less than 1 watt, which is roughly enough energy to power two, mini, incandescent Christmas lights and barely enough power to provide a useful radio signal.

That power, even though ≤ 1 watt, should be enough for the satellite's intended tasks—intelligent power management is definitely required. With such weak signal conditions, it is all the more important to have an amplifying, focused receive and transmit tracking Earth station.

With a focused antenna tracking the position of the satellite, a smallsat signal can be discerned from other radio noise. While many CubeSats used in education operate at VHF (30 to 300 MHz) or UHF (300 to 3000 MHz), others for commercial application are using a variety of higher satellite frequency bands.

With the differences in frequency come distinctions in antenna design and required positioning accuracy. VHF and UHF signals can be focused with more traditional Yagi, Helical and Turnstile antennas, while satellite frequency bands (L-band and higher) are more commonly focused through the use of parabolic reflector antennas.

Regardless of frequency, it is important to track the spacecraft to ensure the most efficient collection of what little energy is being transmitted. Unlike traditional Geostationary (GEO) satellites commonly used for communication, and which a "hang" in one position, LEO satellites appear to constantly move relative to the surface of Earth. LEO satellites are also fast-moving relative to the surface, with most only being visible to a tracking terminal for 15 minutes at a maximum.

The required tracking accuracy is proportional to the frequency being used. As CubeSat operators move out of VHF, and UHF into satellite frequency bands, the required tracking accuracy increases.

In a similar fashion, the required tracking accuracy also increases with parabolic reflector diameter. Naturally, larger diameter reflector antennas are desired for tracking weak signals as they are able to collect and amplify more energy than their smaller counterparts.

For LEO satellites using satellite frequency bands, AvL Technologies terminals provide an answer to the technical challenge of accurate tracking

to maintain an optimum radio link with small spacecraft through the use of advanced signal peaking routines. These routines leverage NORAD Two Line Element (TLE) tracking capabilities and search methods if there is some uncertainty with the spacecraft's position.

With a LEO constellation, another consideration is how many Earth terminals will be needed to keep active communication with each satellite. If, for example, multiple satellites will be launched together, or if a constellation is planned to operate with dozens or hundreds of satellites, many Earth terminals will be needed.

Satellites flying in LEO are typically visible for only 15 minutes or less, with another satellite possibly following close behind, or several satellites may be visible at the same time. Accordingly, Earth terminals must be able to quickly move from the satellite going below the horizon to another as it rises, or a pair of antenna terminals may be needed to coordinate signal management.

With a large constellation of visible and quickly moving satellites, the complexity of Earth terminal tracking, coordination and management will be one of the most significant operational challenges for the network.

Smallsats in MEO

Many of the new satellites operating today in MEO, or planned for MEO, are considerably smaller than the satellites orbiting in GEO. However, they're considerably larger than the CubeSats flying in LEO and have significantly more power capacity.

Each satellite in the O3b constellation, for example, has six solar panels and provides enough power to operate 12 Ka-band antennas. Each antenna provides 700 km spot beams that are independently steerable, enabling O3b to provide mega-bandwidth to customers on demand.

Because the O3b satellites operate with significant power, the power requirements for Earth stations are less demanding. The O3b network operates with nine gateways and each gateway operates with two active Earth stations and one spare station. Each gateway uses make-before-break communications, with one antenna actively tracking and communicating with a satellite while the second antenna waits for the following satellite to come up over the horizon.

O3b's transportable antenna terminals, designed and built by AvL Technologies, also operate in tandem pairs. These tracking antennas are case-based and can be shipped anywhere, set up quickly and on-air in a very short time.

Because of the minimal power requirements, many O3b customers can use very small antennas—such as 85 centimeters—and have more than enough bandwidth. To date, AvL and O3b have collaborated on transportable antenna terminals up to 2.4 meters in size.

One of these terminals operating on the O3b network enables enough bandwidth to reestablish critical phone, data and/or video communications to a medium-sized community or a remote island nation after a disaster.

Other constellations in MEO include the US Global Positioning System (GPS), Russia's version of GPS (called Glonass) and the European Space Agency's global navigation system (Galileo). All of these positioning system networks have modernized with newer spacecraft and upgraded technologies over the past two decades.

They operate with new ground stations that determine the orbital positions of the satellites and transmit information to the satellites for optimal system operation.

Because these global navigation networks are well managed, they enable broad consumer use of the networks with small, mobile receive-only antennas.

No Ground Segment = No Network

Operating a satellite is fundamentally working against the clock. All satellites have a fixed lifespan and, in order to make the most of their operating time, it is often advantageous to have a dedicated, full ground network to maintain a continuous link with the spacecraft. It is not uncommon for the ground segment cost of a commercial satellite to contribute up to 10 percent of the total project costs.

While it is possible to lease time on Earth station antennas, most available today were designed to operate with GEO satellites. Satellites in LEO require complex tracking capabilities, which means a traditional GEO Earth station will not fit the bill.

Further, one Earth station antenna will not be adequate for operating the network, as it will only have up to 15 minutes to communicate with the satellite during each orbit. For an always-on network, Earth terminals will need to be accessible around the globe, and these Earth terminals will require innovative tracking technologies.

Typically an LEO network will require a brief TTandC link with each satellite once per orbit, as well as communications gateways placed near the network users so that both the gateways and users are in view of the LEO satellites at the same time.

Depending on the size of the satellite, as well as its power requirements and orbit, small transportable Earth station antennas with tracking capabilities—such as those offered by AvL Technologies—may be a practical solution. With a transportable antenna system, it can be set up and used anywhere—the roof of a building, a large back yard, a college campus, or mounted to a flatbed trailer. If the satellite operator owns the AvL antenna system, it's always available versus leasing blocks of off-peak time at a teleport.

Focused tracking antennas are an absolute necessity for working with LEO and MEO satellites. Rather than focusing solely on the spacecraft, take some time to consider the ground operations in order to have a networked instrument orbiting overhead rather than just another piece of space debris.

www.avltech.com

Tony Wilkey is Senior Vice President at AvL Technologies with responsibility for US Sales, Marketing and Customer Service. He earned his Bachelor's degree in Mechanical Engineering from Georgia Tech in 1981 and his Master's degree in Mechanical Engineering degree from Stanford in 1983. He has worked his entire career in the satellite industry, most recently with ViaSat, Inc., before joining AvL in 2008.

AvL's Ka- Broadband antennas offer the AvL Cable Drive positioner for stiff and accurate pointing, rapid deployment, and single-button satellite acquisition.

Optical Communications Systems For Smallsats: A BridgeSat Perspective

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

After decades of development, space-based optical (laser) communications appears poised to achieve widespread adoption within the commercial smallsat community.

The capability of this technology to securely downlink large amounts of data has already been well-established on numerous missions. However, recent technological advances and new design approaches in optical comms are allowing innovative companies to bring to market data delivery solutions at a lower cost than equivalent RF designs, while offering much better capabilities. The optical comm systems that are now coming online can achieve high-rate data downlinks for LEO smallsat missions at an ***order of magnitude better than what was previously possible***.

While much has been made about the history of optical communications, the real breakthrough comes from large investments in technologies geared for complex missions with requirements that can't be met by RF systems by organizations including NASA, ESA, JAXA, DLR, and NICT. This new generation of optical comm designs help to overcome the constraints experienced by smallsat operators with traditional RF systems.

The Data Downlink Bottleneck

One of the areas that optical communications can address is the downlink of data from LEO smallsats. Smallsat operators are preparing ever more ambitious projects to feed the big data needs of their target audiences. The value for these companies is based on delivering information, so operators have responded with some incredibly innovative satellite systems to generate the necessary data, leveraging the latest advances in sensor, electronics, small satellites, and cheap launch vehicles.

But there is still one limitation: delivering this valuable data to the ground. Currently, 27 percent of smallsat Earth Observation (EO) missions generate more data than they are ablel to downlink.

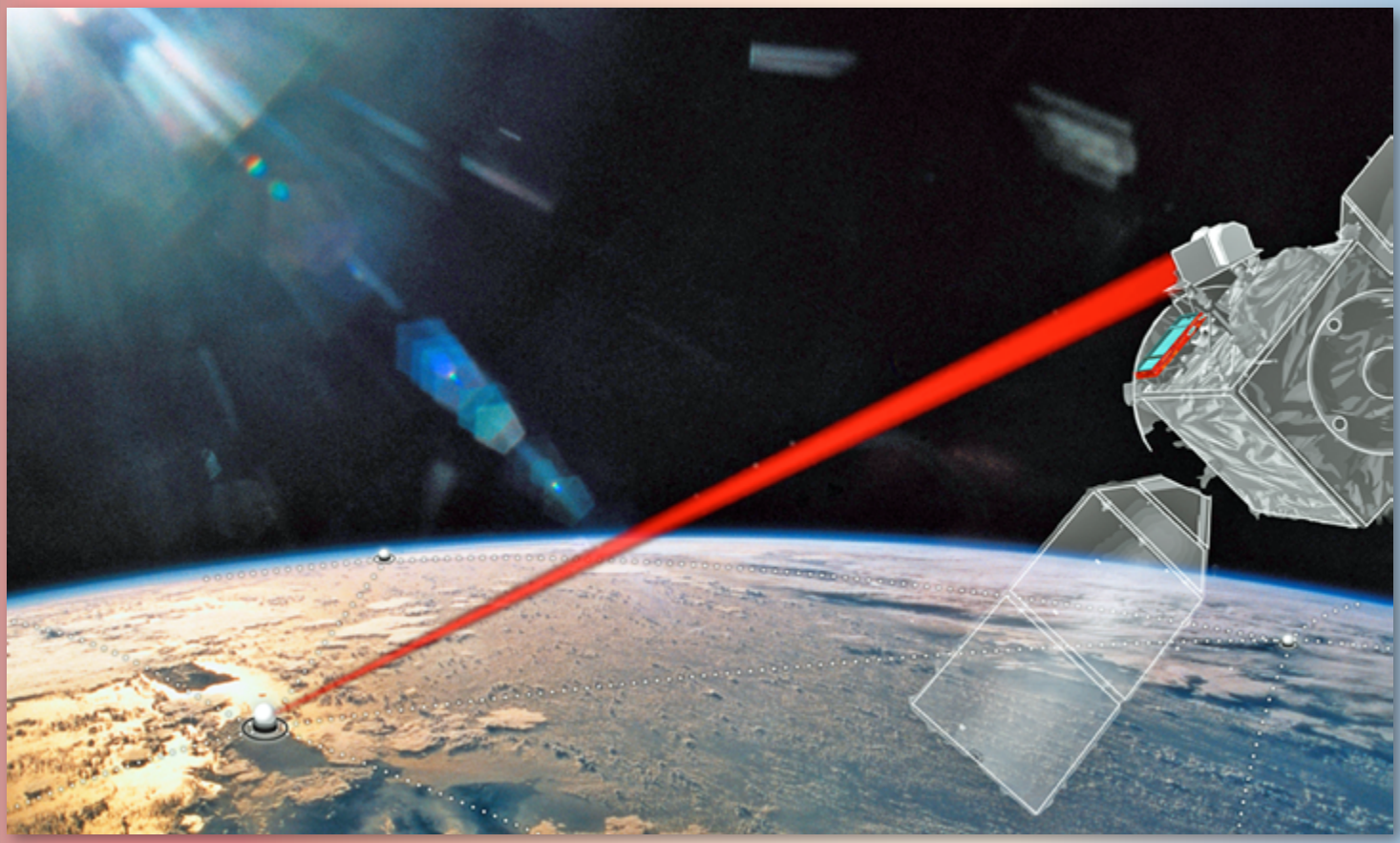
This problem is only going to get worse, according to a study by Northern Sky Research, as it stems from the limited data capability of RF systems, which only offer data rates in the Mbps. Current optical comm systems offer much higher capability: existing hardware provides data rates of 1 to 10 Gbps.

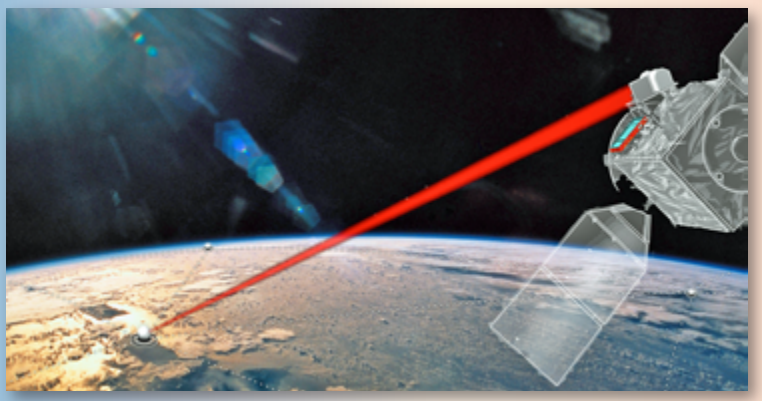
Development is underway for designs capable of 100 Gbps or more. For smallsat operators looking to deploy EO or sensing missions, this improved capability offers the potential to downlink all of their data generated on orbit, without on-board compression or complex priority tasking.

Access to Limited RF Spectrum

Intertwined with the data downlink problem is the limitation in RF spectrum. A new LEO smallsat operator can attempt to overcome the gap between data generation and RF downlink capability by filing for higher frequency Ku- or Ka-band spectrum that can offer multiple Gbps of data downlink.

However, the filing process through the International Telecommunication Union (ITU) is long and difficult and success is not guaranteed. Optical communications do not have that issue because of its inherent directional property that precludes interference. Multiple smallsats with optical comm terminals could all transmit to the same ground location unimpeded, as long as there is a unique ground station terminal linking to each.





Secure Data Links

Also inherent with the directional properties of lasers is the ability to provide a secure data link. In addition to limiting interference, the directional nature of lasers makes it extremely difficult to intercept or jam a smallsat optical comm link.

Of course, this feature is well appreciated by the government and commercial entities that need to pass data securely without being intercepted or located. But this feature is also valuable to new smallsat LEO operators that are downlinking their sensitive imaging or sensor data. Commercial satellite broadcasters have seen an alarming *increase in jamming activity*, so the adoption of optical comms potentially provides insurance against future interference for new LEO operators.

Compact Space Hardware

Until recently, optical communications space terminals were too large to compete with existing RF hardware. However, the landscape for small optical comm terminals has changed dramatically in the last few years. This is largely due to advancements in optical beam steering mechanisms.

To achieve high data rates, optical comms hardware has to achieve either very tight pointing or high power output. This previously drove the design of large, complex steering mechanisms on stable, but heavy, optical benches, in addition to power-inefficient multi-stage optical amplifiers.

Recent optical head assembly designs that utilize fine steering mirrors (FSM) with robust piezoelectric actuators, and optical beacon tracking, provide a tighter optical comm beam in a much smaller package. In turn, this reduces the required power output for the optical amplifiers, resulting in a smaller electronics package. Recent commercially available designs are less than 10 kg, and some are even available in a form factor that fits in CubeSat.

Cost-Effective Solutions

Which brings us to the main benefit for smallsat operators of optical comms: high data downlink at a less expensive price than traditional RF solutions. The aforementioned advancements in optical comm space terminal designs have allowed manufacturers to more readily adopt terrestrial optical comms technology that can be space-qualified.

Until recently, there was another major expense that hindered commercial smallsat adoption of optical communications: access to ground stations that work with optical communications.

For RF systems, satellite operators have numerous ground choices, including leasing access from commercial ground network providers or simply building their own ground stations. Optical comms require a large network of ground stations to provide the necessary site diversity to overcome cloud attenuation. For any single LEO operator to develop this expansive network can be financially prohibitive.

This is where BridgeSat steps in—BridgeSat plans to offer access to a global optical communications ground network on a fixed price per delivered GB that is cheaper than equivalent RF pricing with no upfront capital expenditure. Because BridgeSat will only accept payment once the data is delivered to the operator's cloud storage location, this removes the risk for operators considering the adoption of optical communications.

A Turnkey Optical Communications Solution

For smallsat operators that are developing their satellite architecture, optical comms should be a key part of their trade space. If the satellites are generating a lot of data, then optical comms should be an easy decision. It is understandable that there has been a reluctance to move from the tried-and-true RF realm to optical comms. Partly, this has been due to a lack of commercially feasible optical comms solutions—that is quickly changing.

In addition to deploying a global optical comms ground network, BridgeSat is working with leading suppliers of space-qualified optical comm space terminals to offer a turnkey, end-to-end solution for smallsat operators and manufacturers—BridgeSat is developing a system that will provide:

- *Space hardware that is provided in collaboration with space terminal manufacturers to ensure compatibility with the BridgeSat ground network*
- *A partnership with satellite manufacturers to ensure the interfaces, testing and operations between the satellite, space terminal and ground network*
- *Delivery of a full end-to-end data downlink solution for the smallsat operator, including subsidization for the initial pathfinder mission*

BridgeSat has embarked on achieving this ambitious plan, starting with the goal of developing a satellite-to-ground optical comm test at their first Optical Ground Station. This planned test is expected to demonstrate the feasibility of optical communications to consistently and reliably downlink data from LEO orbit. Once testing is complete, BridgeSat will begin to deploy the remainder of its 10 planned Optical Ground Stations around the world. When all 10 sites are in place, this fully operational network is expected to provide over 2 TB of data downlink per day for Smallsats in a LEO polar orbit.

This network is planned to be operational in time to support smallsat missions launching in 2018. From there, BridgeSat aims to deploy continual ground network expansion and upgrades that will allow much higher data downlink capabilities over time, as demand dictates.

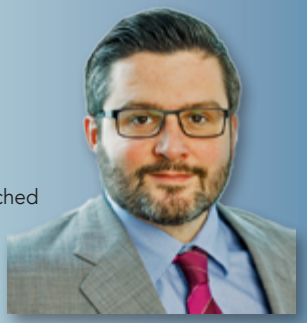
Smallsat operators can now begin to imagine: what would be possible if a downlink bottleneck wasn't an issue? Operators could add more satellites, complex sensors, and persistent data collection to their business, mining the data that is the gold of the new space age.

Smallsat operators have been at the forefront of innovation and adoption of commercial off-the-shelf (COTS) technology, and are the natural leaders in the coming optical communications revolution. Based on these projects, 2017 is expected to be a watershed year for optical communications, as it will be for the smallsat operators that take advantage of it.

bridgesatinc.com/

During his more than 20-year career in the satellite industry, David has served in Systems Engineering and Business Development roles at Hughes Space and Communications (now Boeing Space Systems), Orbital ATK and SSL (Space Systems Loral). David has a BS degree in Aeronautical Engineering from California Polytechnic State University, San Luis Obispo (SLO), a MS degree in Aeronautics and Astronautics from Stanford University, and an MBA from the MIT Sloan School of Management.

A Euroconsult Canada Analysis: The Fast, Evolving, Smallsats Climate



By Adam Keith, Managing Director, Euroconsult Canada

The concept of small satellites [those classified as below 500 kg] is not new—such designs have been used to test new technologies, support science initiatives and as starting points for the development of more extensive missions.

There is no doubt that the current, significant expansion in the number of smallsats being launched is expected to continue into the next decade.

From 2006 to 2015, a total of 780 smallsats were launched; nearly 500 of these were launched in the last three years alone. This is due to a combination of several factors: More launches of smallsat government missions and an increase in launches from university programs.

However, the main factor was the impact of the commercial sector, Planet Labs (<10 kg) launches in particular. This generated a market value from 2006 to 2015 of $12.5 billion (manufacture and launch).

Explosion In Smallsats Expected

These figures are expected to expand significantly. Over the next 10 years, more than 3,600 smallsats are expected to be launched—that's an average of about 360 units a year. More than two-thirds of these satellites will form part of a wider constellation. This figure excludes the potential 4,000+ units from the SpaceX constellation, STEAM.

This is a four-fold increase from the previous decade. The key factor for the expansion of the number of smallsats is the number of constellation ideas being presented to support global connectivity (in SATCOM) or high-frequency change detection (in Earth Observation), aided by the advancement of satellite system miniaturization permitted by new technologies and/or advances in related sectors, particularly in computational technology.

Outside of EO and SATCOM, numerous university projects will spur further growth along with continued government development to support specific science missions or to support further technology development. The total market value resulting from these over the next 10 years is $22 billion (manufacture and launch), a 76 percent increase over 2006 to 2015 ($12.5 billion).

Although this indicates significant growth, it does not reflect the four-fold plus increase in the number of satellites due to the higher number of CubeSat Earth observation constellations launched. It is important to note that not all of this "market value" is received by prime manufactures; a portion of lower-mass satellites are being built in-house.

Despite the vast increase in the number of smallsats launched between the decades, the breakdown in percentage by mass remains roughly similar, the main difference being in the 250 to 500 kg category, which is not expected to demonstrate a similar expansion as other ranges. In short, the launch of constellations with <250 kg units is the main driver, whereas 250 kg+ satellites tend to be one-off missions.

The former is also mainly in the realm of commercial enterprise launching capacity, while relatively heavier missions tend to focus on government initiatives. The changing shift in smallsat ownership is quite abrupt between the decades.

From 2006 to 2015, 65 percent of launches were from government organizations (civil and defense, including universities); the future decade is somewhat different with over 80 percent of the satellites expected to be launched from commercial entities.

The number of commercial units to be launched does not translate into the same proportion of market value. Commercial entities may develop and launch 80 percent or more of the smallsats between 2016 and 2025, but they account for only 42 percent of the future market value ($9.3 billion).

The reasoning is relatively simple: Commercial constellations use smaller, lower-cost systems to build solutions, with cheaper solutions predominantly sought. This is reflected in the average commercial unit cost of $3.1 million in the coming decade.

Civil government missions are also expected to come down in average cost between the decades. While governments are also expected to seek lower-cost COTS solutions for future development, mission size tends to be higher to support wider mission development.

Payloads, therefore, tend to be more complex, with higher associated costs. There is also greater emphasis on supporting R&D for new mission concepts and technologies, thereby keeping costs relatively high.

