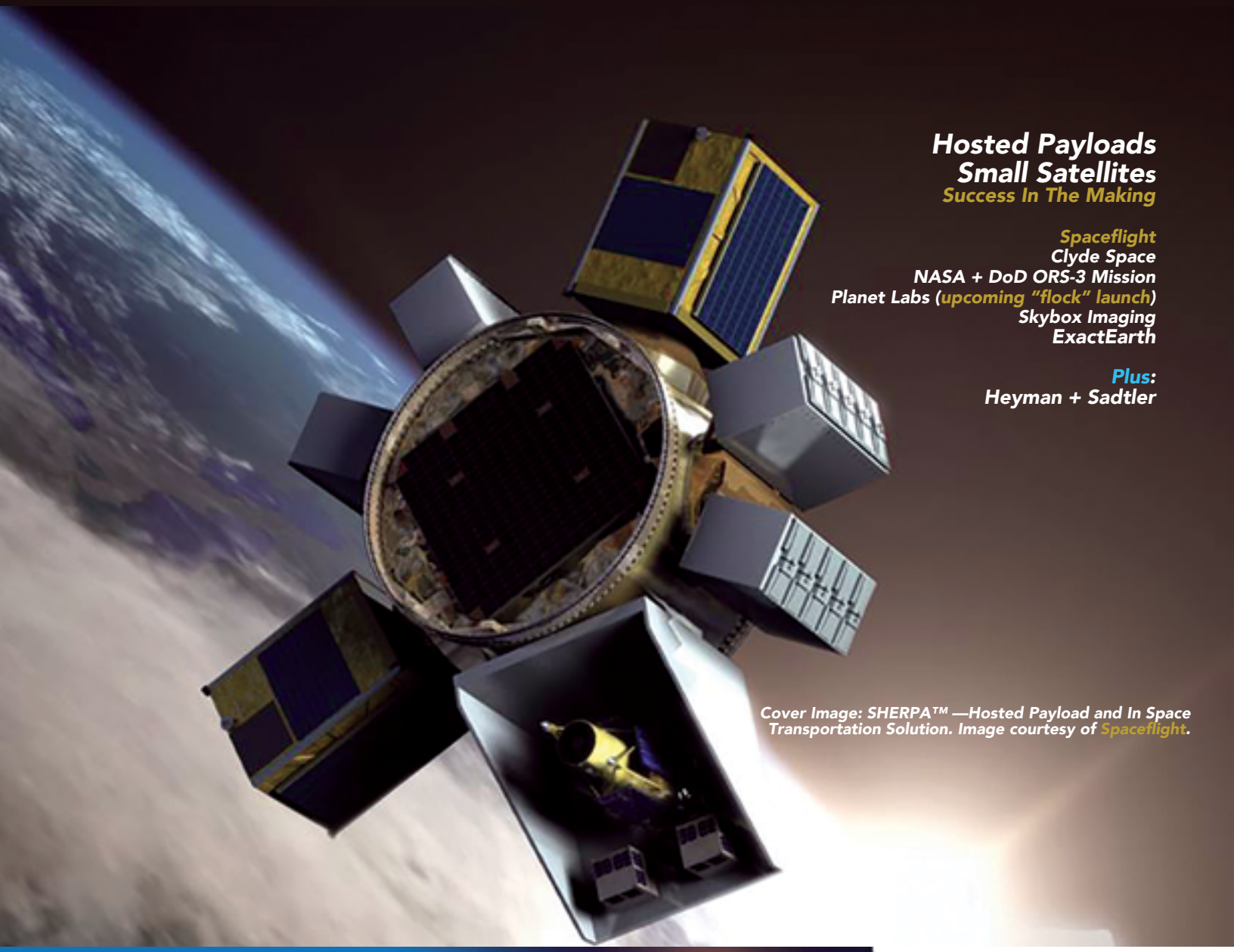
Worldwide Satellite Magazine January 2014

SatMagazine



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SatMagazine

January 2014

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European Space Agency—A Billion Pixels For The Stars

The launch of Gaia.
Photo courtesy of Arianespace and ESA.

The European Space Agency's Gaia spacecraft has launched with a billion pixel camera aboard as well as the capability of 3D mapping and will also test Einstein's Theory as to the influence of dark matter.

Gaia will also be on the hunt for exoplanets as will also measure the bending of light rays, due to gravitational effects.

The scientific satellite Gaia, designed and built by Astrium has been successfully launched from Kourou, French Guiana aboard a Soyuz.