Shifting Application Focus

The application of smallsat technology is also going through a notable shift. In the last decade, the most predominant application area has been "technology," an application loosely defined as a satellite designed to test future technologies and payloads; thus, there is applicability across other application areas.

In the future, smallsats will continue to be used to support technology development. However, as an application, that direction will be overtaken by the growth in EO and SATCOM units.

EO is expected to exhibit the strongest growth in terms of units launched—more than 2,000 satellites are set to be launched between 2016 and 2025. Four companies plan to launch more than 1,400 satellites during this period alone: Planet Labs, Spire Global, BlackSky and Satellogic.

The total number of SATCOM satellites will also increase significantly to nearly 800 between 2016 and 2025 (discounting SpaceX's STEAM constellation). There are six constellations foreseen, though OneWeb is expected to comprise the bulk of these units.

Proportionally, the number of satellites to be launched and market value by application are roughly equal. In the case of EO, which is expecting significant (lower-cost) CubeSat launches, it could be considered surprising that the application will account for 58 percent of units to be launched and maintain 54 percent of the total market value. This is accounted for by larger, more complex government EO missions (costing in the tens of millions) being mixed with the expanding commercial supply.

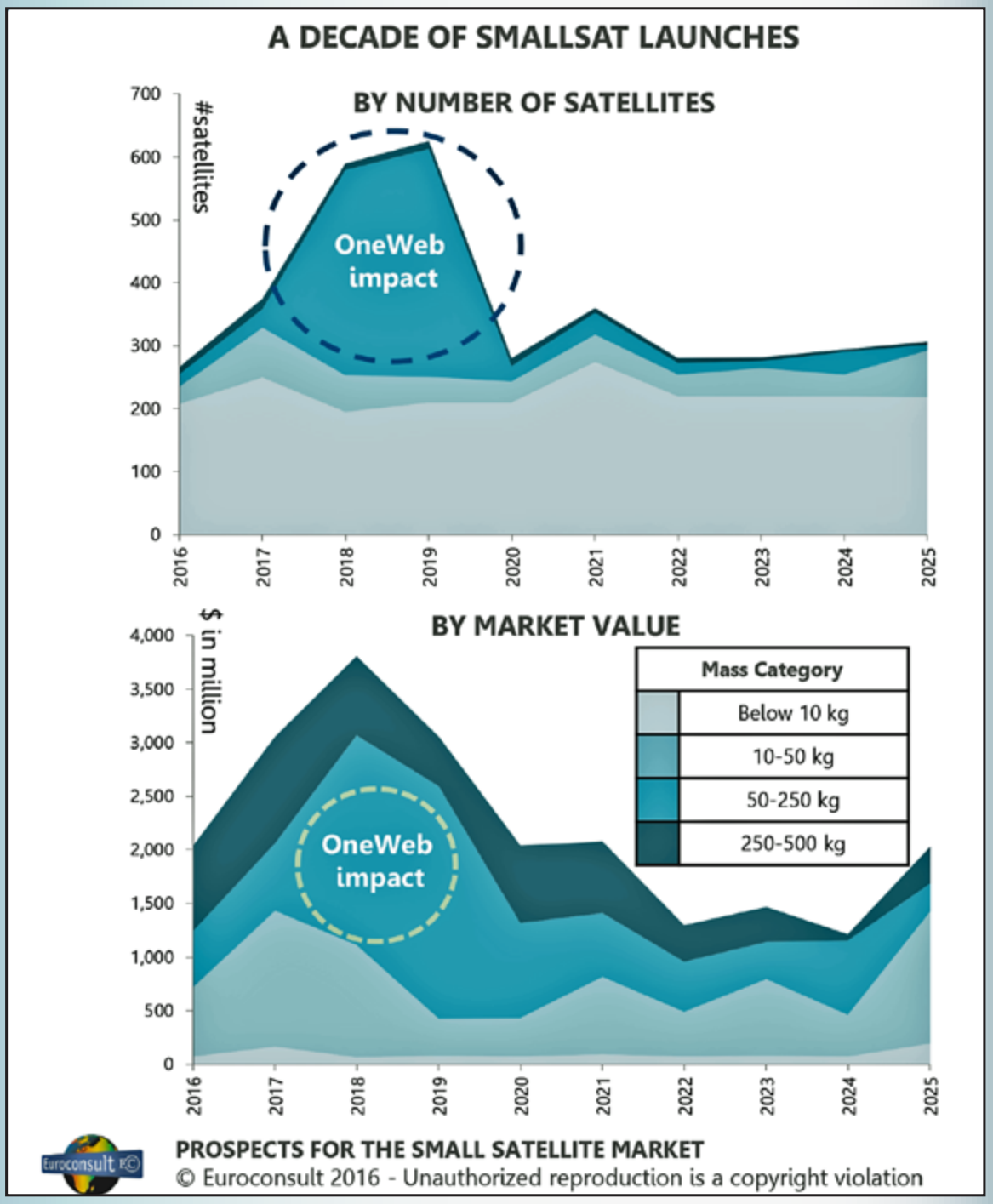
The key driver for the development of EO smallsats is the ability to build a system that provides reduced latency, moving towards as near real-time data collection as possible. Current EO satellite systems are able to acquire point data down to daily rates, though those capabilities do come at a price.

Further, even higher temporal system resolutions (or revisit), reducing latency further into the hourly range, are called for in some application areas, spanning defense, monitoring of infrastructure sites, and perhaps more importantly the development into new application areas built around location-based services and delivered on a web portal subscription basis.

In essence, this is the solution presented by BlackSky, Planet Labs, Urthecast et al., although they have differing application focuses depending on other mission parameters (ground, spectral resolution, etc.). Key enablers of this technology are advances in satellite miniaturization and IT.

Current solutions (such as those from DigitalGlobe and Airbus) provide VHR, high geometric accuracy data from agile cameras at a relatively high satellite cost. Smallsat solutions are invariably less stable, simpler platforms that compromise accuracy (most solutions do not carry advanced star trackers, control moment gyros, etc.). However, the lower-cost approach, reducing the CAPEX, means that operators can price data competitively, potentially disrupting the market.

The key element for SATCOM solutions is being able to provide global connectivity from one system, with a focus on delivering broadband services; the ability to provide connectivity to remote areas at a low-cost being the main driving factor. This is facilitated by new technologies and manufacturing techniques, to mass produce smallsats—moves to higher through-put systems (the HTS market), shift to higher frequency bands (KA) and innovative solutions in the ground segment, including the introduction of active flat antennas. However, there are restrictions that, at least in the short term, will prevent SATCOM satellites from entering the <50 kg class of systems, which is more prevalent in EO.



Opportunities In Manufacturing and Launch

Of the future $22 billion industry market value, nearly $17 billion is associated with the manufacturing of smallsats (including in-house manufacturing). The manufacturing market for smallsats is highly fragmented, with no integrators taking more than a 10 percent market share in either of the 10-year periods assessed.

Including all third-party and in-house manufacturers, around 200 organizations built a smallsat between 2006 and 2015. There is also a clear divide as to what is built in-house versus where third party manufacturers are sought: <50 kg is the realm of in-house company and academia manufacturing; 50 kg+ is largely the realm of dedicated integrating companies (both large integrators and dedicated smallsat manufacturers.)

To illustrate, for satellites <10 kg, only about 1 percent of contracted satellites are expected to be manufactured by dedicated industry, whereas for satellites between 251to 500 kg, the situation is completely reversed, with nearly all manufacturing outsourced.

Revenues generated by smallsat launches in the coming decade are estimated at a little over $5 billion, a 76 percent increase over the previous decade. The figure has grown in relation to more satellites being launched, but as with manufacturing market value, it does not reflect the four-fold increase in the number of satellites to be launched.

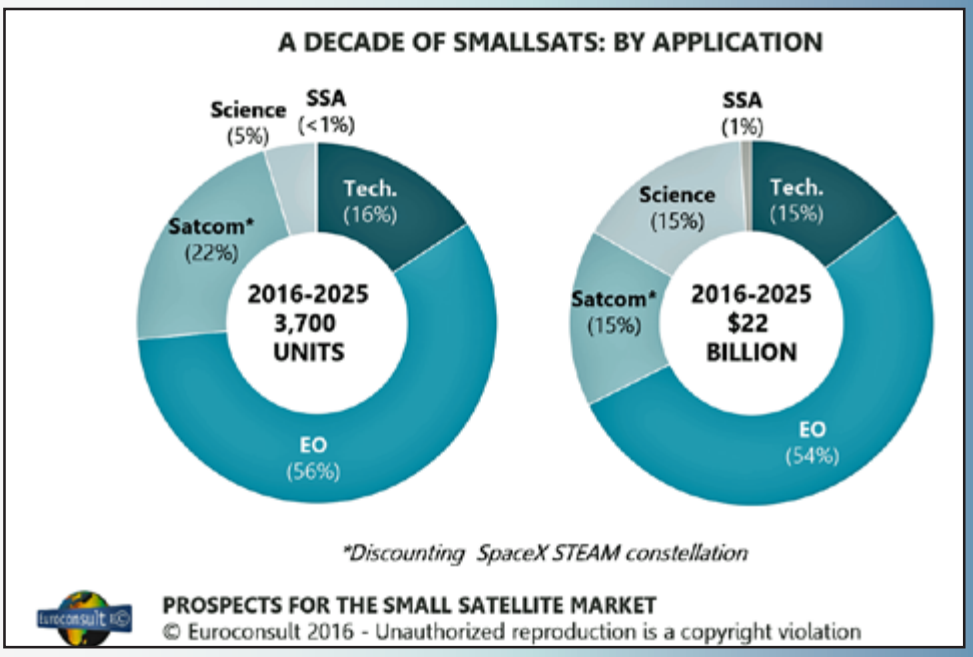
Competition among launch providers, including the development of dedicated solutions, and an increasing proportion in the number of <10 kg CubeSat launched into LEO, are the primary factors of revenues not increasing at the same rate. For LEO, satellite owners have numerous,

possible solutions, ranging from heavy-lift (capable of accommodating multiple satellites) to dedicated small-lift vehicles.

In reality, as heavy-lift vehicles concentrate their efforts on large government and commercial satellites, the largest of the smallsats launched are only a primary payload on medium-lift launch vehicles, while the smallest fly as co-passengers on the same launch vehicles.

Flying as secondary passengers in shared launches does not allow for optimizing the orbital destination. In addition, a shared launch does not allow launch on demand, even if satellite development time was short.

The growing demand for launch to date has been captured mainly by heavy- and medium-lift vehicles through rideshare and piggyback opportunities. Launch price ranges to LEO are from $7.5k/kg to $30k/kg. The variation reflects the differences between vehicles (launch capacity, versatility etc.). For now, launch competition remains driven by price; other factors, such as launch slot guarantee, come second.



Small-lift vehicles in development will add further specialized supply. Prices from Firefly, Rocket Lab and Virgin Galactic are to range between $30k to $50k per kg, meaning they are not expected to undercut existing supply prices.

Smallsat operators have seen greater impact from launch bottlenecks than operators of heavier satellites, given that they are not the first target of existing launch providers, causing delays in finding rideshare opportunities and being dependent on the readiness of the primary payload. Heavier launch vehicles would also expect to host payloads of hundreds of kilograms rather than accommodating numerous smaller satellites.

Despite higher cost-per-kg ratios, the benefit of quicker and dedicated access to space could be attractive for smallsat operators by enabling them to provide operational services in shorter periods of time than today. With these new launch solutions, price per kilogram may not be the only appropriate metric to compare vehicles.

With more vehicles becoming available, operators could be more selective, using length of the launch campaign, launch manifest reliability and services associated with payload integration as additional parameters in their decision making, and could prefer dedicated solutions.

euroconsult-ec.com

Adam Keith is the Managing Director of Euroconsult Canada. In his 15+ years working in the space sector, Adam has advised a wide range of clients including space agencies, government organizations and commercial actors along the value chain. Leading to 2015 he was the Director of Euroconsult's Space and Earth observation practice.

When joining the firm in 2006, Adam initiated Euroconsult's research and consulting activity in the EO sector. He managed and contributed to over 50 consulting missions, specializing in the Earth observation market and industry, satellite operations and government programs. Adam leads the firm's EO research reports, including the flagship Earth Observation: Market Prospects, now in its 9th edition (2016). Starting in Euroconsult's Paris office, he helped set up the firm's North American offices in 2008.

His previous experience includes working for the European Space Agency (ESA-ESRIN). Projects focused on Earth observation market development. He also served as an ESA delegated project manager to the International Charter for Space and Major Disasters and worked in R&D for applications development focused around the Envisat mission. The early part of his career was spent working for the UK National Remote Sensing Center (now Airbus Defence and Space).

Adam holds a Masters in GIS and Remote Sensing from Cambridge University and a B.Sc. in Geology from the University of London. He is a frequently invited speaker and moderator at international events focusing on evolution, market trends and dynamics within the space and EO sector.

Euroconsult's recently published *Prospects for the Small Satellite Market* presents the various factors that will drive/inhibit growth in demand for smallsats over the next 10 years.

This report considers satellites by four mass categories, six regions, five satellite applications and five manufacturer typologies.

Extensive figures and Analysis for the coming decade

All Euroconsult research has, at its core, data derived from over 30 years of tracking all levels of the satellite/space value chain.

To this, Euroconsult has added dozens of dedicated industry interviews each year, along with the continual refinement of their data models, and the collection and interpretation of company press releases and financial filings. The firm's consultants have decades of experience interpreting and analyzing our proprietary databases in light of the broader value chain.

When research from Euroconsult is purchased, thousands of data points are received and included is the expert interpretation of what this means for specific verticals and sectors of the satellite value chain, including forecasts based on years of data and highly refined models.

For further details regarding this informative analysis, addresses the following URL: http://www.euroconsult-ec.com/shop/space-industry/82-smallsats.html

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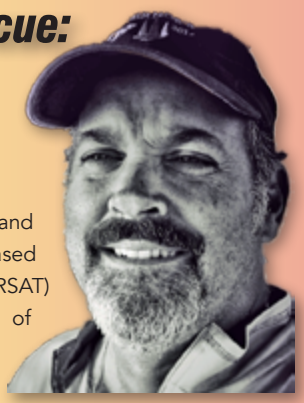
Using Smallsats To Take The "Search" Out Of Search and Rescue: A Hawkeye 360 Perspective



By Russ Matijevich, Vice President, HawkEye 360

In an emergency, minutes matter—however, the aging technologies currently supporting search-and-rescue (SAR) missions can often hamper the efficiency and efficacy of teams racing to save lives.

The current system for collecting and disseminating SAR information is dependent on satellites that are nearing their end of life, resulting in critical gaps in coverage for locating and tracking emergencies once they fail.

The renaissance in smallsat-fueled space mission design, and the increasing commercialization of the Low Earth Orbit (LEO) regime, offers an opportunity to enhance emergency search-and-rescue efforts, often at a significant cost savings over government-developed and deployed systems. In the same way the commercialization of communications satellites in the 1960s and Earth Observation (EO) satellites in the 1990s transformed those predominantly governmental functions, industry now has an opportunity to provide an important public service through the use of space-based radio frequency (RF) spectrum survey technology.

At HawkEye 360 (HE360), one of the company's goals is to use innovations in technology and data analytics to provide disaster response agencies and search and rescue teams with more accurate and timely information, allowing them to better pinpoint people in distress (including first responders) and characterize the post-disaster environment.

The HE360 system, if necessary, aims to bring commercial satellite support to civilian and military search and rescue (SAR) efforts by providing favorable spacecraft collection geometries and low altitude collection. The company has designed commercial RF sensing, geolocation, and analytics capabilities to independently locate and collect information from emergency locator beacons and to account for damaged GPS receivers or locations with poor GPS reception. These are important qualities that will help to maximize the probability of detection and geolocation for isolated persons, especially in mountainous terrain.

The HE360 team plans to work with first responders and emergency government agencies to quickly gather critical intelligence and offer multiple services to support response efforts. Working in close collaboration with these agencies, the company can help take the "*search*" out of search and rescue by providing a cost-effective replacement to the government's aging satellite-aided detection and geolocation infrastructure.

Illustration of the COSPAS-SARSAT system..

SARSAT

The United States National Oceanographic and Atmospheric Administration's (NOAA) space-based Search and Rescue Satellite Aided Tracking (SARSAT) system provides global coverage in support of the international COSPAS-SARSAT search and rescue program.

SARSAT uses an international beacon standard set to broadcast at 406 MHz. Rescue beacons using this standard come in three different configurations: Emergency Position Indicating Radio Beacons (EPIRB) for ship use; Emergency Locator Transmitters (ELT) for general aviation aircraft use; and handheld Personal Locator Beacons (PLB) for personal use.

Each of these beacons report their registration number and GPS location, if available, directly to the SARSAT system to automatically stimulate a SAR response. This system requires the user to make a one-time purchase of the appropriate beacon (based on intended use) and properly register the unit with their country's SARSAT administrator.

Since the beginning of the program in 1982, the SARSAT system has contributed to the rescue of more than 41,000 people worldwide—with more than 280 persons rescued in just the US last year. However, this important system now faces identified gaps in coverage due to the natural aging of the host satellites. These gaps may occur as early as this year while the identified replacement government host satellites experience schedule delays and cost overruns.

As the Trump Administration looks to modernize the United States' space-based infrastructure, the commercial space industry is well positioned to provide advanced capabilities for the SARSAT mission as well as others at a fraction of the cost of government-developed systems.

HE360 offers an example of this emerging capability. By using smallsats, the company aims to bring capability and capacity to the market at a fraction of the cost of traditional government satellite systems.

For example, many government space systems cost hundreds of millions, or even billions, of dollars to develop, launch, and operate. Secondary Payload (such as SARSAT) integration costs for these large, complex satellites can range from $50 million to $100 million. The integration cost savings alone have the potential to fund decades of the company's commercial support to SAR.

Commercial Support to Search and Rescue

For several years, the commercial space industry has supported search and rescue via commercial satellite communications (SATCOM) platforms such as Iridium and Globalstar. These subscription SATCOM services require the user to purchase the required handset as well as to purchase air time on a specific communications satellite system.

These commercial systems typically send location reports to user-designated lists via email or text message. While good for keeping loved ones apprised of location and activity, they're not necessarily fully integrated with the NOAA SARSAT system or the international Global Maritime Distress and Safety System (GMDSS) which, in some cases, could delay search and rescue responses should a user need immediate assistance.

HE360's approach to commercial SAR support will be quite different. The firm is designing what is believed to be the first commercial satellite

system to detect, collect, geolocate, and report multiple signals of interest, including the 406 MHz international rescue beacon standard.

In addition to the 406 MHz standard, HE360 is evaluating an ability to also detect, collect, geolocate and report man overboard (MOB) beacons using the Automated Information System (AIS). In some respects, an AIS-enabled MOB beacon is a better solution for ocean-going mariners because it provides an immediate notification to their ship should they fall overboard, thus allowing for a speedy recovery.

The biggest downside to these AIS MOB beacons is the lack of satellite collection coverage and automated reporting to the GMDSS. (*Author's note: Providing that satellite solution is of particular interest to me, as I carry an AIS MOB beacon when I race sailboats offshore.*)

During 2016, HE360 conducted multiple airborne proof-of-concept tests using a commercial prototype of our satellite's software-defined payload and our geolocation algorithms. Targeting a "*bursty*" signal as the test signal, HE360 subsequently demonstrated that its system can produce geolocations on par with those demonstrated by the testing of NASA's Goddard Space Flight Center prototype Distress Alerting Satellite System (DASS) payload, and well within the overall system's miss-distance requirements.

Flexible Options for Search and Rescue

Currently, the Search and Rescue Satellite Aided Tracking (SARSAT) system and the planned DASS use a dedicated secondary payload on board government-owned satellites. These dedicated payloads are expensive to build and operate.

The HE360 system is designed to be multi-purpose and cost-effective, allowing the system costs to be shared across multiple customer sets, lowering the per-customer operating price.

For example, one receiver on one of the HE360's three spacecraft clusters will be used to continuously monitor for a 406 MHz beacon, freeing up the remaining receivers to conduct other customer missions. Should that one receiver hear a distress call, it would issue an immediate tuning request to the other spacecraft receivers. This would allow HE360's system to rapidly, and efficiently, identify and geolocate the distress beacon using similar frequency and time difference of arrival (FDOA/TDOA) geolocation algorithms to those demonstrated by NASA Goddard during their DASS proof of concept testing. This multi-use construct would significantly offset operating and maintenance costs compared to a dedicated search and rescue system.

HE360's software defined radio (SDR) receivers will also provide the capability to expand the types of rescue beacons that the firm can support. For example, if someone with a commercial SATCOM tracking device is in distress, but has problems reporting their GPS position, the HE360 system could be tasked to locate that user.

Also planned is support for legacy search and rescue beacons if the need arises. Also being investigated is the detection and geolocation of first responder radios/beacons so that HE360 can assist, should the rescuers themselves ever need to be rescued.

Disaster response beyond search and rescue

HE360 is also examining opportunities to support disaster response agencies such as the Federal Emergency Management Agency. For example, in the chaotic aftermath of a natural disaster, such as a hurricane landfall, one of the critical first tasks is to establish reliable lines of communications between first responders, disaster response agencies, rescue organizations, and survivors. Today, this assessment must be performed on the ground by personnel deploying RF survey equipment in a costly, slow, and potentially hazardous process.

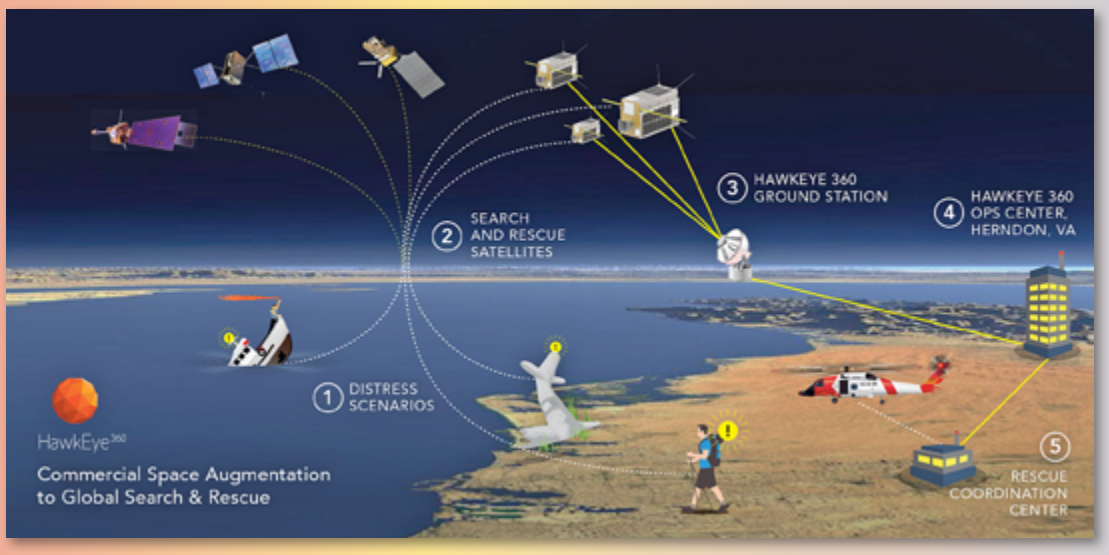
In the future, HE360 aims to minimize cost and reduce personnel risk in this mission area. HE360 is designing its RF mapping capability to quickly identify the wireless communications technologies (*e.g.*, radio towers) still in operation and the available communications mechanisms. This allows a safe and cost-effective way to assess and establish lines of communication between the relief organizations and the survivors.

Cost-effective solutions

As has been noted over the past decade, replacing the nation's aging on orbit infrastructure has proven to be a time consuming and costly endeavor—but it doesn't have to be. Sensible alternatives are available, now, that can provide mission solutions at a fraction of the cost and schedule normally associated with government-developed programs.

This is especially true for secondary (in size/weight/power terms, not importance) payloads, such as SARSAT supporting the SAR mission. HE360 looks forward to working with the Trump Administration to identify and implement the areas where the commercial smallsat industry can help achieve this most important, life-saving task.

he360.com/



As Vice President at HawkEye 360, Russ develops and manages relationships with commercial, government, and international clientele. He is a retired US Air Force Lieutenant Colonel with more than 25 years of space, satellite, and aeronautics experience.

During his military career, Russ led teams on worldwide deployments, integrating space-based solutions into tactical environments; routinely briefed high-level military and civil officials on complex national security issues; and managed high-budget aerospace technology programs.

Since his retirement from active duty in 2011, Russ has served in key business development positions with SAIC and Northrop Grumman and owns his own consulting firm focused on aerospace technology market analysis. An accomplished competitive sailboat racer, he also enjoys songwriting and playing his guitar in church.

Smallsat Startups—Life Imitates Art: A Hogan Lovells Perspective

By Randy Segal, Partner, Hogan Lovells

Every startup is exciting and certainly no more exciting than in the space industry, where virtually anything is possible.

Many satellite companies start off with a clean sheet of paper, which opens up tremendous opportunities to create the newest game changer the correct way from the start. However, satellite-based companies (especially startup companies) require creativity, drive, and significant cash. They also need to overcome many interrelated challenges and risks on the road to success.

As all great entrepreneurs know, failure comes with the territory. There are always bumps (and often disasters) along the road to success, and nowhere more so than when space is involved.

I have been working in the space industry for the past 25 years and have taken a number of startup satellite companies public. All of my startup satellite clients have had hopes and aspirations to accomplish something extraordinary. Today, one would say, they all wanted to become the next billion dollar unicorn.

Enter Small Sats (Smallsats)

The advent of smallsats presents a new, almost "*down to Earth*" way to consider satellite startups. They are less expensive, offer innovation, and present applications that may provide closer (and better) alternatives to terrestrial systems for remote sensing, Earth Observation (EO), the Internet of Things (IoT) and Big Data Analytics, just to name a few.

They provide alternatives to terrestrial solutions for connecting the world and have been embraced by global technology providers as another platform for providing services. Smallsats have been accepted as a means to the end, as an extension of an existing service offering, rather than a separate industry.

For many years, bigger was better: larger satellites, with more complexity, larger antennae, and with extensive years of useful life supported by a multitude of internal redundancies. Now, smaller satellites with shorter useful lives and build cycles allow for quicker deployment, near-assembly line production, and an opportunity for technology refresh along a time period more commensurate with changing technology... a virtual wireless laptop in the sky. At the same time, space startups are never easy and the future of assembly line satellites is not yet a reality. Even with smallsats, there will remain many challenges along the road to success.

Enter the Movies

Along with my passion for all things satellite, I am also a huge movie buff. Movie references often come to mind as I wend my way through my satellite-infused workday. In anticipation of this year's *SmallSat Symposium*, I have reflected upon some lessons learned and catch phrases that encapsulate things to consider when helping to create the next unicorn.

Jurassic Park: "Good things come in small packages."

Some of you may remember the first generation of satellite phones that were used in 1997 in the movie *Jurassic Park 2*. The satphone was a large briefcase device atop a Jeep with one character asking the other "*why in the hell doesn't this thing ever work*?" to which the second character responds "*you know it's not a landline; you're not in a phone booth; you gotta wait for a decent signal*."

The dialogue in the movie reflected what many thought about satellite phones 20 years ago. By the time *Jurassic Park 3* came around in 2001, satellite phones were much smaller, handheld and convenient for use in an impending crisis. Though they'd come a long way, satellite phones still couldn't raise a signal before the dinosaurs attacked.

Apollo 13: "Houston, we have a problem."

Whenever something goes wrong in a satellite project (development, launch, regulatory, or funding) the phrase "*Houston, we have a problem*" goes through my head. And I indeed hear it often. However...

- *Failure is not an option. Just as in Apollo 13, there is usually a solution to be developed, so never give up. In my first satellite startup, my CEO had the real TK Mattingly*

(played by Gary Sinise in the movie) join our team. Mattingly was originally intended as the Command Module Pilot for Apollo 13, but exposure to the measles kept him from being part of the crew at launch.

After a spacecraft "problem" arose and presented multiple, serious risks to the crew's survival and return to Earth, significant team efforts both from the crew in space and the team on the ground (including by Mattingly) heroically, and against all odds, brought the astronauts home safely.

***The Martian:** Space startups are like survival on Mars.*

To me, working on space startups is just like survival on Mars. Something always goes wrong, and if you don't fix the problem, you likely will not survive. This is not a question of "*if*" something bad will happen, but rather a question of "*when*" and "*what*" will happen.

- *You may run out of money, and like oxygen, that's not a good thing. Money for space startups is just as necessary for survival as oxygen, water, and food were to the character played by Matt Damon. His character had to figure out how to grow enough food and how to create enough water and oxygen to survive before he could be rescued. He had to crunch the numbers ("You do the math"), think outside the box, and incorporate all of his skills to work out solutions to the problems he faced. And he had to do it repeatedly as new problems arose that required new solutions ("You solve one problem and you solve the next one, and then the next.")*

  In satellite startups, you also need to determine how to maintain financial solvency to avoid the death (insolvency) of your business, through creative funding, cost sharing, strategic partnerships, cost-cutting measures, and creative business planning. The goal for space startups is to obtain funding (that maintains maximum equity and provides flexibility to cash flow positive), to develop a business plan that closes (with a compelling product), and to create a go-to-market strategy that capitalizes on the market opportunity in a timely manner.

  Given the costs, risks, delays, and challenges historically faced by space startups, there are many notable industry failures and rebirths, even after jettisoning the initial equity. Smallsats present the possibility of greater technical simplicity, lower costs, greater speed to market, and therefore a higher likelihood of success. Many see smallsats as the platform for future unicorns.

- *Regulatory licenses and spectrum. Space startups present significant regulatory issues, costs, and challenges. For some projects it is reflected in obtaining adequate, competitive, or novel spectrum allocations. There are many competitors for such licenses, limited spectrum, and/or challenges from incumbents that must be overcome.*

  Satellites also compete with terrestrial wireless and other new applications, such as drones, for spectrum allocations. Financing often depends on showing that regulatory risks are not insurmountable. Regulatory licensing requirements and spectrum needs are like food, oxygen, and water for many satellite startups: necessary for survival. The risks and hurdles can be tremendous. Add in international jurisdictions, and it becomes even more complex, costly, and time consuming.

- *Delays and cost overruns. As in "The Martian," you can carefully plan and budget what you will need to survive. But inevitably, most startup satellite programs have delays and cost overruns. And like "The Martian," those delays and cost overruns can threaten survival of your business if creative efforts are not expended to develop a solution.*

By the time you get into business, the niche you were targeting may no longer be robust. Satellites can take a long time to build and could result in other business alternatives coming into play. Smartphones, with smaller fit, form, and function and broader terrestrial build out may present less costly and more user-friendly alternatives. Much can occur to derail a business plan during the three to four years (or more) required to build and deploy a startup satellite system. This is precisely part of the appeal of smallsats.

- *Launch Failures (yes, I said it). Satellite launches are not much more than a controlled explosion. Every year we may see a handful of notable launch failures, which often present*

catastrophic business plan implications for the satellite operator, customers, and/or launch services provider.

The prospect of smallsats, and more numerous, flexible, and cost-efficient launch vehicles, presents a potential paradigm shift as it relates to launch failures. Launch or in-orbit failures will be assumed, and additional "assembly line" smallsats can be immediately ready to launch after the statistically inevitable failure. The cost of satellites and launches will be reduced, and backup satellites can be routinely built and launched.

- *In short, satellite startups are like a multi-level chess game. You have to be thinking all the time, at every level, and considering how every requirement ties to the next: financing, regulatory, technical, legal, contractual, business plan, market appetite, and terrestrial (or other) competitors. If any one element goes wrong, or if the timing of any element is not properly considered, it can cause the failure of the entire project.*

- *Something will always go wrong. In all satellite-based programs, it is not "if" but "when" something will go wrong, and how much it will cost to remedy the situation, the delays that are caused, and/or the workarounds that will be required to develop a solution. Creativity will be required. As in "The Martian," you will need to crunch the numbers. You will need to keep on trying and never give up. Think of your creativity and problem-solving as your duct tape. And don't ever forget to bring along your duct tape!*

Star Wars: *Positive thinking and a healthy dose of fear*

Last, but not least, I will close with the quotes which resonate with me the most when I think about the satellite industry. These quotes capture the particular mixture of energy and emotions that define the satellite industry: the power of positive thinking intermingled with a healthy dose of fear.

- *"**I can do this. I can do this**." (Rey and Finn) This is my mantra. I never let fear stop me from trying, but that does not mean that I'm not afraid about the ability to succeed. If you don't try, you will never succeed.*

- *"**Never tell me the odds**." (Han Solo) Positive thinking and a "can do" attitude will build the confidence of your team and counterparties, which alone may lead to success that otherwise would have been elusive.*

- *"**Are you sure you are up for this**?" (Han Solo to Finn) You may often feel this way, but do not let it stop you. Unicorns are created by people who don't accept failure, and even if they do fail at some point, they just get up and try again.*

- *"**Traveling through hyperspace ain't like dusting crops**." (Han Solo) Satellite startups are not for the faint of heart. It takes a strong will, technological sophistication, and determination not to let obstacles stop you in your tracks.*

Will smallsats bring about change for satellite startups?

Yes, but it still ain't going to be like dusting crops!

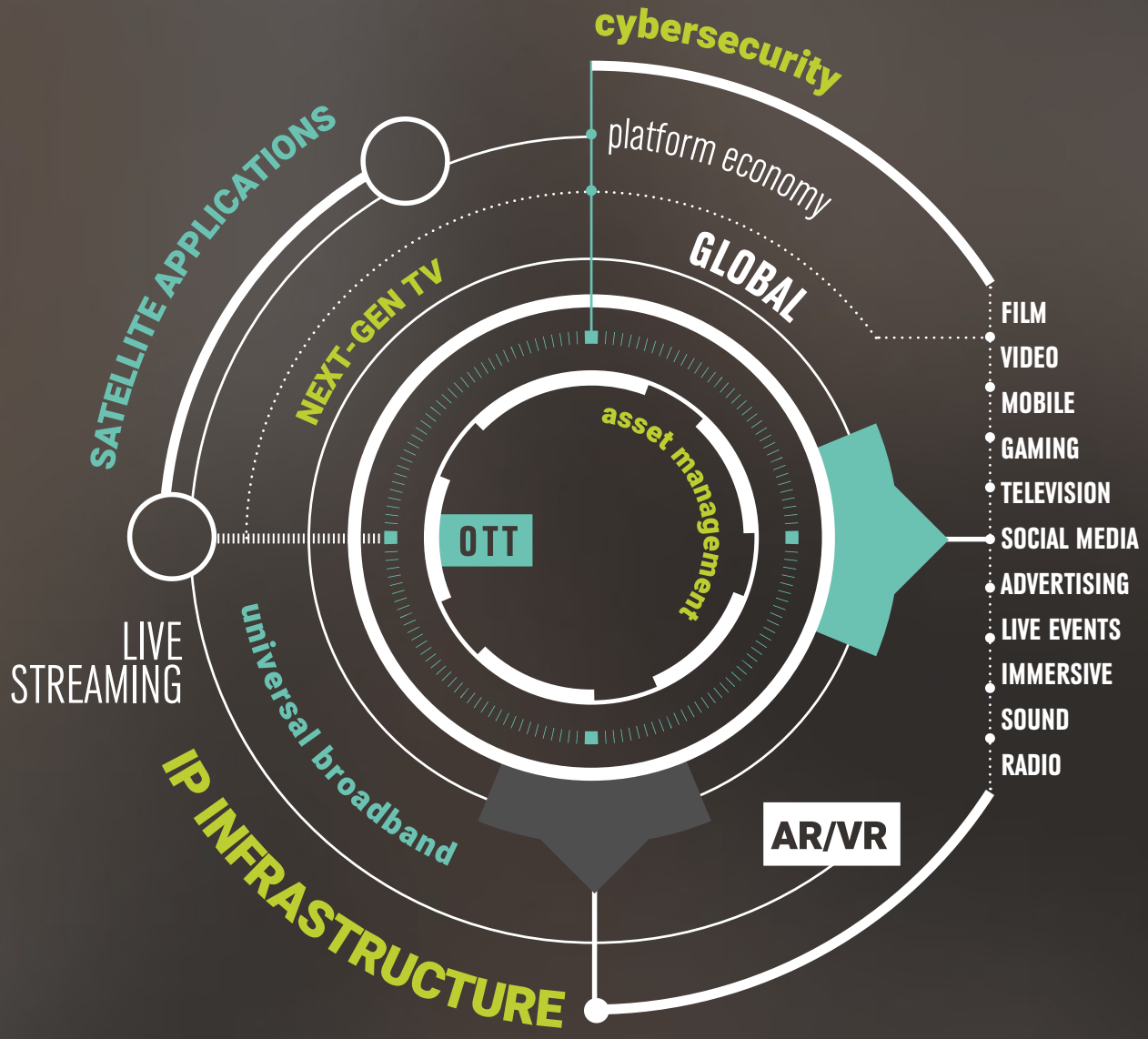
hoganlovells.com/randy-segal

With 18 years of in-house general counsel experience, Randy Segal brings an individual perspective to every matter she handles, both as your outside counsel and as someone who has walked in your shoes. With a focus on satellite, wireless, drone, and technology transactions, Randy provides commercially practical solutions in industries where technological change is ever-present. Randy's practice often involves multi-level chess games, where every move needs to be considered from a multitude of angles to be successful.

As a result, Randy's practice is reflected in three segments. First, as co-leader of the Space and Satellite practice, Randy has handled many types of transactions, from day-to-day matters to the most complex international transactions for industry operators, investors, and technology providers. She has been involved in taking companies public, advising on acquisitions, divestitures, and complex cross-border joint ventures, as well as large satellite system development, deployments and funding.

Second, as advisor to technology investors and their portfolio companies, Randy has advised on transactions focused on big data analytics, IT, wireless systems, spectrum licenses, environmental analytics, wireless proximity analysis, drone technology, terrestrial positioning, and other innovative technologies.

Third, Randy provides "strand of pearls" advice to global clients, working seamlessly with their international offices to develop familiar, comfortable and "right sized" solutions. Randy's extensive cross-border experience has resulted in an extensive tool-kit of resolutions for the most complex of legal regimes. Randy's transactional and advisory experience is both deep and broad, working throughout North and South America, Europe, Asia and the Middle East and on the most complex of international programs and legal issues.



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LET'S THRIVE.

Cybersecurity Best Practices for Smallsat Ground Networks: A Kratos Perspective

By Ted Vera, Business Area Manager, Cybersecurity Lead, RT Logic, a Kratos Company

With numerous examples in the news, it should come as no surprise that cybersecurity attacks are on the rise.

Verizon's *2016 Data Breach Investigations Report* summarizes 64,199 cybersecurity incidents including 2,260 breaches with confirmed data loss that occurred during 2015 alone[1]. Intel Security / McAfee's conservative estimate of the annual cost to the global economy from cybercrime is more than $375 billion in losses[2]. These attacks targeted all types of public and private organizations and industries, highlighting the fact that there are no network connected systems that are immune from online threats.

Smallsat ground networks are no exception—they, too, are exposed to an increasing number of targeted cyberthreats, including those attempting to exploit vulnerabilities not found in most traditional Information Technology (IT) network environments.

This article is intended to be a security primer for smallsat ground network operators, discussing security best practices such as Information Assurance (IA) hardening and continuous monitoring; leveraging frameworks such as Defense Information Systems Agency (DISA) Security Technical Information Guides (STIGs); and tools such as Security Information and Event Managers (SIEMs) and Security Content Automation Protocol (SCAP) compliant applications.

Mission-Unique Attack Surface

Ground networks have unique cybersecurity challenges such as: mission-unique equipment and applications, specialized protocols; high regression test costs and tight budgetary constraints. Mission-unique equipment found in satellite ground networks primarily consists of radio frequency (RF) signal processing gear and test equipment such as oscilloscopes, spectrum analyzers and channel simulators.

Specialized protocols and applications include Software Defined Radio (SDR) and Command and Control (C2) suites among others. These niche devices, applications and protocols present unique attack surfaces for potential exploitation. As end-to-end IP architectures become mainstream in smallsat ground networks, additional security challenges are introduced.

Unlike traditional network environments, which are primarily concerned with IP based attacks, satellite ground networks also need to consider RF based threats. For example, in addition to Internet based scans, amateur satellite enthusiasts are on the constant lookout for new satellite feeds detectable using low-cost commodity RF hardware and open-source software.

> **Smallsat Tip**: Attacks like this demonstrate that, when possible, it is important to encrypt not only command and control links, but also telemetry / downlink channels. Even simplex telemetry containing unencrypted metadata can lead to potential exploits.

One such exploit is described in a report by Kaspersky Labs which claims that a Russian-speaking spy gang known as Turla uses hijacked satellite IP addresses of legitimate users, sent as unencrypted metadata, to steal data from other infected machines in a way that hides their malware command and control server[3].

Resources and Best Practices

Recognizing that smallsat ground network operators may lack the resources and budgets of traditional satellite operators, it is beneficial to leverage lessons learned, along with frameworks, and tools from Government and Industry to help better defend their networks.

The NIST Special Publications (SP) library provides a wealth of information and resources that can be leveraged by smallsat ground network operators who are just getting started developing a security program. The SP800 series consists of Computer Security related guidelines, recommendations and reference materials. The new SP1800 series Cybersecurity Practice Guides provide practical user-friendly guidance to help public and private sector users adopt a standards-based cybersecurity approach.

Security Process

Before diving into the technical controls that are often the initial thought for network engineers, a solid security program must include policies and procedures to help manage the security needs of the organization. NIST SP guides and frameworks can be used to help establish and drive policy. Tools, such as the Risk Management Framework and Contingency Planning Guide, can help an organization get a strong starting point for security and IT infrastructure beyond purely hardware related controls.

An overview of the Risk Management Process is contained in ***NIST SP 800-37 Guide for Applying the Risk Management Framework to Federal Information Systems***. The Risk Management Framework is an iterative process consisting of the following six steps: Categorize, Select, Implement, Assess, Authorize, and Monitor, as illustrated in ***Figure 1*** above.

> ***Step 1:*** *Categorize the information systems and the information they process, store and transmit, based on a risk/impact analysis.*
>
> ***Step 2****: Select the baseline security controls and tailor as needed to meet the organization's risk assessment.*
>
> ***Step 3****: Implement the selected security controls and document how they are employed within the information system and its operational environment. DISA STIGs and SCAP tools can be used to help automate and document portions of this step.*
>
> ***Step 4****: Assess the security controls to ensure they are implemented correctly. Assessment can be accomplished using automated vulnerability scanners (i.e.: Nessus) or through manual inspection and validation. DISA STIGs and SCAP tools can be used to help automate and document portions of this step.*
>
> ***Step 5****: Authorize operation of the information system based on determination that residual risk is acceptable to the organization.*
>
> ***Step 6****: Monitor information system security controls on an ongoing basis. Practice good configuration management to document changes to the system and operational environment. SIEM and SCAP tools can help automate and document portions of this step.*

> **Smallsat Tip**: Each step in the process can be tailored to meet the specific needs of the organization.

Figure 1.

System Hardening

NIST 800-53 provides general guidance for security controls; however controls do not always translate easily into actionable items that can be implemented on a system. DISA Security Requirements Guides (SRGs) are a compilation of Control Correlation Identifiers (CCIs) which break down NIST SP 800-53 controls into actionable items, grouped into specific technology areas such as operating systems, applications, networking devices, and policy.

DISA STIGs are validated hardening guides, updated quarterly for major operating systems, applications and network hardware. Configuring systems in accordance with applicable STIGs can help to remove or mitigate configuration vulnerabilities present in satellite ground network devices.

The DISA STIG Viewer is a freely available tool that can be used to complete and document STIG checklists while implementing system security controls. Download it at ***http://iase.disa.mil/stigs/Pages/stig-viewing-guidance.aspx.***

Continuous Monitoring

SIEMS are a product class that can help organizations meet their continuous monitoring requirements through real-time event processing, alerting and reporting. Included in this category are CyberC4:Alert and CyberC4:Guard from RT Logic, a Kratos Subsidiary.

CyberC4:Alert, the first SIEM designed for satellite networks and operations, provides real-time cyber situational awareness for satellite ground networks; and CyberC4:Guard to protect satellite control-related communications across unclassified and classified domains within secure networks.

The use of SIEMs in the commercial sector has become an industry-accepted best practice for monitoring security risks. Real-time alerting helps mitigate the risks associated with vulnerable mission-unique equipment, specialized protocols, untimely patching, and deprecated protocols. Furthermore, scripted active response capabilities allow an organization to fight through a contested network environment.

> **Smallsat Tip**: Challenges associated with implementing a SIEM for a smallsat ground network include: developing custom plug-ins for mission-unique equipment; monitoring specialized protocols, and writing rules and scripts for active responses to detected threats.

Smallsat systems are vulnerable to cyber threats and care should be taken as ground networks are designed. The guidelines and tools presented in this article can help secure smallsat ground networks from potential hackers and cyber threats. Ground operators can benefit from the resources and tools that are broadly in use among Government organizations. NIST Special Publications provide a solid framework for establishing a comprehensive security program.

DISA STIGs and tools can be used to perform and document information assurance hardening of smallsat ground network devices and applications. Security Information and Event Managers and SCAP compliant tools help the organization to continuously monitor security controls on an ongoing basis.

Ted Vera is a Business Area Manager and Cybersecurity Lead at RT Logic, a Kratos company.

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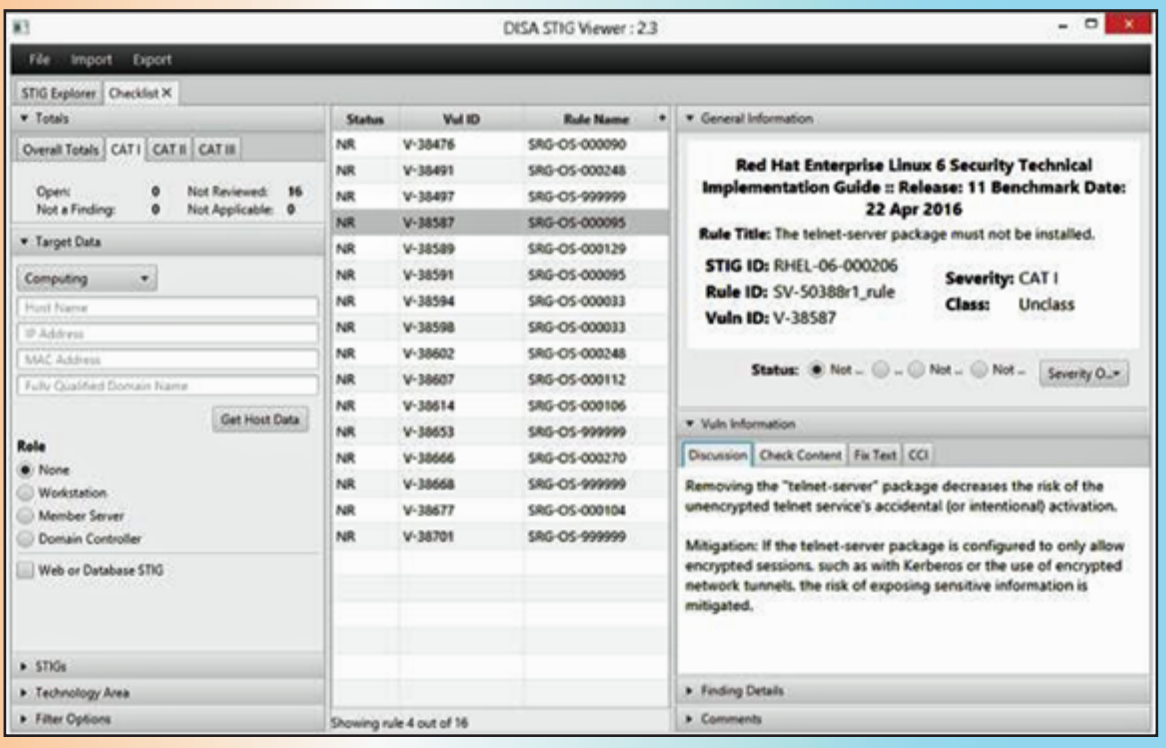
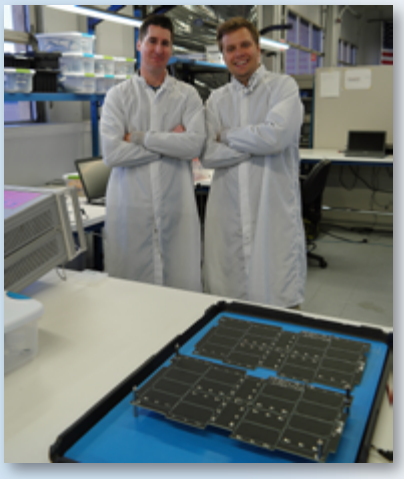


Delivering The Globe: An Interview with KSAT and Astro Digital

By Arild Jose Jensen

KSAT (Kongsberg Satellite Services), based in Norway, recently signed a new contract in Silicon Valley with Mountain View-based Astro Digital, a company founded on enabling big data analytics from space.

Astro Digital and KSAT worked together to bring this new Ka-band capability into the KSAT Lite portfolio. They have created a cost-optimized Ka-band solution, in line with X-, S- and UHF/VHF solutions. The result is a commercially available Ka-band asset designed for high throughput and at an optimized price point.



KSAT's uniquely positioned ground stations—spanning from 78 degrees North in Svalbard, Norway, to 72 degrees South in Antarctica—offer coverage that few can match.

KSAT Lite, the ground station network optimized for smallsats and constellations, allows affordable access from any point in the world.

As US Sales Director, Stig-Are Thrana, emphasized, "*Continuous innovation and development of new capabilities is of paramount importance to us.*"

Astro Digital designs, manufactures and operates the Landmapper constellation of satellites from their office located in the NASA AMES Research Park. This company has designed a system for maximum throughput of data from space to Earth, with the KSAT Lite ground stations a critical component of this system: they enable data deluge from space, all the while keeping costs in line with the scale of data produced. Together, KSAT and Astro Digital intend to revolutionize the collection and delivery of big data.

Astro Digital's Landmapper constellation includes two satellite designs. The first is Landmapper-HD, which is a 16U CubeSat that captures the blue, green, red, near-infrared and red edge spectral bands. The second design is Landmapper-BC, a 6U CubeSat that captures the green, red, and near-infrared spectral bands. With 20 Landmapper-HD and 10 Landmapper-BC sensors in the constellation, Astro Digital will produce a global, daily feed of imagery tuned for trend and change analysis. The Landmapper constellation is tuned for large scale monitoring of crop, forest, urban, and infrastructure land use as well as on-demand applications such as disaster response and national security.

Silicon Valley features everything KSAT and Astro Digital need to be successful: an ecosystem built on pioneering technologies, the most cutting-edge smallsats neighbors and a pool of talented innovators.

Interviewed by the author, Arild Jose Jensen (AJJ), are...

Stig-Are Thrana, Director of Sales, Kongsberg Satellite Services—he heads Kongsberg Satellite Services in the Silicon Valley. He has more than 10 years of experience in satellite and radio communications, derived from his work at Telemar, Polaris Electronics and the Norwegian Navy. Thrana received his B.S. in Entrepreneurship and Innovation from Oslo.

Chris Biddy, Co-Founder and CEO, Astro Digital—he is the co-founder and CEO of Astro Digital and runs operations, develops partnerships and leads the company's overall direction. Prior to Astro Digital, Biddy led the Engineering team at Canopus Systems, directing efforts to build commercial satellite systems. Biddy received his M.S. in Mechanical Engineering from California Polytechnic State University.

Arild Jose Jensen (AJJ)
What is most valuable about the KSAT-Astro Digital partnership?

Sig-Are Thrana (SAT)
Together, the companies are paving the way for commercially available Ka-band applications and high data rates from small spacecraft.

Chris Biddy (CB)
We are innovating together from two different perspectives—spacecraft and ground infrastructure designed for high-volume data capture and downlink, as well as a business model that makes the massive data load accessible for a fast-growing company like us. We benefit from leveraging each other's complementary technology and infrastructure.

AJJ
How is Ka-band different than other bands?

SAT
Ka-band allows for higher bandwidth and more data to be downloaded each day. This is exactly the same as obtaining higher and higher data rates on your mobile phone and on your wireless routers over the years. The technology in our ground stations is groundbreaking. This will contribute to making Astro Digital—and their customers —successful.

CB
By building our transmitters to operate in the Ka-band spectrum, we achieve very high data rates in small, efficient packages. The high rates enable us to get large volumes of imagery from the satellite to the ground; the small packages are an added benefit because they lower the cost of our satellite and our launch. Because the cost of our imagery data is reduced, we can attract new customers in the commercial market and change the way traditional government buyers access large-scale monitoring from space.

AJJ
What inspired you to enter the satellite world? What was your journey?

SAT
During my time in the Norwegian Navy, I started working with radio and telex systems. I learned about communication and bridge systems, particularly radio and VSAT technology, while finishing my B.S. in Innovation at the Oslo

Business School. My quest for new challenges brought me to KSAT.

This has been a fascinating journey. I have learned a great deal and have dealt with space businesses at every scale, from leading space agencies and world-class satellite companies to space startups. I initially brought KSAT Lite to the drawing board but, since then, the service has developed robustly, benefiting from the feedback of smallsat companies as well as the expertise of the experienced KSAT team.

CAD

My business partner, Bronwyn Agrios, and I met through a shared contact in the satellite industry and quickly realized our potential to collaborate—bringing together my team's expertise in designing small and highly capable spacecraft and her background in building mapping products. There were many highly capable smallsats, but my 10+ years of work building smallsat systems and Agrios' product experience came together to move beyond existing solutions. We recognized the inefficiencies in the market and saw ways to optimize the remote sensing system for the life of a satellite.

I like to make the analogy that our CubeSat are currently in their "*Model T Phase.*" Like the Model T, CubeSats are made to a standard. This standard makes Astro Digital satellites compatible with any launch vehicle available for a ride to orbit. The satellite can be designed independently of the rocket that takes it to orbit because it has a standardized size and shape. This maximizes the opportunities to get to space and reduces the time and cost to get there.

AJJ

How has the satellite world changed in the last five years?

SAT

Wow—that's difficult to provide a short answer, but I believe what we are seeing right now (in the LEO industry) is—from my perspective—both intriguing and disruptive. There are so many changes in so many parts of the value chain—spacecraft buses and platforms, payloads, availability of launches, new platforms on the data and downstream services—and, of course, cutting-edge ground station solutions. All of the above bring new capabilities and price points to the market.

The number of competing companies has brought the cost down, allowing more efficient and faster deployment. The industry is working collaboratively and pushing its limits. Since the beginning, we have been working with market leaders, aiming towards standardization to keep future costs low.

CB

We are seeing an expansion in the user base of remote sensing data. Traditional government buyers and military applications have extended to include more emphasis on uses for commercial business. New technology makes possible solutions and business models that are attractive for commercial customers. We have been able to produce an extremely capital-efficient solution. We keep our overall costs down and create products that are accessible to both government and commercial markets.

AJJ

How will the satellite world change in the next 10 years?

SAT

Who would dare to answer that question in print? Apart from a significant increase in constellations rather than single satellites, one trend I clearly see is that the satellite industry is no longer a "locked community" as it once used to be. Of course, the industry will become even more open over time. Different industries are obtaining a clearer vision on how their businesses can benefit from satellite information and solutions in space. The satellite industry, in turn, is searching to see how it can partner with technology from other industries to bring new value to customers.

In the end, this is all about creating value to users—from improved cost points, or better access to actionable information, user friendly platforms, combining multiple sources of data/information and more. The software industry is now in space and enables this in a totally new way.

I believe the space industry shares many similarities to the changes that swept through the computer industry during the last decade. The big conglomerate organizations and new space startups will find a mutual middle ground and begin to use "*the best practice of both worlds.*" They will not be as separate as they have been during the past years.

CB

The demand for big data has grown to staggering levels. Market growth for agriculture alone would have been unimaginable even two years ago. Close to $166 million was invested in satellite technology for precision agriculture in 2015, up 140 percent from 2014. Based on the collected data, experts now predict that global crop production must double over the next 35 years to keep pace with growing needs. Easy access to information places greater emphasis on data-driven decisions. This trend is apparent across many verticals, and will fuel innovation in the satellite industry over the next ten years.

AJJ

What is the biggest challenge facing the satellite industry today?

SAT

One of the big bottlenecks today is launch capacity, but that might change quickly over the next year or two with the current ramp-up from existing and new launch providers. At least we hope such will be the case.

CB

Stig and I see eye-to-eye on this one. Launch is probably the biggest challenge facing our industry today. We build on the CubeSat standard so we can take advantage of the "*rideshare*" business model that has really improved the opportunities with existing launch vehicles.

We need to see the reliability of this area of the industry to improve so that launches slipping by a year isn't the norm. We also need to see business models for launch continue to evolve so that we're not paying 90 percent of the launch up to as much as a year before the actual launch itself.

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The World's First "NEP Certification": A KSF Space Perspective

By Dr. Kayyali Mohamed, Founder and CEO, KSF Space

The NEP Certification pathway will address aerospace engineers and experts and will be recognized by major space companies, organizations, foundations and agencies.

Many industries are going to work with KSF Space to review the content of the course material and accredit the certificate by recognizing NEP Certification as the world's first and only smallsat engineering professional course.

One example of an aerospace company in the US that recognizes the NEP Certificate is Interorbital Systems in California—that firm aims to develop simple, yet robust technology to become the lowest-cost launch provider in the commercial space industry. Interorbital Systems is currently engaged in building a launch vehicle for the Google Lunar X Prize and for commercial launches.

Another aerospace company in US who recognize the NEP Certificate from KSF Space is Exos aerospace, a company that has taken the skills acquired from more than a decade of practical lessons learned, and millions of dollars worth of development and flight experience gained by the KSF Space team, and moved into the commercial space race—Exos Aerospace has fulfilled multiple contracts with NASA.

NEP recognition

NEP Certification will come to the market early this year and will be totally concentrated on the smallsat market sector. The benefits of being NEP Certified include...

- *Recognizes space engineering skills across the globe: an NEP credential is a perfect addition for all aerospace engineers*
- *Noting smallsat skills to international employers: an NEP credential will become globally recognized and required—becoming NEP certified helps the aerospace engineering companies world recognize needed skill sets*
- *Reveals the ability to handle challenging complex satellite projects: the NEP exam eligibility criteria are based on a space engineering education and experience. A credential proves these skills and experience by successfully completing challenging and crucial industry-based aerospace and smallsat projects.*

The certificate program will be divided into two major criteria:

1. *NTP NanoSatellite Technical Professional Certificate for VET (Vocational Education Training)*
2. *NEP NanoSatellite Engineering Professional Certificate (For Engineering and post graduate level)*

Diversifying investment into academic and vocational education provides more options for training, meeting the needs of a more diversely skilled youth. Moreover, in the long-term, more widespread levels of education are associated with increased tax revenue and lower levels of unemployment. There is also some, albeit limited, evidence linking education to health care savings and a reduction in crime.

Individuals typically earn more after undergoing vocational training. The gains for level 3 qualifications or apprenticeship can be as much as a 20 percent increase in average wages and a 14 percent increase in employment prospects.

Level 2 qualifications remain primarily a stepping stone to level 3 qualifications, in terms of improving career prospects.

In the near future, the importance of vocational training for the economy may rise as demographic shifts and technological advances affect the industrial landscape. The aging population is projected to require an increase in vocational positions, especially in sectors such as the smallsats industry. These are positions that cannot be easily replaced by machines, and they require need young, healthy, skilled workers in order to be filled.

KSF Space initiative was basically addressing VET sectors and working to encourage developing countries to build better futures for their nations by gaining such accredited certificates. KSF Space is currently seeking potential partners (foundation, universities, organizations and private sectors) to support this global initiative.

An NEP Certificate will be globally recognized and accepted and will assist in ensuring better job opportunities in the satellite industry in the future. Many future jobs will have a mandatory requirement of an NEP certification—if some satellite /telecom / electronics engineers are not NEP certified, they may not be qualified for the position, no matter how many years of experience they may possess.

Being NEP Certified means...

- *You will have chances for collaborating and networking with other NEP professionals around the world, which can certainly increase your chances of professional success and development.*
- *You will be ahead of other NEP professionals, in terms of nanosatellite engineering knowledge as well as its application in the field of nanosatellites.*
- *Attaining a NEP Credential, you can reach out to potential employers from across the globe.*
- *There will be a great demand for the NEP certified employees.*

Also, KSF Space is working with academic sectors across the globe to manage and help them write proposals and to then submit them to KSF Space's Amateur Radio partners to win a scheduled event for a direct and live communication with the crew of the International Space Station (ISS).

KSF Space will enable students to chat directly with crew members of the ISS and will encourage them to engage in various discussions of science, technology and engineering. Radio organizations and space agencies in the USA, Russia, Canada, Japan and Europe sponsor this educational opportunity by providing the equipment and operational support to enable this direct communication via Amateur Radio. Hundreds of Amateur Radio operators around the world work behind the scenes to make these educational experiences possible.

According to Said Dr. Kayyali Mohamed, the founder of KSF Space, the company works with all universities and academic sectors that are interested in such experiments and will support and guide them in writing their proposal and off the guidelines for managing winning proposals.

In addition, KSF Space announced they will assist universities and academic aerospace, engineering and telecommunication departments to train students on how to construct and build smallsat (CubeSat) Ground Segment (GS) in order to track missions such as the QB50 initiative.

Finally, KSF Space will also announce the world's first initiative between universities globally to kick off an R&D project for smallsat "*Developing Bid Data Integrated System Approach for NanoSatellites,*" with more than three universities having already signed a contract with KSF Space for Ph.D. and Master degree research collaboration—the project should start by mid-2017.

ksf.space

KSF Space was initially founded to enable cost-effective access to LEO with zero-environmental impact flying solutions. The foundation offers access to near-space and LEO for research and scientific experiments in many fields, such as Earth or Space Observation, biological testing, satellite positioning detection, Earth magnetic field measurement, radio transmission, atmospheric science and technology experimentation. The foundation encourages universities to develop R&D missions using smallsats, as these tiny spacecraft have become one of the most important elements in developing future scientific space missions.

Late last year, KSF Space Foundation signed a Memorandum of Understanding (MOU) with Interorbital Systems (IOS), wherein the latter firm will identify launch opportunities as well as provide associated pre-launch support for KSF missions.

According to IOS, by mid-2017/early 2018, the firm will initiate launch services for smallsats to a circular, polar orbit at 310 km altitude. Their current manifest numbers 135 smallsats awaiting launch.

Interorbital Systems has developed a simple, robust rocket technology that will enable that firm to be the lowest-cost launch provider in the commercial space industry. Interorbital Systems is currently engaged in building a Moon rocket, NEPTUNE 8 LUNA (N8), for the Google Lunar X Prize Team SYNERGY MOON and other NEPTUNE rocket-series variants, such as the N3, and N5 for commercial satellite launches.

KSF Space was initially founded to enable cost-effective access to LEO with zero-environmental impact flying solutions. The foundation offers access to near-space and LEO for research and scientific experiments in many fields, such as Earth or Space Observation, biological testing, satellite positioning detection, Earth magnetic field measurement, radio transmit, atmosphere science and technology experiment.

The foundation encourage universities to develop R&D missions using smallsats as these tiny spacecraft have become one of the most important elements in developing future scientific space missions.

My Payload Won't Fit Into A CubeSat... Now What? A NovaWurks™ Inc. Perspective

By Walt Mirczak, Director of Systems Engineering, and Bill Crandall, Chief of Advanced Products, NovaWurks™

CubeSats have revolutionized the nanosatellite/smallsat market, making space available to more people than ever before for their spacecraft.

The availability of CubeSat kits and components and government sponsorship of launches has changed the landscape for entry into the once cost prohibitive world of small satellites. Traditionally the realm only of large multinational companies and big government agencies, now universities, smaller government labs, and many start-up companies are able to afford to test out their ideas on orbit.

What's Next for "Small Space" and Where Do We Go From Here?

CubeSat-specific technology developments began within universities, government agencies, and industry. As noted in the National Academies report, "*Achieving Science with CubeSats, Thinking Inside the Box*," the pace of CubeSat development accelerated rapidly in the mid-2000s with an expansion of both the number and the type of organizations, with commercial missions accounting for the largest single use type.

However, as the needs of the space community grows, a new, supportive approach to building satellites is emerging. Birthed out of the DARPA Phoenix program and advancing CubeSat technology, this approach uses mass produced building blocks (cells) to fabricate the satellite, known as a Package of Aggregated Cells or PAC, either on the ground or on orbit.

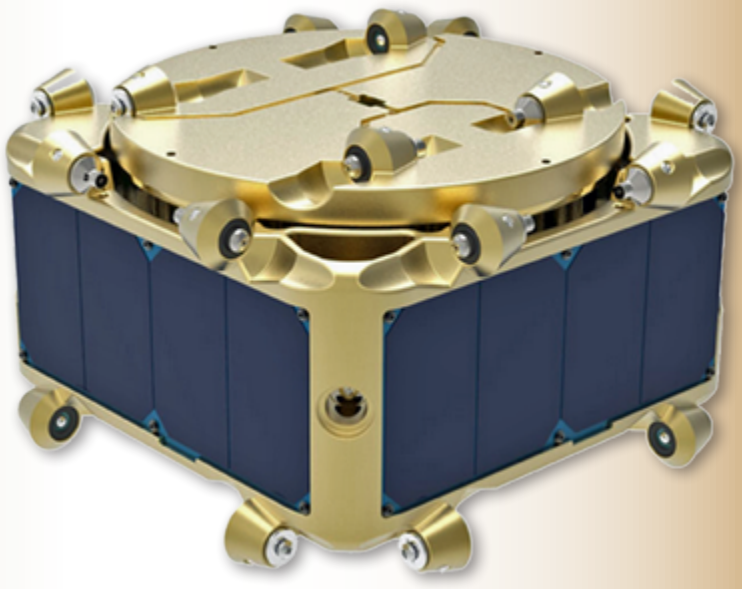
Each building block, called Hyper-Integrated Satlets, or HISats™, is identical and contains all the functions that the satellite requires. Each HISat's role in the satellite is configured by software to optimize the entire spacecraft. All HISats share power, thermal, and are in constant communication with one another. The software can move functions around within the architecture to minimize thermal impacts, or maximize data storage or throughput, as needed to support the payload.

As the HISats are designed to be mass produced, the cost of building a HISat PAC is greatly reduced compared to traditional approaches, and the consistency of building with mass produced standard building blocks improves quality and reduces risk in the integration and test phase. Moving beyond CubeSats, HISat PACs from 75 kg to more than 3,000 kg have been designed to support various payloads and missions. The HISat building block was designed and qualified for GEO and is therefore radiation tolerant for most orbits.

The advantages of a building block approach to configuring a satellite bus may not be obvious, but the benefits are many. The initial motivation for CubeSats was focused on education and training (formal, informal, and early career development), and HISats also possess characteristics well suited for those areas. They are relatively affordable and provide easy access to space. As discussed above, the cost is greatly reduced due to mass production. However, what might not be as obvious is the incredible flexibility in accommodating a payload.

A HISat PAC is payload centric, meaning that the payload can be designed in virtually any size or shape that is best for the payload, and the HISats are used to build the spacecraft bus around the payload. Payload NRE, schedule, and therefore time to orbit, is minimized.

The flexibility of the HISat PAC is one of the reasons that NorthStar is cooperating with the NovaWurks team to assess this new bus technology for the build of 40 LEO satellites designed to keep tabs on the environment, both in space and on the ground. The NorthStar satellites likely will not all carry the same complement of payloads, so multiple configurations of HISat PACs will be needed to accommodate the various payloads, yet they all use the same architecture with significantly lower costs for the different configurations. PACs are even combinable on-orbit which provides benefits now being discovered by the space exploration community.



Still Not Convinced?

Resiliency is another key benefit to a HISat PAC. With multiple HISats configured by software, many management options become available to the user. All spacecraft functions are aggregated to provide greater power, throughput, memory, orbit knowledge, thermal capacity, and control authority. In the case of failure, multiple cells have the hardware needed to replace the failed unit by simply re-configuring the satellite function based on the remaining HISats. Instead of switching from primary to redundant on the satellite and hoping no other failures occur, a HISat PAC has multiple ways of recovering from errors that a traditional satellite just can't implement.

HISats have completed thorough flight qualification to space environmental standard (GEVS) levels and are currently at technical readiness level 8 (TRL 8). In addition, HISats are approved for assembly inside of the International Space Station (ISS), and are in fact currently on the ISS awaiting satellite assembly by the astronauts. The satellite on the ISS is comprised of six HISats, two solar arrays and four payloads that will be assembled, on orbit, inside the ISS, then launched.

A second larger spacecraft, called eXCITe, has been fully assembled in the NovaWurks cleanroom, functionally and environmentally tested to meet Falcon 9 and SHERPA flight requirements and is currently awaiting launch on an upcoming Falcon 9 out of Vandenberg AFB in 2017. This mission will fly in a LEO SSO with an attached telescope which will be released by the HISat PAC to become a free flyer. In total, this HISat PAC carries five payloads and will test and validate a number of CONOPS requirements throughout its lifetime.

A third HISat PAC has been delivered to a GEO host for integration and completion of spacecraft level environmental vibration and thermal vacuum testing. This HISat PAC will be deployed fr`om the GEO host to fly on its

own and gather data in the GTO/GEO environments. The launch of this vehicle is also planned for 2017.

How HISats Improve on CubeSats

HISats are similar to CubeSats in that they are a disruptive innovation in the space industry as well as within industries that use space-based resources. Both have been advanced by enabling technologies and commercial enterprises with business models not followed by incumbent aerospace vehicle providers. Both have followed the unique characteristics that define disruptive innovation in that they are significantly cheaper, and offers a price point that attracts the underserved, those with new applications and industry users not typically in aerospace.

As a result, CubeSat and HISat performance have improved rapidly. However, CubeSats typically have less capability than traditional spacecraft while HISats have actually achieved improved performance while still remaining at a relatively low cost.

In contrast to CubeSats, a benefit of the building block approach is improved early payload testing. A single building block can serve not only as the interface to the payload but also accomplish actual payload to real PAC functional testing. This can be done as early as the payload is ready, and can be done at NovaWurks or at the customer's facility. The HISat software is designed to be transparent to the payload, so if you have one HISat connected to the payload it is the same as having many HISats connected to your payload.

Payload to HISat PAC integration is streamlined by use of the User Defined Adapter (UDA), which is a programmable 'space ready' support system that allows for flexible and rapid integration. A marked improvement from CubeSats, this standardized interface, the UDA, provides power, data, and thermal management to the payload.

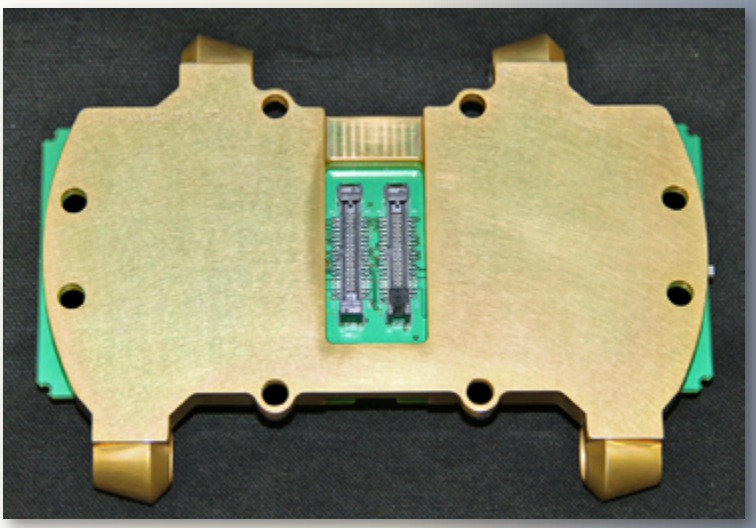
One or more of these UDAs are used to provide the payload a HISat interface that can be placed, as needed, on any HISat or carried across multiple HISats. The aggregation capability of the HISat PAC allows the payload to be structurally supported by multiple HISats, but also to combine the thermal transfer capability, and also the ability to port data to multiple HISats to increase throughput from the Payload to the PAC, and to get valuable data into the HISat provided Solid State Recorders built into each HISat.

This data can be processed onboard or sent raw to the ground. The HISat PAC can host the radio or optical downlink solution that is best for the payload. And similar to CubeSat deployers, PACs can easily be secondary payloads by using UDAs and any of the standard separation mechanisms that are readily available for launch vehicles.

What Else Can HISats Do?

In addition to the missions already discussed, there are several upcoming missions in work, with launch dates in 2018 and beyond. Some of these missions have available space for payload hosting. These flights make payload hosting easy for the payload developer to fly a one-time experiment, or to fly a proof of concept payload, or to raise the TRL of a payload. Hosted payload missions are very cost effective and can accommodate virtually any payload at a cost lower than developing a CubeSat. All on orbit satellite bus support is provided and a configurable soft ride launch allows payloads to meet a less stringent vibration qualification prior to launch.

The commercial space industry is expected to grow rapidly over the next 10 years, mainly due to advances in small satellites. Small satellites are producing images and data useful to industries here on Earth, such as agriculture, mining, and banking, and at costs well within the range of traditional startup seed funding. Many of these scientific or commercial missions require multipoint data, *i.e.*, large constellations. Similar to



NovaWurks™ UserDefined Adapter (UDA).

CubeSats, HISats are a natural choice for these types of missions as a PAC constellation cost is more likely within budgetary constraints, especially for more sophisticated or capable payloads. And like the low cost of CubeSats has brought a whole new set of risk paradigms to the space industry, HISats can also be used in hazardous orbits where the risk to a traditional large space vehicle is not acceptable—for example, utilizing the atmospheric boundary region and lower ionosphere where orbital lifetimes are short.

Other future missions will focus on dedicated payload hosting for single satellites or constellations, providing outstanding in-class performance for micro- and mini-satellites and even larger spacecraft at a lower price point than alternatives. Because the HISat PAC conforms to the payload, NRE in payload design is reduced as well. HISats can conform not only to the payload, but to any launch vehicle, and to any orbit including LEO, HEO, MEO, GEO, or beyond.

NovaWurks is democratizing space where anyone, regardless of background, can bring their innovation, ideas, and talent to the market. The HISat PAC construct has the ability to host larger payloads than can be hosted on CubeSats, and provides the interface to several standard launch adapters. Designing with HISats provides Scalability beyond CubeSats, Flexibility beyond CubeSats, and Resiliency that rivals any unmanned satellite flying in space today. All of the benefits of cellular architecture are cost competitive to current systems with the added advantage of saving NRE in payload design and integration.

If you are looking to fly a payload larger than a CubeSat can accommodate, then a NovaWurks HISat PAC has a solution that you need to investigate. Discuss with NovaWurks how a HISat PAC can provide everything needed, and all at a lower cost and a shorter build schedule.

novawurks.com/

Walt Mirczak is Director of Systems Engineering at NovaWurks™ Inc., a provider of high technology space products and services. Mirczak is responsible for leading the team in development of mission and system architecture concepts that incorporate innovative engineering approaches. With more than 30 years of experience, Mirczak has been responsible for multiple projects from conceptual design through on orbit operations. He held a series of progressively responsible positions at Northrop Grumman Aerospace Systems including TDRSS Launch Team Leader and On Orbit Test Manager.

Bill Crandall is the Chief of Advanced Projects at NovaWurks™ Inc., a provider of high technology space products and services. He oversees and is responsible for business development and project management at the company. He has more than 30+ years of experience working an all aspects of hardware design, including the building process and the testing of high reliability products. He also has more than 20+ years of experience working on space-qualified hardware.

An NSR Analysis: Behind the Scenes of the Smallsat Revolution

By Carolyn Belle, Senior Analyst, Northern Sky Research (NSR)

Smallsat operators leverage a different model for success than that of traditional satellite endeavors, requiring a unique and robust supporting industry of manufacturers, launch providers, and in-orbit services.

Emerging and growing smallsat operators are scaling up activities in response to growing market potential, resulting in NSR's forecasts for the launch of nearly three thousand smallsats through the next decade. Alongside this strengthening of smallsat usage and anticipated future demand has come the development of ancillary services tailored to smallsat operators: components and manufacturing, launch solutions, communications systems, and niche services.

The two are codependent; smallsat operators depend on these services to efficiently implement their business plans, while the service providers require smallsat operators as customers. The ongoing strength of this supporting industry is a critical, behind-the-scenes factor in addressing lingering and emerging challenges to enable smallsat market expansion.

Smallsats, and particularly the new mindset regarding how to leverage smallsats, require a support architecture distinct from the one already in place for larger, conventional satellites. Characteristics such as use of COTS components, rapid and iterative design-build-launch cycles, high rate production, small launch mass, low frequency communications, and strict cost controls were not fully accommodated by traditional suppliers—even the likes of SSTL who specialized in smaller platforms—prompting development of solutions by operators themselves and presenting a market opportunity for new commercial players. Companies have emerged to fill this gap in three main areas: manufacturing, launch, and in-orbit services. Whether operators elect to address requirements entirely commercially or with a combination of in-house and commercial components, the building blocks to implement diverse smallsat missions are converging.

Manufacturing

During the flat growth years of the early/mid-2000s, the smallsat market was largely using CubeSats based on kits or with COTS chassis and components combined with consumer electronics. Some manufacturing and most integration was performed in-house. Component options were limited, and the scope of operator involvement was high—a barrier to entry and an impediment to capability expansion.

The establishment of more systems-minded companies such as Tyvak presented the option of procuring full nanosat busses, simplifying an operators' design and integration process. As a result, operators could focus on payload and overall mission development as well as keep a leaner staff. This has expanded from nanosats to a variety of smallsat busses in recent years, facilitating activity in a wider array of form factors and alleviating the engineering expertise requirements of operators even further.

Forty commercial prime manufacturers have now obtained heritage in the smallsat arena, and an additional nine have secured prime contracts without heritage. Operators thus have more competitive offerings to choose from, yet gaps remain: some operators have elected to build in-house because the right combination of price and capability remains unavailable in the market.

As suppliers turn R&D into improved capabilities, operators are leveraging these to enhance the business case and address demand previously unattainable. For example, higher power can lead to longer duty cycles or the use of on-board processing, more precise ADCS can enable simulated apertures, or propulsion can allow a satellite to reach an optimal orbit from a sub-optimal launch trajectory.

Testing and quality assurance are new areas of development for smallsats. While the industry started with a test-in-space mentality, and some operators continue to rely on this for rapid proofing, as customers begin to depend on uninterrupted smallsat services the risk of failure overshadows cost and time drawbacks of testing.

The growing military and government user population in particular requires a higher degree of quality assurance throughout project lifecycle. Yet the cost of owning and maintaining test equipment and trained personnel is often prohibitive—the emergence of full service testing facilities such as at Utah State University's Space Dynamics Laboratory or SSL mitigate the expense and expertise requirements.

Launch Services

Launch access has long been the main challenge of smallsat operators. Early university-based efforts to coordinate the launch of several smallsats on a single vehicle go back to 2003, but widespread acceptance of the rideshare model was slow to manifest: additional satellites were seen as an added risk to the primary payload, and even if willing to host secondary payloads, most launch service providers did not want to undertake the task of coordinating many small payloads for minimal added revenue.

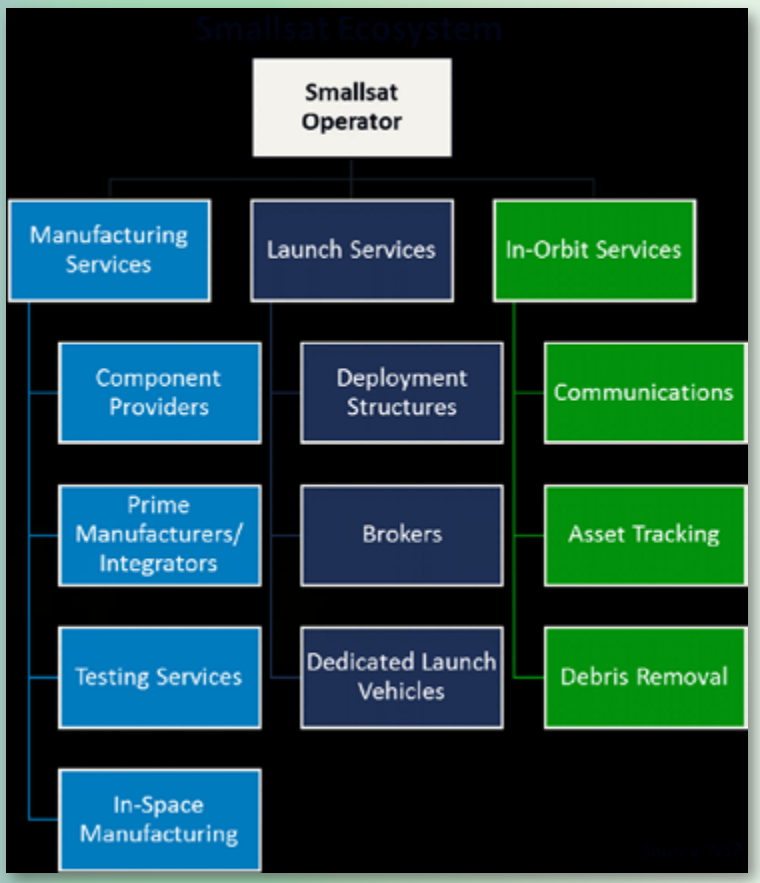
Two developments from the supporting industry were key to countering these challenges: reducing risk and risk perception, and simplifying the process for launch service providers. Universities and commercial players developed canisterized deployers to control secondary payloads until after the primary payload was released.

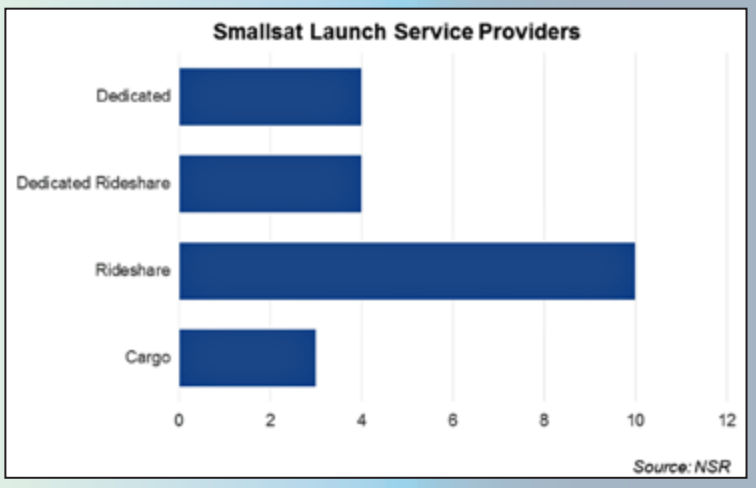
The advent of commercial launch coordination and brokerage services, such as Spaceflight Industries and Innovative Space Logistics, increased access by simplifying the coordination required of launch service providers and consistently engaging a wider net of vehicles—especially those like Falcon 9 that would have been unavailable without pooling. Brokers also alleviate operator strain by addressing the tasks of export licenses, ITAR compliance, dispensers/deployment systems, and interface control.

Rideshare continues to provide the highest availability for launches, a consequence of more than twice as many active service providers as present for other launch methods.

The first ISS cargo deployments in 2012 opened a new avenue to orbit for smallsats and nearly doubled launch rates. While only three players are active, ISS has been a source of an average 51 percent of launch access since NanoRacks established a regular commercial service in 2014.

While access to orbit is critical, access to the right orbit on the right timeline are what the commercial and government/military operator communities require to build a strong business case. As mission goals become more complex, and as constellations are spread across several launches, reaching the right altitude and inclination with every launch is key to optimizing capabilities and satellite lifetime.





Dedicated Rideshare missions will partly address this for popular orbits, but dedicated vehicles are required to give operators full control over launch variables. Operational dedicated vehicles are too expensive, and while dozens more are under development, delays have been common. Affordable dedicated launch is the most pressing demand of smallsat operators on the supporting industry.

On Orbit Services

On orbit services has been the slowest sub-market to develop, as volume demand emerged only after commercial efforts began in earnest and more advanced smallsats were designed.

Most smallsats through the 2000s operated with a low data rate, meeting requirements with a 9.6 kbps UHF system downlinking only when passing the operator's own rooftop antenna. As data collection abilities increased, operators lacked the ability to downlink all data with such low data rates and infrequent passes.

Industry was initially slow to respond, though plans for higher throughput technology and end-to-end services have now set the stage for a robust market of communications solutions. New offerings such as BridgeSat's optical payload and ground system, or X- and Ka-band transmitters paired with a globally distributed ground segment such as Atlas Space Operations or KSAT Lite, offer higher throughput, frequent passes, and more cost-effective access.

Several data relay networks, both LEO- and GEO-based, are in planning stages as well and would allow operators to reduce scope of the on-board data downlink system—saving mass and volume. With these new solutions, operators will be able to retrieve a greater volume of data, feeding demand for Big Data and enhancing science objectives. Moreover, leased access to commercial systems reduces the CAPEX and effort an operator would spend to achieve the same functionality.

The ballooning amount of smallsats on orbit, short lifetimes, frequent failures, and rising concerns about space debris have pressured operators to take more responsibility in maintaining the space environment—both for self-preservation and industry-wide efforts at space sustainability. New commercial satellite and debris tracking services like LeoLabs can reduce the threat of collision at deployment and during operations, manufacturers are developing a series of devices to rapidly de-orbit retired satellites, and debris removal services have been pioneered to actively eliminate non-responsive satellites or debris. Greater availability and utilization of these services by operators is critical to the long-term health of the smallsat market and its acceptance within the wider space industry.

Bottom Line

The innovative mindset and approach of smallsat projects has demanded a myriad of new services and a distinct supporting industry to address unconventional requirements. Satellite industry veterans and entirely new companies have emerged with offerings tailored to this demand, eliminating barriers to growth and facilitating smallsat market evolution.

This ancillary industry is important not only to provide operators the building blocks to implement their plans, but so that operators can outsource requirements to concentrate on business objectives. Ancillary players have already delivered behind the scenes benefits to the smallsat market, but the two must continue to develop in tandem if smallsat growth is to become a smallsat revolution.

Carolyn Belle is a senior analyst for the market research and consulting firm Northern Sky Research (NSR), based in Boston. Her main focus is international satellite manufacturing and launch markets, and in particular the trends surrounding creation of diversified space architectures including the growing utilization of smallsats.

Ms. Belle regularly contributes to the diverse tailored consulting projects undertaken at NSR, lending expertise to feasibility studies, satellite procurement assessments, analysis of competitive dynamics, and addressable market sizing for both start-ups and industry leaders.

She came to NSR from the Research and Analysis team at the Space Foundation, where her research efforts primarily addressed new and emerging space products and services as well as International Space Station utilization. She has been active in leading STEM outreach initiatives such as Yuri's Night and Cool Science.

New Interconnection Tools for Smallsat Electronics: Omnetics Connector Corporation

By Bob Stanton, Director of Technology, Omnetics Connector Corporation

The exponential growth of smallsat technologies is driving a rapid expansion of miniaturized sensors, image devices, data analysis systems and even micro-sized onboard computers that we will all benefit from.

Two leading programs have pioneered a way for lower cost, shorter time to data and new information that was nearly unachievable in the past. Both CubeSat and TubeSat systems allow and encourage individual satellites to be launched into the atmosphere to gather, analyze and send data that can be used in many ways. Private launch companies such as SpaceX, Orbital, Virgin and others offer a range of options from rocket launch to space-plane releases to carry and release a plethora of miniature orbital devices to applicable orbits in space.

Universities have gained significantly from early lifts on larger space launch systems and can now ride up on lower cost, more available launch methods that will serve mankind's innate needs for more new data... and faster.

However, as more advanced electronic devices and interconnect systems are being configured for these smallsats, some additional factors must be considered to assure longer term performance and reliability. Critical factors to plan for include survival during launch and flight to orbit, performance during orbit and longer term effects from the environment.

During the design phase, a good idea is to start to use and design using TubeSat and CubeSat kits that can help significantly in getting a set of proven standard architecture up and running during the development of new programs. For example, Interorbital Systems Corporation is a key supplier and educator that assists universities and small corporations worldwide. ***See photo on right of their TubeSat and CubeSat assembly kits.***

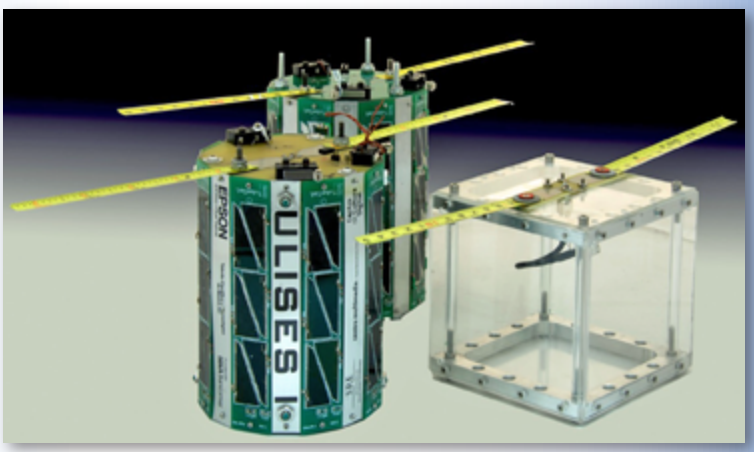
As JPL and other government labs are getting more involved in smallsat programs, attention to connector and cabling materials, design and processing capability should be reviewed. We see smallsat sizes changing, being used in double stacks and many electronic functions getting more sophisticated.

With new components and systems on-board, one must insure they perform and remain reliable during high shock and vibrations that occur during launch.

As many circuits run at very low current and voltages, they now allow the use of wire gauge to be 30 awg or smaller and connector sizes to be as small as nano-size. Over the years, nano and micro pin and socket connectors have proven performance in smallsats and beyond into deep space to even perform well on Mars.

Micro pin standard spacing is at .050" pitch and nano pin standard spacing is set at .025' pin to pin. Their size and weight is about one-third that of micro-sized connectors and, when mounted onto PC boards, survive High-G shock better than larger, heavier connectors. Planning to use gold plated BeCu spring pins mated into sockets help to retain constant signal integrity over some of the older spade and blade connectors, especially when in lower atmospheric environments. Use of "Non-Outgassing" materials are critical in many space applications.

Designers should watch carefully when designing with connectors to insure that the epoxy sealing of the pins and sockets are NASA certified. Chlorine and other gasses that can emit from heated connectors will directly destroy the silicon circuitry in the system.



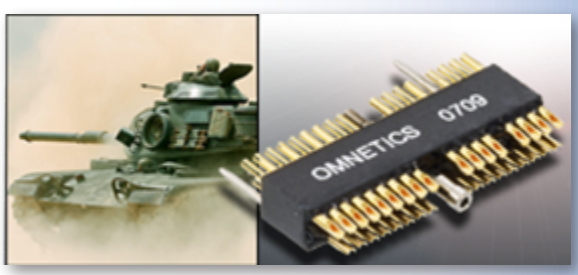
TubeSat and CubeSat kits from Interorbital Systems.

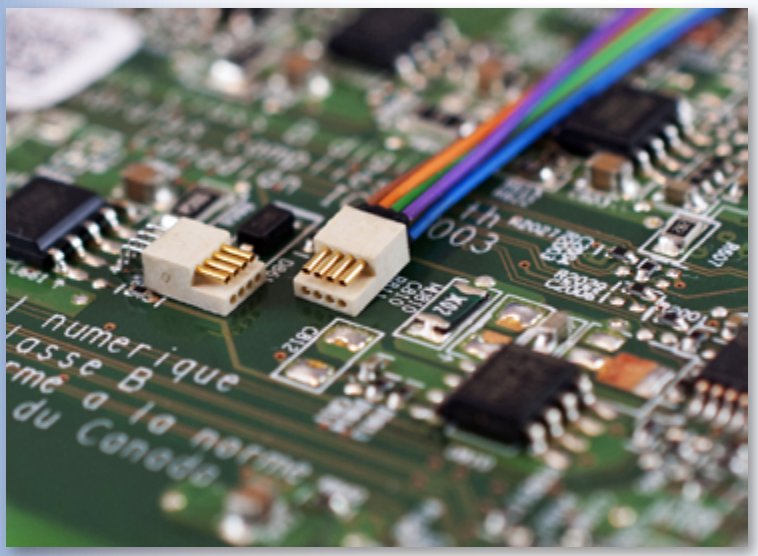
Various styles of micro and nano-sized edge card connectors can support either small diameter wiring and or directly mount onto flex-circuits. DuPont now offers space qualified Paralux® HT and Paralux® TK flexible circuits for some of the most efficient inter-module wiring available and can be connected directly to PC boards or with connectors.

Designers should also consider reviewing the circuit modules for differences in the thermal coefficient of expansion of the materials they use. Boards have been known to expand rapidly and tear-off components that don't expand at the same rate.

To help protect from some problems of gas erosion or physical damage, one can pre-seal circuits for critical applications using Paralyene®. This coating provides strong, pinhole-free coverage for crevices, sharp edges, and unusual shapes that protect circuits while allowing the boards to flex and expand as the device travels through potentially wide temperature changes in space.

The function of many of the smallsats vary greatly and the selection of cable to connector style is often driven by the electronic signals needed. Many smallsats are aimed for LEO at 160 km around the Earth.





Omnetics' Nano Connectors.

LEO satellites traveling at near 18,000 miles an hour and have little time to reside over any one portion of the Earth.

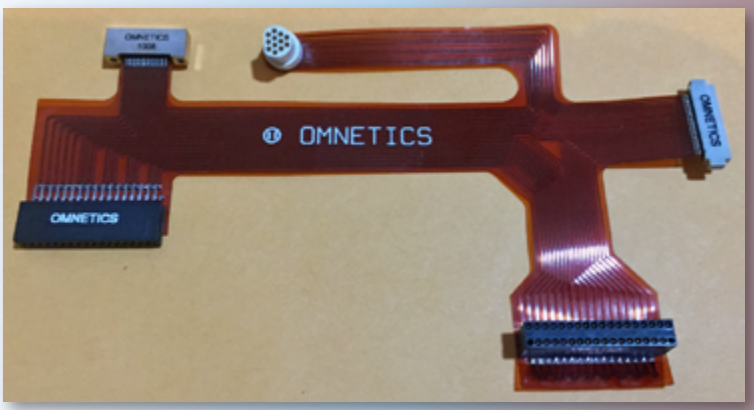
They are also traveling through some atmospheric drag that can cause a low level continuous vibration. In some cases the cable and connector should be shielded from EMI, (electromotive interference and or solar energy spots).

Orbit speed also directly affects some applications. Satellites with imaging agendas need to gather high resolution images at a very high rate as the unit flies over its target.

For example, a camera using even a small frame size of 20 Megapixels must run at 30 frames per second and will be consuming 5 to 7 Gigabits of digital data per second. Ultra-miniature connector and cabling will be routing this information to computer storage and or transmission equipment. In this case the cable and connector must handle massive high speed signals while maintaining a very low bit error rate to provide the full view image.

Matched cable and connector to the impedance of the circuit is critical. These interconnect systems are now available in both micro- and nano-sized systems that add very low weight and mass to the system.

As smallsats expand their technology and the functions they provide universities and industry, new connector and cable designs can be quickly modeled and upgraded to meet the needs.



Flex Circuits and Nano Connectors

Omnetics and other connector design companies offer variations of current designs using lower cost solid work design models.

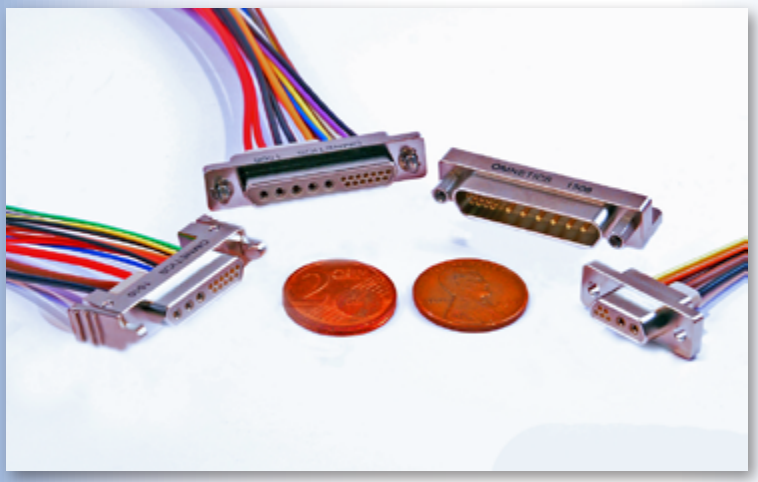
Oftentimes, connector designers work online with smallsat developers to visualize the new connectors and fit them into tight spaces and show wiring routes. Solid models of new connectors can direct 3-D printing and/or connected directly to CNC machines to help make new application specific connectors.

One example of quickly-made custom connectors are those offering the combination of power and high speed digital signaling within one micro or nano cable system. Instead of two cables, one serves both purposes. The connector has larger pin and sockets designed for the power rating needed but separated from the set of smaller signal pins and sockets.

Size and weight are reduced, while signal integrity is maintained for higher speed signal management.

Many standard connectors are also available that have been certified for EEE-INST-002 in COTS and Standard inventories from Space qualified connector suppliers. Miniature space rated connector technology is ready and available to serve the smallsat industry.

omnetics.com



Estimating the Income Generated from a Satellite Mission: A Saber Astronautics Perspective

By Dr. Jason Held, Chief Executive Officer and Director, Saber Astronautics

A key part of any business plan involving satellites is the ability to estimate potential income for the mission—this task is just as important for investors doing due-diligence on a new company as it is for large established companies deciding on a new program.

Estimating income, however, is a complex problem due to relationships between the customer products, the satellite's ability to deliver and the planned orbits. A change in any one of these three categories can affect the others and can greatly affect the profitability of the mission as well.

This article shows how to use the Predictive Ground Station Project (a.k.a., "PIGI") to map these relationships and quickly estimate a mission's income potential during the conceptual design stage. The approach is mapped within the context of a workshop for entrepreneurs and universities, delivered as a competition.

Participants are given some constraints—a $2.5 million budget to 'purchase' satellites and infrastructure, modeled in PIGI, and must balance strategically the impact of spending more money on ground infrastructure vs. more money on satellites. The Participant with the most profitable mission profile wins the competition and receives a small award, chocolate for the younglings, or a bottle of wine for older participants.

About PIGI

PIGI is mission control and simulation software developed by Saber Astronautics which uses video game technology to enable people to operate large numbers of satellites with very little training. The science behind video game technology is a mix of computer science and human factors. Commercial studios compete heavily in making games which allow people to handle large complex tasks with the greatest speed and minimal training.

PIGI represents ongoing research applying the same principles to space operations. There are two reasons why this is important today.

First, the complexity of spacecraft data has steadily increased over the last two decades. Modern designs are calling for greater fidelity of health with increased number of telemetry items requiring tracking. For example, the 560 kg NASA Advanced Composition Explorer (NASA ACE) satellite, launched in 1997, operates on 1,600 telemetry words, updating every 16 seconds. Twenty years later, there are many commercial satellites of one-fifth the mass of the NASA ACE which demand 6,000 telemetry words, updating at 1 Hz. This increase in complexity is likely driven by better technology and greater demand for reliability. Faster computers and better communications mean that better health data is available.

Second is the growth in the number of NewSpace companies in the last three years, in particular, CubeSat missions. There are several trends to note—the costs of a CubeSat mission is fairly low, $150 to $250 thousand for a minimal viable product.

Space entrepreneurs are not necessarily from the space industry, and while most of these ventures have talented engineers, many are recent graduates or otherwise new to the field. This has resulted in a range of errors, sometimes affecting the flights, sometimes affecting the operations, and always affecting the pocketbook.

PIGI handles these two problems (complexity and training) by creating a single global simulation, data management, and user experience. Navigating the simulation is designed to be familiar to anyone practiced at playing first-person shooters.

Complex data, such as detailed telemetry, is abstracted by the graphics until the user needs it, *i.e.*, via an alert system or on demand from the user. Also, similar to video games, much of PIGI's ergonomics are meant to encourage self-training. The UI is icon rich and text is minimized where possible. Icons and other graphics were tested to be as intuitive as possible regardless of age, sex, or ethnicity of the user.

The simulation datasets include the Hipparcos star charts (~150,000 stars), magnetic field models, gravitational, and SGP4 orbital mechanics. Space weather integrated data is provided by the Space Environment Center (NOAA/SEC) and Australia's Department of Meteorology. Users can import their own satellites using a Python driven CAD converter. Implemented in C++, PIGI is currently in Alpha-release PC and Mac.

Saber Astronautics started using the PIGI casual license in a range of entrepreneurial workshops last year as part of user testing. The workshops, designed for students/STEM, and entrepreneurs/enthusiasts uses a simple but effective 'cookbook' approach. The methods are simple enough for most people to participate but with high enough fidelity to give reasonable solutions suitable for feasibility studies or conceptual design missions.

Define Customer and Product

First, a set of customer requirements and space delivered products are defined. Conventional satellite products usually fall within the realm of space imagery, scientific data, or communications. Simple examples are the publicly available panchromatic photos transmitted by NOAA weather satellites or data transmissions relayed from a ground based IoT sensor. Workshop members define the use cases for the products and identify any impacts to spacecraft design. Of interest is the size of the product in bits and the location where their customers are regionally located.

The spacecraft SATCOM system is also considered, in particular calculating theoretical upper boundaries for data downlink rates. A simple approach is to use Shannon Information, which provides a theoretical limit to the capacity of channel.

The equation is high school level, so it is easy and quick; however, there are also limitations in estimating data rates. Shannon does not consider a full link budget analysis, multiple access requirements, losses, etc. Data header information and overheads, such as encoding, and check sums are also missing, so expansion ratio is applied. At early stage mission planning, SATCOM hardware has not been selected and much of this information is unknown, so a 2x ratio is often used.

Define Orbit and Overpasses

The next step is to calculate overpass duration and frequency. Overpass times are affected by orbital parameters and SATCOM beam widths. The customer is king, so the user experiences that they want are important here but requirements can quickly conflict.

For example, higher altitudes and larger beamwidths increase overpass durations and service areas. This will minimize out of service areas (service gaps). However, increased altitudes and large beamwidths are costly because they can reduce gain. The satellite will need a stronger EPS to close the link, which is especially challenging for CubeSat and microsat missions which are more power constrained.

A user can add space assets in PIGI in one of three ways. They can load a TLE from the Satellite Catalog, manually enter a TLE from text, or enter the six orbital elements directly. Likewise, adding a new ground station is easy, via the SATCOM interface, entering the lat/long, station name, and beam width for the station. A lock/unlock button allows the user to modify beam widths and orbital parameters to experiment with different configurations and overpass times.

Saber also has a range of MATLAB scripts which enables the user to pre-generate constellations. This can be very useful for Monte Carlo testing and optimization of large 100+ satellite constellations.

Calculate Sum Overpass Times

The Time bar shows overpass information for each ground station, color-coded by satellite. The user can propagate forward or backwards in simulation time. Clicking on the ground station label shows a list of overpasses for that site which can be exported to an excel spreadsheet.

Acquisition of Signal (AOS) and Loss of Signal (LOS) fractional Julian Dates are saved for each overpass for each satellite in the constellation. Overpass duration and gap durations are easily calculated from AOS and LOS times.

Duration of a single overpass in seconds is simply the difference between AOS and LOS for that pass. Gap duration is the difference between AOS for the given satellite and LOS for the prior satellite. Satellites which overlap are represented as zero gap time, however satellites overlapping a given area is also inefficient.

Estimate Potential Volume

At this point in the workshop, the mission planners know a size of product for downlinking, the maximum pipeline given by the SATCOM systems, and the effects of their mission simulation from PIGI. Summing the overpasses in seconds gives the pipeline available for a single day. Dividing this number by the product size gives the number of products downloaded on that day. The planner can simply multiply this number by 365 days to give an annual potential volume of products for that mission and experiment with a price point per product to estimate maximum potential sales revenue.

It is important to note that this method is simplistic and results in a maximum possible revenue. "Maximum" in this context means that every data bit downlinked from the constellation is sold at the cost provided. More realistic ways to temper this number will depend a great deal on the use cases provided by the mission.

However, the outputs can provide important insight supporting conceptual design stage. Onboard memory volume requirements, for example, can be estimated from summing the gap times. With properly constructed SATCOM specifications (rather than simple Shannon Information). Saber was able to quickly optimize orbits for large constellations of 100+ satellites and validate a mission plan. This provided key evidence for a customer under due diligence to earn their Series-A investment.

One of the problems with spaceflight software is that it is bespoke. Operators need a wide range of features, from dish control to diagnostics, in order to be effective. Many of these features are usually a mash of varying text based tools from different sources.

As one engineer exclaimed, "*You have to learn to knead your own bread in order to make a sandwich.*" PIGI aims to solve this problem with integrated tools and easy-to-use interfaces.

The combination enables the 'democratization' of space so people with less formal training can plan their missions, approach investors, and quickly add their talent to our industry.

saberastro.com/

Prior to founding Saber Astronautics, Dr. Held was a US Army Major and team leader for USSTRATCOM (formerly Space Command) and deployed internationally in support of military space missions. He was a lead instructor at the Interservice Space Fundamentals Course and an engineer at Army Space and Missile Command Battle Lab. He conducted flight software for the Wide Field Camera 3 of the Hubble Space Telescope and testing for the International Space Station. He also conducted testing for an invasive class II medical device.

Dr. Held guest lectured for the IRS Space Station Design Workshop, University of New South Wales, and International Space University. He led a research expedition in the high Canadian Arctic and co-founded the Delta-V Startup Accelerator and the University of Sydney space engineering laboratory.

The Challenges of New Space: A Surrey Satellite Technology Ltd. Perspective

By Sir Martin Sweeting, Group Executive Chairman, Surrey Satellite Technology Ltd. (SSTL), UK

We live and work in an era of very fast expansion of satellite applications, with a new constellation being announced almost every week.

At the last count, my colleague Alex da Silva listed 68 small satellite (smallsat) constellations being proposed around the world. Most already have some funding and in many cases attract amounts of cash that are the envy of more established operators.

The numbers can very quickly become mind boggling: if the more optimistic predictions are correct, we will end up with a few thousand additional Earth satellites in the near future. Some estimates point to a total value of these constellations in the order of $22 billion.

Currently, the investment figure is more likely to be around the $3 to $4 billion mark, still a rather impressive number for those of us more accustomed to think of the smallsat industry as a (very) few million dollar industry.

For a satellite manufacturer, this is great news. Having seen the highs and lows of the industry over the years, and the slow growth of smallsats in the early years, the prospect of thousands of smallsats being needed in the coming years is exciting. However, the question I am frequently asked these days is how real this 'boom' is, and if after the "boom" comes a 'bust.'

I am a firm believer in a 'boom'—the technology now delivers a performance that is financially attractive and the investment capital is available to make systems based on that technology. But as for the size of the 'boom' and the possibility of a 'bust,' that will depend on successfully navigating a few challenges and hurdles.

Some of these are industry wide and we need to address them together to ensure we create an environment that allows for the success of the current new space revolution.

The first hurdle is possibly the less exciting of them all: regulatory. The long discussions about debris mitigation and its impact on smallsat constellations are well known and several solutions have been proposed. The jury is still out on how effective these solutions are, but I wouldn't expect this to stop the boom.

There is another regulatory aspect that might have a bigger impact for communications constellations: spectrum allocation and frequency licensing. In private (and sometimes in public), spectrum regulators are voicing concerns at what they see as possible misuses of spectrum.

Interference, or potential interference between LEO communication constellations and GEO satellites, as well as other LEO constellations, is likely to generate substantial uncertainty for some of the proposed communications constellations.

This is unlikely to stop the boom but does have the potential to limit the rate of expansion. Building and launching precursor satellites for frequency allocation will rapidly become a necessity for constellation business plans to secure further funding.

The ITU is also being very proactive in shaping and supporting the licensing of future smallsat constellations and space systems and the industry needs to support those efforts.

The second hurdle is possibly the biggest obstacle for a rapid expansion of satellite numbers and the only real 'boom' killer: launch capacity. Despite the promise of the last few years, rather than an increase in the smallsat capacity, we have actually seen a reduction in the overall launcher availability.

With the effective mothballing of Dnepr over the past few years, the world is increasingly dependent on the ISRO's PSLV to launch smallsats at cost effective prices. There are alternatives, but these rarely materialize in the required time frames and at a cost that closes the business plan.

By now, we expected to have several new small launchers up and running, increasing capacity and driving down prices. Unfortunately, this has not materialized and, of the 25 or so serious small launcher ventures, not one has yet completed a commercial test launch.

In recent years, the promise of low cost, frequent launches with small manifests seems to be stuck or going in the wrong direction: prices per kg launched in some of these new launchers are approaching that of conventional launchers and minimum mass launch is growing, thereby making it far harder to launch one or two small spacecraft into dedicated orbital planes.

Communication and RF sensing (AIS, ADS-B, etc.) constellations, in particular, require multiple operational planes to be effective and need frequent launch opportunities. There is an urgent need to address the constraint on launch capacity and ensure the success of new launcher initiatives. Only in this way can the space industry fulfill the promise of a 'boom' in satellite numbers.

One likely outcome of this situation is that in the next few years, Chinese built constellations will have a significant commercial advantage in relation to their foreign counterparts, as they will have access to locally built low cost launchers, that the majority of western companies are barred from using due to export restrictions. This could create a situation where Chinese companies become dominant in the new space business because of their easy access to launchers.

The third hurdle is financing. Many of these constellations require substantial initial investment to design, build and launch. Although capital markets have been generous with the satellite sector in the past few years, further funding is increasingly linked to demonstrating a degree of success.

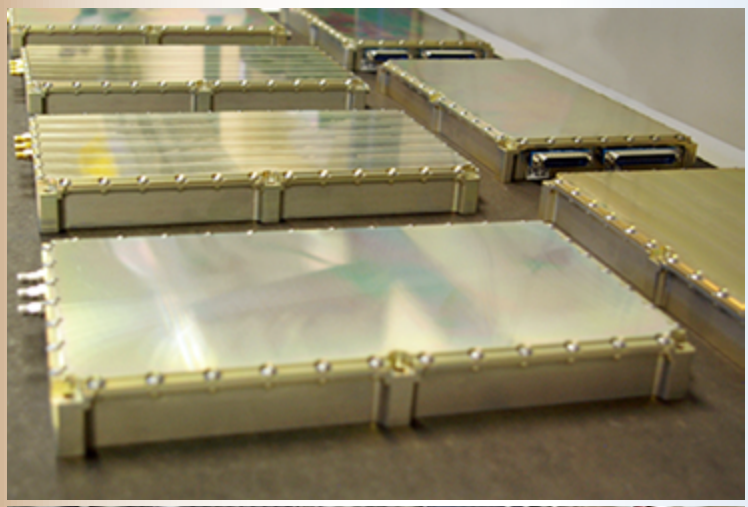
The ability to demonstrate on orbit results is a necessary (but sometimes not sufficient) step in securing further funding. Precursor satellites, pathfinders, demonstrators are becoming common as a first step in convincing the investor community that owners of the business and its staff are able to manage the technology.

For ventures that do not have their own in-house technology capability, selecting the correct technology partner is a crucial step in assuring their investors that they can deliver on their promises. This is not about the space segment: as or more important is the overall system design, including command and control systems and the tools for downstream use of the system. These are many times forgotten and are an essential part of the success of a constellation.

The future success of the systems being proposed will depend largely on the success of their business models. As obvious as this statement might sound, it is not always clear how value will be generated and what is the likelihood of success. In some cases the challenge is more the technical solution and in others is more the business model itself.

Good, reliable technical solutions are a very important first step to achieve success. These have to be balanced with ambitious cutting edge designs that extract the maximum performance out of the technology and give a business advantage to the final user. In my experience, the key for technical success is having teams of people with good solid knowledge, mixed in with highly creative and innovative types. The environment built around that team needs to allow both types to flourish and deliver, what can be a rather challenging task for the leaders of the team (and also for their investors).

Likewise, good, solid business propositions are important to show investors that they will get a return in the future. Of course, such a proposition also needs to be innovative and show why this investment is better than others. There can be a temptation to sometimes present a better business proposition based on a more "adventurous" technical solution. Although this can improve the chances of getting in early investment tranches, it runs the risk of being based on a physical impossibility that might limit future investments.



Top image: CYGNSS SGR ReSI flight models. Image credit Surrey Satellites. Bottom image: CYGNSS satellite. Image credit Southwest Reserach Institute.

Surrey Satellite Technology's Space GNSS Receiver Remote Sensing Instrument (SGR-ReSI) is the primary payload onboard NASA's CYGNSS constellation that was launched on December 15. The Cyclone Global Navigation Satellite System (CYGNSS) mission is part of the NASA Earth System Science Pathfinder Program that aims to improve extreme weather prediction by studying how tropical cyclones form. The CYGNSS space segment consists of a constellation of eight microsatellites, each carrying the Surrey SGR-ReSI as the observatory payload in the form of a delay Doppler mapping instrument (DDMI). Making use of reflected global positioning signals, the DDMI collects ocean surface roughness data using a technique called GNSS reflectometry, providing CYGNSS with a new method for looking inside hurricanes. Wind speed will be estimated from this reflectometry data.

It is important to ensure that a dose of realism is used when assessing the business plans of new ventures, but accepting that risk is part of the investment process.

There are excellent business propositions among the many commercial ventures being put forward, most of which are truly innovative and game changers. Ensuring the success of such ventures it is critical to ensure that there is only a boom and no bust. The sustainability of the industry depends on the success of the current projects.

Addressing the main potential hurdles in regulation, launch and finance are the key objectives for the near future. The strength of the business propositions needs good, solid and innovative technical solutions that can deliver the vision of the entrepreneurs that created them.

Ensuring good system design is fundamental so the systems being deployed deliver the performance required of them. That will generate the return that investors expect, and in this way the industry will remain buoyant with the continued support of the investor community.

Should we succeed, there should be no bust phase at all, just a continuous strong growth in the years to come.

sstl.co.uk/

Professor Sir Martin Sweeting is the Founder and Executive Chairman of Surrey Satellite Technology Ltd. He pioneered rapid-response, low-cost and highly capable small satellites using modern consumer (COTS) electronics devices to change the economics of space.

In 1985, he founded a spin-off University company (SSTL), which has now designed, built, launched and operated in orbit 49 nano-, micro- and mini-satellites. These smallsats include the international Disaster Monitoring Constellation (DMC). SSTL also built all of the 22 navigation payloads for the European Galileo operational constellation and a low-cost, medium-resolution SAR minisatellite (NovaSAR).

SSTL has grown to 500 staff in number, with annual revenues of $150 million—total export sales to 24 countries have approached $1 billion. As Chairman of the Surrey Space Centre as well as being a distinguished professor at the University of Surrey, Sir Martin heads a team of 90 faculty and doctoral researchers investigating advanced smallsat concepts and techniques, acting as the research laboratory for SSTL — a true example of real academic-commercial synergy.

Sir Martin has been appointed OBE and knighted by HM The Queen, elected a Fellow of the Royal Society and a Fellow of the Royal Academy of Engineering, and he has received the prestigious von Karman Wings Award from CalTech/JPL.

In 2016, Sir Martin was identified by The Sunday Times as one of the UK's 20 most influential engineers, confirmed again in Debrett's 2017 list of the 500 most influential people in the UK.

Busting Down The Barriers Facing Space Entrepreneurs: A York Space Systems Perspective

By Dirk Wallinger, Co-Founder and Chief Executive Officer, York Space Systems

Tremendous pent-up demand for space data and services has created great opportunities for space entrepreneurs today.

While there is great opportunity for entrepreneurs looking to space, there remains today significant barriers for the bright ideas of tomorrow. With shared launch available for spacecraft and numerous smallsat dedicated launchers on the horizon, the promise of accessibility to space is bright.

Exciting developments on the launch front are encouraging; however, the other enabling elements of the space segment lag far behind and remain significant barriers for taking today's bright ideas and turning them into the game changers of tomorrow.

What's holding us back? What keeps all these great ideas from becoming reality in the commercial space domain? '*Bespoke*' engineering talent and immense infrastructure spending all result in large amounts of required capital deployed over long timelines. What needs to change to enable good ideas to become achievable?

Just as we witnessed in the early days of the Internet, to transition from the rarefied, scientific R&D world of ARPANET and create today's ubiquitous booming Internet, you needed affordability (the PC) and accessibility (the Internet and Netscape). Fast forward to today, with a standardized piece of hardware such as a smartphone, almost anyone, anywhere, with an idea can affordably and easily prototype their plans with just a bit of time, devotion, and little capital. This has powered our economy as well as presented growth and opportunity for millions.

To enable the commercial space entrepreneurs of the future, we need the same ingredients for space. The question remains, how do we accomplish that task?

Even today's emerging entrepreneurial space companies with novel payloads and business concepts harbor a false belief that you must start by hiring a score of engineers, build clean rooms, design a satellite bus, integrate a payload, and establish your own ground segment—all years down the road before the first product can be delivered. The majority of capital raised in entrepreneurial space companies is spent building and developing items that already exist.

Innovation should be about addressing unmet business needs, not reinventing existing space technology and operations. Standardized, ready-to-ship spacecraft platforms are being produced now and there are available numerous shared and dedicated commercial ground segment providers. These products are accessible and engineered to work together—the time has come to cease reinventing the wheel!

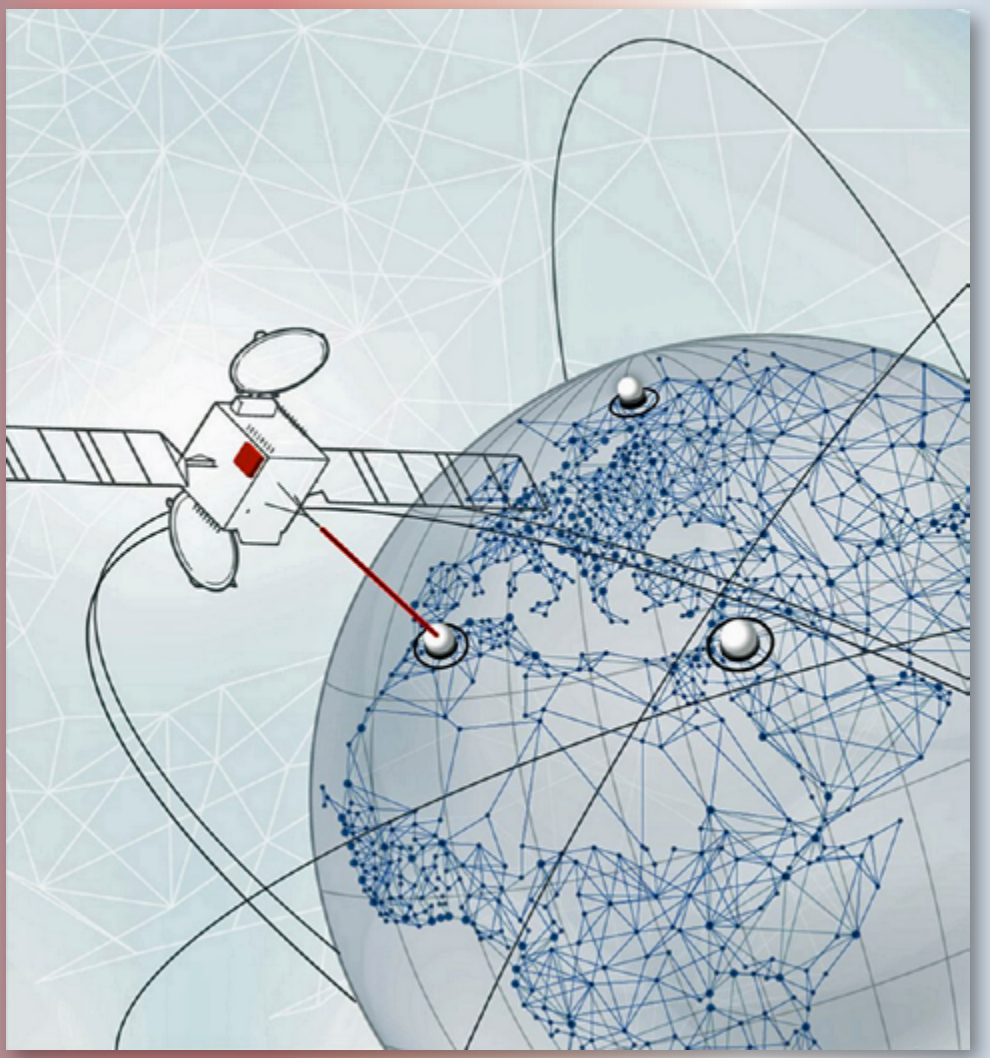
After all, FEDEX and UPS didn't build their own planes and delivery trucks—they leveraged existing assets and technologies whose development costs were already amortized across a broad cross section of customers. They focused on developing and scaling their innovative logistics and delivery businesses. Similarly, Amazon could not have become a success without the use of existing distribution networks.

By leveraging existing low-cost providers who already have partnerships in place, entrepreneurs can significantly reduce execution risk, lower required capital, shorten R&D timelines and reduce time to market. Companies such as York Space Systems, and its added-value partners, can put together complete end-to-end space-segment solutions for space entrepreneurs allowing them to focus on their business and data products, and avoid the added complexities, costs and inherent delays of developing and fielding a dedicated space infrastructure.

Ever since humankind first started reaching to the heavens it was accepted as an expensive endeavor, and with all things expensive, customization was accepted, and for the most part expected. This made sense then, but does it still make sense today in space? For example, think of the revolution in custom applications software (apps) that was driven by adoption of the modern cell phone complete with its standardized operating systems, software and hardware interfaces.

With a readily available standardized piece of hardware, smart phones packaged processors, memory, display, wireless connectivity, GPS, accelerometers, barometers and other sensors. With infrastructure networks already in existence as well as standardized hardware platforms, innovation has flourished and time to market for new ideas is now measured in months.

For simplicity, consider the first space startup, the ride-sharing company Uber. They didn't have to build a global satellite navigation constellation (GPS, GLONASS, Galileo). They didn't have to develop user hardware (cell phones), either. Rather, Uber figured out how to use what was in existence to create something new. Perhaps entrepreneurs and the space industry should look a little more closely at how goals are achieved. Your end goal might be a constellation of 400 satellites delivering and collecting real-time data every second of every day, but do you really have to deploy the 400 simultaneously to achieve the first objective or to field the minimum, viable product (MVP)?



Wouldn't it be easier to deploy a single, simple version of the product that demonstrates the key features of the value proposition first, with hardware that is standardized, available in short order at low cost? Imagine having a real space asset beaming information down from space during your pitch. The capital raise would be significantly lower; time to first orbit would be significantly shorter. With much of the technological risk retired, wouldn't the capital raised for the rest of the fleet be significantly easier?

By figuring out how to leverage what is available and affordable, it is likely the entire industry might gain by creating a space economy of standardized available products instead of designing a custom solution every time.

When solutions are exceptionally expensive, it alters your risk tolerance and stifles innovation. This has been demonstrated time and time again over the past 50+ years. Now, seemingly, every space program exhibits the same snowball effect paradigm. The first thought is "*space is expensive,*" so if it is expensive this satellite needs to do '*more.*' When it needs to do '*more,*' it gets complex quite quickly.

Increased complexity then causes delays in development and increased cost. Rather than adopting new technology with increased cost, schedule and risk, older technology is selected. The end-user is often left with an expensive compromise in capability: a complex spacecraft incorporating older technology that becomes obsolete prior to liftoff. The other outcome is program scope reduction, less spacecraft or outright cancellation of the program.

The time has come to shift the mentality toward flying more often, iterating quickly, and building on lessons learned; advancing technology and quickly performing through evolution rather than revolutionizing from scratch. By advancing technology in smaller increments, more frequently, we can lower the costs, shorten schedules, and create a more robust market environment across the industry enabling access and "*the willingness to try*" for a whole new generation of entrepreneurs.

Although the future shows great promise for space entrepreneurs, the barriers to entrance remain high, with historical based perceptions of what can be done, combined with antiquated approaches to achievement. Ultimately the path to unlocking the potential of space should be based on creating the infrastructure needed to provide affordability and rapid accessibility, the key parameters required to unlock the mass markets of the past.

The challenges facing entrepreneurs today are no longer technological in nature, but instead require thought and business transformation. Imagine instantiation of a novel space-based business plan in months rather than years, and capital requirements in the millions as opposed to hundreds of millions of dollars.

By leveraging existing standardized hardware, infrastructure, and incrementally evolving product technology, we can begin to implement the type of rapid iteration, risk reduction, decreased cost, and shortened time to market required for space to become truly innovative and vibrant once more.

yorkspacesystems.com

Dirk Wallinger is an industry expert with extensive experience as the Principal Lead System and Subsystem Engineer on multiple space vehicles, including GeoEye1, ORS-1, Fermi Gamma Ray Observatory, NFIRE, and numerous classified programs. He has successfully executed programs for a wide range of customers that include NASA Goddard, USAF, DoD, NRL, NGA, ORS, and GeoEye (now DigitalGlobe).

During employment with industry leaders, including Orbital Sciences, General Dynamics, and Lockheed Martin, he led Senior Management market assessments, evaluated new market entrance opportunities, set system pricing, and coordinated proposal strategy and messaging for company critical proposals. Dirk currently leads business development, provides technical guidance for the platform, while developing and implementing York's strategic initiatives and partnerships. Dirk holds a B.S. in Mechanical Engineering from the University of Arizona, Summa Cum Laude.

The Gathering Storm—The Threat of Fake Weather News... Why Environmental Intelligence is the Next "Big Thing"

By Cory Springer, Director, Weather and Environment, Strategic Operations, Ball Aerospace

Imagine the following scenario: An earthquake in the Atlantic Ocean is detected, and within minutes, a prominent newscaster scanning Instagram sees a post warning that a tsunami is about to hit the northeastern seaboard.

At first, she dismisses it because it hasn't been reported as credible elsewhere. Minutes later, however, social media erupts as ABCNews.com.co reports that the National Weather Agency has issued a tsunami warning for New York City and is urging immediate mass evacuations.

The stock market begins to tumble amid speculation that Wall Street will be flooded, and police are dispatched to deal with massive overcrowding on the subways. Within two hours, New York is crippled by fear, panic and confusion—despite the fact that there is no tsunami, and never was.

With the memory of 2012's Hurricane Sandy fresh in the minds of many New Yorkers, it is not unreasonable to expect that people would be especially attuned to headlines of extreme weather reports, without necessarily paying attention to the details or the source generating the news.

Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season, and with damages estimated in excess of $75 billion, it was also the second-costliest hurricane in United States history.

The emergence of "fake news" sites, with fraudulent yet official-sounding entities like ABCNews.com.co or the National Weather Agency, has greatly increased the likelihood that legitimate weather events like an earthquake can be distorted through fake news sites—and then amplified through social media. And from a national security perspective, the probability that such efforts could be made with malicious intent is increasingly significant. Indeed, Forbes recently published a story on the imminent danger to the general public posed by fake weather forecasts that have gone viral through social media.

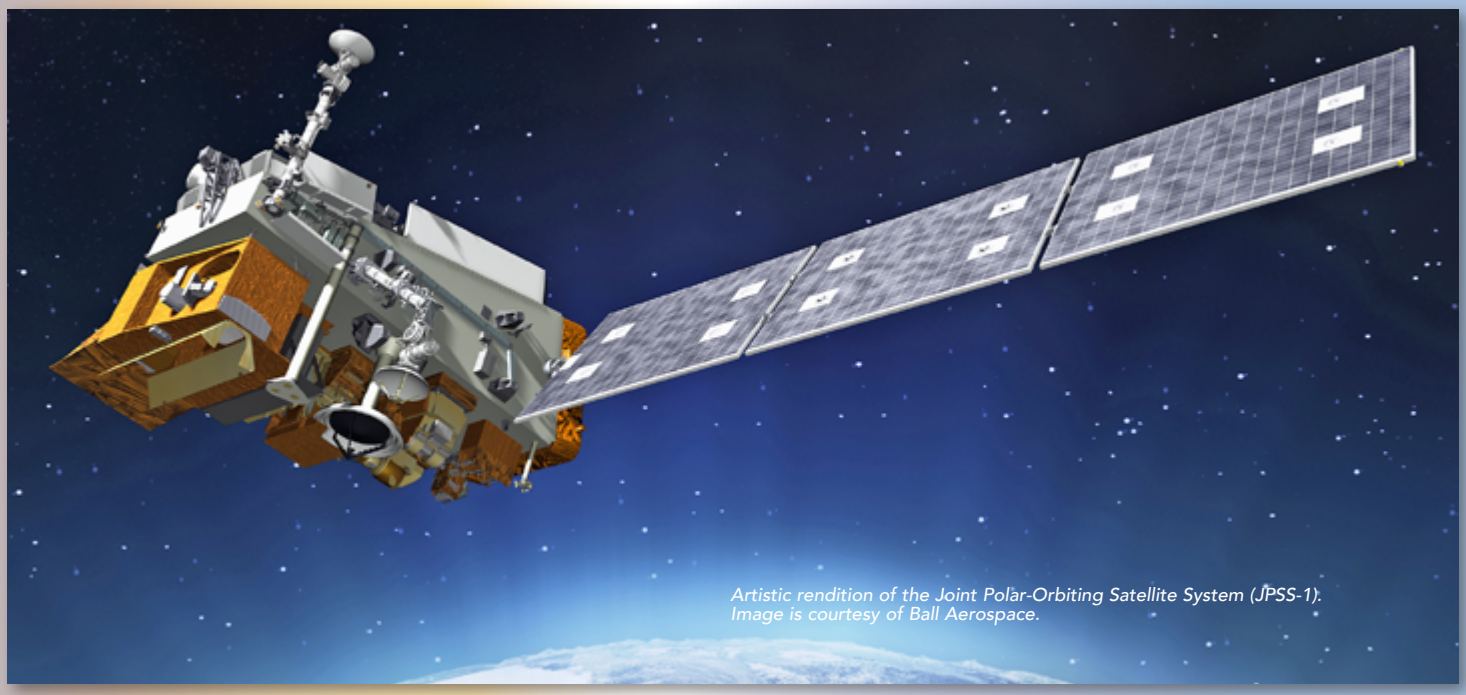
The Case for Stronger Environmental Intelligence

With so much potential for noise in the system, the need for credible Environmental Intelligence—and the instruments and platforms to gather the necessary data points—has never been stronger. The ability to routinely provide accurate Environmental Intelligence is critical to protecting lives and the nation's infrastructure. As reported by NOAA, there have been more than 130 extreme weather events—including hurricanes, wildfires, floods or droughts, which have collectively caused more than $1 billion each in damage in the United States since the year 2000.

Simply defined, Environmental Intelligence is actionable information about the natural environment that has been analyzed and refined so it is useful to policy makers and the general public. Environmental Intelligence is used to help make decisions that protect lives, safeguard the country's infrastructure, grow the economy, give the military a competitive advantage and even help people make day-to-day decisions.

The basic ingredients of Environmental Intelligence often include the following characteristics: relevant observations of the atmosphere, ocean and land surface; sophisticated systems to vet the observations and place them in a usable format; and powerful computing resources to run models and decision aids that produce useful products.

For more than 40 years, Ball Aerospace has designed and built innovative space systems that support actionable Environmental Intelligence. When Hurricane Sandy hit the United States' east coast in November 2012, the Ball-built and NOAA-operated Suomi-NPP satellite provided critical measurements to help models predict that Sandy would take the infamous "left hook" into southern New Jersey. The National Weather Service model gave people on the ground more time to prepare, which likely saved lives and made a significant difference in how resources were deployed and evacuations planned.



Artistic rendition of the Joint Polar-Orbiting Satellite System (JPSS-1). Image is courtesy of Ball Aerospace.

Observation satellites operated by NOAA and NASA, including operational platforms like the next-generation Joint Polar-Orbiting Satellite System (JPSS-1), Suomi-NPP's successor, will play a significant and irreplaceable role in providing actionable Environmental Intelligence to decision-makers in government, business and the general public.

"*With Sandy, the weather forecasters were able to get the prediction right,*" said Scott Tennant, Ball Aerospace's program manager for Suomi-NPP. "*I think it saved some lives. It could have been much worse had they not dialed that path right in to determine where the hurricane would land. Suomi-NPP gives us more confidence about hurricanes' paths and how to get people out of the way—safely.*"

How Environmental Intelligence is Collected

Environmental Intelligence began in earnest with systematic observations of weather from fixed points on land and on water, but it wasn't until the age of satellites that meteorologists and scientists began seeing entire weather systems and ocean features from the vantage of space. Space-based observations have the advantage of being able to make critical observations over the entire globe, which is particularly important because the physical environment has no boundaries.

The breadth and depth of Environmental Intelligence touches almost every aspect of human and commercial activity:

- *Measuring ozone in the stratosphere. There are a number of government platforms and instruments that support NASA Earth science to provide decision-makers with the information they need to better understand the changing landscape of our planet. For example, the Ball-built Solar Backscatter Utlraviolet instrument (SBUV/2) helped to discover the ozone hole above Antarctica in 1987, and Ball's Ozone Mapping and Profiler Suite (OMPS)—currently aboard Suomi-NPP and which will also fly on JPSS—will continue to measure and monitor the protective blanket of stratospheric ozone that surrounds the Earth into the 2030s.*

- *Enabling more accurate weather forecasts. CALIPSO and CloudSat are part of a constellation of spacecraft called the "A-Train," including Aqua, Aura and PARASOL, dedicated to studying how clouds and atmospheric aerosols—key elements of the water cycle—impact long-range and short-term forecasts. In addition, the Global precipitation Measurement-Microwave Imager (GMI), the new microwave instrument calibration standard currently operating on the joint NASA-Japanese Aerospace Exploration Agency Global Precipitation Measurement (GPM) satellite, is improving scientific understanding of precipitation and enabling operational forecasters to better predict tropical storm intensities and tracks.*

- *Producing seasonal drought forecasts for farmers and fire prevention plans. The precisely calibrated Operational Land Imager (OLI) continues Landsat's unprecedented 45-year record of earth remote sensing, helping experts make routine drought assessments and fire prevention plans; monitor land changes; and better understand the Earth's ecosystem.*

- *Enabling first responders in disasters. In the aftermath of natural disasters, Environmental Intelligence is also helping first responders and emergency teams to deploy faster and more efficiently to priority areas. For example, the high resolution Earth imagery captured by WorldView satellites, three of which were built by Ball for DigitalGlobe, is used for civil government mapping, land-use planning, disaster relief, exploration, defense and intelligence, visualization and simulation environments, and navigation technology such as Google Maps.*

Space-Based Environmental Intelligence Systems

The cost-effective development and delivery of Environmental Intelligence products and policies requires creative partnerships between industry, the government and academia. For this reason, there is a need to improve the capabilities and capacities of collective Environmental Intelligence-gathering efforts. This will need to be done with a combination of existing and new contracting mechanisms, large and small space systems, and new and upgraded ground infrastructures. Ball has strong partnerships with NASA, NOAA and the USGS, and continues to design and develop space-based observing technologies and strategies to help meet their critical Environmental Intelligence needs.

By continuing to develop technology critical to filling these observation gaps, the quality of actionable Environmental Intelligence for decision makers and the public can be improved. For example, the World Meteorological Organization (WMO) has stated that the development of satellite-based wind profiling systems remains a priority for the future global observing system. In particular, studies have shown that hurricane and typhoon intensity and track forecasts would be improved with direct measurements of 3-D winds. Improved forecasts give more advanced notice of extreme weather events to local governments, first responders and the public, which can help save lives and property.

NASA has made investments over many years in space-based wind LIDAR technology, and this remains an imperative area for future investment.

Looking Forward

It is possible that the "fake news" phenomenon will quickly pass as more people become aware of its existence, and that the general publics' faith in weather forecasting will remain high. Ensuring both the credibility and the fidelity of these forecasts must remain a priority.

It is perhaps easiest to think that Environmental Intelligence is really about having a complete picture of the physical properties in the world that affects our way of life. Extreme weather events happen, and will likely increase in frequency and in the amount of damage caused. Through additional investments in Environmental Intelligence capabilities and continued public-private collaborations, the capacity to provide credible, accurate and longer-term predictions will ensure that national interests are safeguarded and US citizens remain safe.

Cory Springer is the Director, Weather & Environment, Strategic Operations at Ball Aerospace.

Artistic rendition of the WorldView-3 satellite. Image is courtesy of Ball Aerospace.

Collecting Evidence of Extraterrestrial Intelligence

By Michael David Cote, CubeSat.tech (CubeSat 4 Disclosure)

A cubeSat can carry a payload that ranges from imaging systems, scientific experiments, technology demonstrations and more.

CubeSat 4 Disclosure will carry a number of instruments that will allow for scientific observation of certain phenomena in LEO that pertain to extraterrestrial intelligence.

For the past 70 years, the topic of extraterrestrial intelligent beings and UFO's has been controversial, if not ridiculed. Despite many sightings and events, the government, military and media have made a strong attempt to discredit the idea of extraterrestrial "aliens."

In the face of their apparent "disbelief" of the topic, the same military and governments have spent huge amounts of money secretly studying these "ridiculous" UFO's and aliens. Thanks to freedom of information, and the actions of many with first hand experience, thousands of documents, witness testimony and data have surfaced, making the ridicule heaped upon ufology by media and governments seem staged and forced, with a secret intent behind such disdain. CubeSat 4 Disclosure's objective is to build a 2U CubeSat to search for anomalies in LEO. The CubeSat must be capable of receiving commands and to transmit telemetry and mission data to Earth.

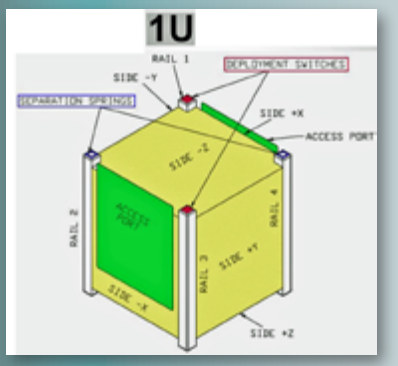
On-board experiments include: real-time magnetometer observations, real-time Geiger counter observations, on orbit HD image capture (the camera is capable of taking images in five second increments; the CubeSat will transmit images back to Earth where the images will be available to public in raw format (untampered/unedited), the camera will have a global shutter for capturing moving objects and will also be capable of coarse pointing accuracy.

This scientific observational experiment will correlate visual observations made with the sensor data to give a more solid evaluation of evidence of extraterrestrial intelligence existing in various contexts within LEO.

Visual and sensor data will be transmitted via Globalsat's network of Iridium satellites through a modem onboard the CubeSat. This data stream will be relayed through the Internet to the CubeSat 4 Disclosure team's infosite and will be available for scientific review.

The CubeSat 4 Disclosure team includes: Michael David, Matt Lippert, Dave Shock, Gianna Young, Nathalie Savoie, Mark Richfield and Pat Regan. Cote is a graduate from Simon Fraser University and specializes in software development.

Lippert teaches CubeSat technology and building at the United States Air Force Institute of Technology (AFIT). Shock had previously tried launching a full satellite project for Disclosure. Young, Savoie, Richfield and Regan have had experiences and/or encounters with Unidentified Arial Phenomena. Together, the team raised approximately $30,000 and have subsequently paid for the building of the CubeSat, the launch and the data costs. The launch is scheduled to occur in July of 2017 from the Mojave desert in California, USA, and will be provided by Interorbital Systems (IOS).



Funding for CubeSat for Disclosure was done through IndieGogo and Kickstarter as well as by private donors. In the fundraising process, many media and news agencies contacted the CubeSat 4 Disclosure group and several articles and interviews are available online and elsewhere.

Amazing is that with the amount of interest and evidence regarding Unidentified Arial Phenomena, and the impact that knowledge of extraterrestrial advanced life would have on society at large, that so little scientific study has been expended on this topic.

Many sightings of UFOs have been documented, numbering in the millions, and yet an experiment of this scale has never been conducted to allow for the correlation of multiple data points toward identifying these phenomena. Now, for the first time, the CubeSat 4 Disclosure team will send a smallsat to orbit for this purpose and this endeavor is unattached to any government or corporate entity. A technical breakdown of the CubeSat 4 Disclosures components follows:

LT Command and Data Handler/Electrical Power System Board:
32-bit AVR flash microcontroller featuring 512KB Flash, 68KB SRAM; Running OpenSAT FreeRTOS, lightweight multitasking architecture; Redundant µSD storage (2x 8GB); Real Time Clock; On-board Temperature Sensor; 4x External Temperature Sensor(user mountable); External(from µController) On-board Watchdog; USB Bootloader; Virtual USB for easy Debugging; On-board Inertial Measurement Unit - Magnetometer, Gyroscope, Accelerometer; Compatible with CMOS(UART) camera(TBD); Compatibility with Lippert Technologies, LLC Flight Radio/Educational Radio; Compatibility with NSL: NearSpace Launch Inc. Eyestar Duplex Modem; Compatibility with Lippert Technologies, LLC OpenSat Educational Payload Board; Compatibility with Lippert Technologies, LLC Magnetorquer Board; Compatible with PC-104 mechanical Interface

LT Battery Pack:
Li-Ion Battery Pack; Utilizes four 18650 series battery cells; 10000 mAh Capacity; ~7.4 V voltage Range; Temperature Sensors;
Compatible with Lippert Technologies, LLC Command and Data Handler/ Electrical Power System; Compatible with PC-104 mechanical interface

LT Magnetorquer Board:
3-axis magnetic torque rod system; 3-axis magnetometer; Coarse Control Pointing; Three actuators; two torque rods and one air core torquer; Current Sensors for each torquers; Telemetry over I2C; Detumble up to 3U; Direct analog control of actuators with direct PWM signal; Compatible with PC-104 mechanical interface; Compatible with Lippert Technologies, LLC Command and Data Handler/Electrical Power System

LT 1U Flight Solar Panel:
Twenty-two percent cell efficiency; Coarse Sun Sensor -ADC; Temperature Sensor; Protection Diodes; Voltage: ~12v; Current: 104mA; Power: ~ 1250 mW peak; Compatible with Lippert Technologies, LLC 1U, 2U,3U Chassis

LT Flight Imager Payload Board:
BeagleBone Black header connector; BeagleBone Black with 8GB SD card included; Geiger Counter

3MP CMOS Sensor Color Camera:
35mm lens/F1.9; Camera Mount included; 25.8 fps; Global Shutter for capturing moving objects; Rolling Shutter for low-noise, high-contrast images; Near InfraRed version with twice the infrared sensitivity

OpenSat Payload Software Package:
JPEG Compression, compatible with PC-104 mechanical interface

LT 2U Flight Chassis:
AL 6061; Tight Tolerances TBD; Detachable Side Panels; Kill-switch mechanism; PC-104 compatible; 94mm x 94mm PCBs; Compatible with NSL's Eyestar Duplex Modem

Michael David Cote is a graduate from Simon Fraser University, works in software engineering and is a technology enthusiast. Following are a few links for those interested in learning more:

https://en.wikipedia.org/wiki/Center_for_the_Study_of_Extraterrestrial_Intelligence

http://www.siriusdisclosure.com/

https://www.youtube.com/watch?v=7vyVe-6YdUk

http://www.citizenhearing.org/

https://www.youtube.com/user/CitizenHearing

Supporting Companies and Organizations for the SmallSat Symposium

Someone once intimated that it takes a village... in the case of SmallSat Symposium 2017, a village simply wouldn't be effective whatsoever... however, sponsoring companies area a boon to those who have worked so diligently to bring a world-class event for those interested in this dynamic smallsat industry.

Satnews Publishers would like to thank the following companies for their timely and highly appreciated assistance with this major event...

Arianespace *is the world's leading satellite launch company, providing innovation to its customers since 1980. Backed by 21 shareholders and the European Space Agency, the company offers an international workforce renowned for a culture of commitment and excellence. Arianespace has launched more than half the commercial satellites operating in geostationary orbit today.*

As of October 29, 2014, 220 Ariane launches, 35 Soyuz launches (9 at the Guiana Space Center and 26 at Baikonur with Starsem) and three Vega launches have been performed. The company's headquarters is in Evry, near Paris, and has local offices in Washington, D.C. (United States), Tokyo (Japan) and Singapore. For more information, please visit ***arianespace.com****.*

Ball Aerospace *pioneers discoveries that enable our customers to perform beyond expectation and protect what matters most. The company creates innovative space solutions, enables more accurate weather forecasts, drives insightful observations of our planet, delivers actionable data and intelligence, and ensures those who defend our freedom go forward bravely and return home safely. For more information, visit* ***ball.com/aerospace****.*

The 2017 SmallSat Symposium is pleased to welcome Boeing as a sponsor to this years event.

Clyde Space *is an award winning globally recognized innovator and supplier of CubeSat and small-satellite systems. The company's approach to designing and building spacecraft systems is enabling a new generation of spacecraft for commercial, civil and military applications and is defining the standard for today's 'New Space' revolution.*

Now in its 12th year of operation, Clyde Space continues to expand its capability and is now supporting missions at all levels, from conceptual design, development, integration, testing, through to launch and on-orbit operations.

Clyde Space has heavily invested in development over the past year, recruiting heavily, expanding facilities and announced their international expansion plans. The company has over 80 staff and are growing at rate of over 50 percent per year, a rate on par with their facilities. This increase is enabling Clyde Space to win greater orders and develop over 70 satellites this year alone, 80 percent of these sales are with Europe and half of which are US, influencing their decision to internationalize. For additional information: ***clyde.space/***

DHV Technology *designs and manufactures fully custom solar panels on PCB substrate or aluminum honeycomb substrate (CFRP), body mounted or deployable. Sensors and other elements could be integrated under customer requirements. DHV Technology has great expertize on photovoltaic technology. DHV Technology manufactured the solar panels for the Italian satellite UNISAT-6 that was launched from Yasni (Russia) on June 19, 2014. The solar panels are working currently under nominal conditions according to the telemetry installed on the Satellite. DHV Technology has signed a contract with G.A.U.S.S. Srl to supply the solar panels of UNISAT-7 that will be launched in 2017.*

DHV Technology has participated in several other projects, as well, for 1U, 2U, 3U and PocketQubes. For example, DHV Technology is external provider of solar arrays for TRISAT mission, funded by ESA and developed by Maribor University in Slovenia. It is a 3U CubeSat project with deployable solar arrays. DHV Technology's pricing is very competitive and offers excellent quality and deliveries. DHV Technology is an ISO 9001 and ISO 14001 certified company. DHV Technology is listed in the NASA publications NASA/TP-2015-216648/ REV1 "Small Spacecraft Technology State of the Art" (pp.24-26) within the Small Satellite technology available for the market. More info: ***dhvtechnology.com/***

Glavkosmos' history starts in February of 1985, with the main objective being the engagement of space activities with foreign partners. A number of intergovernmental and interdepartmental agreements were received, wherein Glavkosmos was defined as responsible for their implementation. Space research and its application for peaceful purposes requiring research and development as well as commercial cooperation in the fields of materials science, remote sensing, biology and medicine, solar physics, astrophysics, solar system research, communication, implementation of mutual projects on designing, launching and operating of spacecraft, were and are the priority areas of collaboration. Glavkosmos has consistently expanded its successful experience in carrying out commercial projects in the exploration of space for peaceful purposes with other countries and space agencies as well as private companies. Glavkosmos delivers a unique space experience to both the Russian and international markets. ***glavkosmos.ru/***

Hogan Lovells *is a cutting-edge, end-to-end strategic legal practice for satellite system operators, investors, manufacturers, or other transaction parties. We work with those involved in "traditional" space, NewSpace, and government procurements, around the world. Hogan Lovells helps companies take their satellite systems from drawing board to implementation, and safely navigate the multi-layered risks and issues they will face. We understand the technology, business, and regulatory issues ahead of you, and know the strategies necessary to achieve real world success. Acting as an integrated part of your team, we work to understand the challenges you face to structure the best transaction for you. Hogan Lovells has a robust inventory of winning resolutions, unparalleled complex deal experience, a cohesive global team approach, and deep industry expertise. We are pioneers alongside our entrepreneurial clients for their most innovative industry developments, providing practical legal solutions wherever your work takes you. The company offers 2,500 lawyers in more than 45 offices in 26 countries to serve their clients. Additional details are readily available at:* ***hoganlovells.com.***

Kratos *is the leading global provider of turnkey enterprise-grade ground segment solutions that assures operations and communications performance across satellite, terrestrial and hybrid networks. Products include the Monics® family of industry leading carrier monitoring; interference detection, geolocation and mitigation capabilities; EPOCH® IPS, the leading Command and Control (C2) product; COMPASS® for network monitoring and control and NeuralStar®SQM for end-to-end service management. With experience spanning 300 missions over 30 years, Kratos assures secure management, delivery and distribution of data and information from space and terrestrial-based platforms for defense, intelligence, government and commercial satellite partners. For more information:* ***kratosdefense.com/.***

Since the company's founding in 1884, ***Mitsubishi Heavy Industries*** (MHI) has been the pioneer in the manufacturing industry, including aerospace rockets. From 2007, the company began providing launch services for commercial and government missions. MHI will continue to make new approaches, and strive to be the best in the space industry. Learn more at ***mhi-global.com/***

Orbital Systems *is a leading manufacturer of ground station antenna systems including complete cost effective solutions for TT&C antennas used to control and monitor satellites. Orbital offers antenna positioners and integrated RF subsystems with single or multi-band feeds, upconverters, downconverters and HPAs in X-, S- and L-bands, in sizes from 5m to 1.5m. Orbital's field proven antenna systems are fully range tested, reliable and safe, and fully compliant with international standards. Select* ***www.orbitalsystems.com/*** *for more info.*

The 2017 SmallSat Symposium is pleased to welcome ***Pumpkin Space*** *Systems as a sponsor to this year's event. Additional company information is available at* ***pumpkinspace.com/.***

Space Systems Loral *(SSL) is a leading provider of commercial satellites with broad expertise to support satellite operators and innovative space related missions. In addition to its GEO communications satellite expertise the company has launched more than 80 LEO satellites and currently has LEOs in production for communications, Earth observation and science missions with customers such as TerraBella, Telesat and RCM.*

Best known for their satellites and spacecraft systems, SSL also offers full product life cycle support to new space ventures from concept development to space qualification of COTs hardware, affordable access to space through hosted and dispensed payloads, and launch site and on orbit operations support. As a Silicon Valley innovator for more than 50 years, SSL's advanced product line also includes sophisticated robotics and automation solutions for remote operations. More information, visit ***sslmda.com****.*

GVF *is the single and unified voice of the global satellite industry. Founded in 1997, it brings together organizations engaged in the delivery of advanced broadband and narrowband satellite services to consumers, and commercial and government enterprises worldwide. Headquartered in London, GVF is an independent, non-partisan and non-profit organization. The broad-based membership represents every major world region and every sector of the satellite industry, including fixed and mobile satellite operators, satellite network operators, teleports, satellite Earth station manufacturers, system integrators, value added and enhanced service providers, telecom carriers, consultants, law firms, and users. Find additional information at* ***gvf.org.***

Satellite Industry Association (SIA) is a US-based trade association providing representation of the leading satellite operators, service providers, manufacturers, launch services providers, and ground equipment suppliers. For more than two decades, SIA has advocated on ehalf of the U.S. satellite industry on policy, regulatory, and legislative issues affecting the satellite business. For more information, visit ***sia.org****.*

The Space Foundation *is the foremost advocate for all sectors of space and is a global, nonprofit leader in space awareness activities, educational programs and major industry events, including the annual Space Symposium, all which support of its mission "to advance space-related endeavors to inspire, enable and propel humanity." Space Foundation World Headquarters, located in Colorado Springs, Colorado, USA, has a museum-quality Discovery Center open to the public. The Space Foundation offers a wide array of science, technology, engineering and mathematics (STEM) based education programs and publishes The Space Report: The Authoritative Guide to Global Space Activity. Through its Space Certification and Space Technology Hall of Fame® programs, the Space Foundation recognizes space-based innovations that improve life on Earth. To learn more about Space Foundation, please visit* ***spacefoundation.org.***

Thanks to all who supported and attended SmallSat Symposium 2017 — we look forward to presenting the smallsat industry with an informative and exhilerating event once again in 2018.

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