Lift off occurred at 6:12:19 a.m., local time, on December 19th, 2013, aboard a Soyuz launch vehicle under the control of Arianespace. This was Flight VS06 and was Arianespace' sixth mission using the Russian-built vehicle at French Guiana, known as the European Spaceport.

The workhorse launcher performed a powered phase of its three lower stages, and two burns of the autonomous Fregat upper stage to deploy Gaia, which had an estimated liftoff mass of 2,034kg and was released 41 minutes and 59 seconds after liftoff.

A second firing of the Fregat 11 minutes later took Gaia into its transfer orbit, followed by separation from the upper stage 42 minutes after liftoff.

Ground telemetry and attitude control were established by controllers at ESA's operations center in Darmstadt, Germany, and the spacecraft began activating its systems.

The sunshield, which keeps Gaia at its working temperature and carries solar cells to power the satellite, was deployed in a 10-minute automatic sequence, completed around 88 minutes after launch.

Europe's most advanced space telescope Gaia, built for the European Space Agency (ESA), will produce a highly accurate 3D map of our galaxy, the Milky Way, and discover and map objects far beyond its boundaries so as to improve our understanding of its origins and evolution.

The Gaia mission is also expected to discover hundreds of thousands of unknown celestial objects, including extra-solar planets and failed stars, known as brown dwarfs. And within our solar system, Gaia will be able to identify tens of thousands of asteroids.

Gaia draws on the best in space technology and will carry ultra-modern instruments, including the most sensitive telescope ever made.

This cutting-edge equipment draws on unique expertise developed by Astrium in the field of silicon carbide (SiC) telescopes, such as that used for the space telescope on ESA's Herschel mission, as well as for all the instruments made by Astrium for Earth observation missions.

Through their space programs, Astrium and its partner Boostec have created a successful new economic sector.

The SiC produced in the French Midi-Pyrénées region enables Astrium and its partners to produce exceptional optical payloads for scientific missions and Earth Observation.

"Gaia is an unparalleled space system: the precision of its instruments and its technical conception once again prove Astrium's unique expertise in optical payloads," said Eric Béranger, CEO of Astrium Satellites. "Mastering these exceptional technologies enables us to maintain Astrium's rank as the world leader in the export of Earth observation satellites."

Gaia will also use a 'photographic' sensor of unprecedented accuracy. The precision of the measurements taken by Gaia's optical instruments will be extremely high.

For instance, Gaia would be capable of picking out a strand of hair from a distance of 700 kilometres—the equivalent of the altitude of Earth observation satellites—by using its huge focal plane made up of 106 CCD detectors gathering 1 billion pixels.

For its attitude control, the spacecraft will use a cold gas propulsion system with micro-thrusters, enabling it to remain perfectly stable and point with the required extreme accuracy.

Gaia will be located at one of the five Lagrangian points in the Sun-Earth system, at the L2 point.

The Lagrangian points in our solar system are points of gravitational balance where a body such as a spacecraft orbits around the Sun at the same rate as Earth, thereby remaining in a fixed position relative to the Earth-Sun line.

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European Space Agency—A Billion Pixels For The Stars *(continued)*

Engineers from SENER and Astrium stow Gaia's Deployable Sunshield Assembly (DSA) against the spacecraft, in the S1B cleanroom at the Centre Spatial Guyanais in Kourou, French Guiana.
This photo is courtesy of ESA-CNES-Arianespace Optique Vidéo du CSG—JM Guillon

Gaia being lowered onto the Fregat stage.
Photo courtesy of ESA.

Artistic impression of the Soyuz launcher carrying Gaia into orbit, showing the jettison of the fairing.
Image credit: ESA—D. Ducros

Located 1.5 million kilometers from Earth, the L2 point is vital for astronomy observation missions, which require high pointing stability.

The objectives of this new ESA astronomy mission are ambitious: Chart a 3D map of about a billion objects in our galaxy with a precision of 0.001 percent in order to better understand the mechanisms of galaxy formation.

Gaia should also enable scientists to have a more precise insight in the inner workings of the stars as well as to better assess the influence of dark matter.

Accuracy being one of its main features, Gaia will also be on the hunt for exoplanets as well as measuring the bending of light rays due to gravitational effects.

With 40 million observations per day, the cumulative data flow after five years of operation, even after having been compressed by software, will fill the equivalent of more than 200,000 DVDs.

It is precisely to develop the management software of the Gaia Payload Data Handling Unit that SPACEBEL was selected and joined the industrial consortium under the leadership of Astrium Ltd. in 2007.

The Payload Data Handling Unit is a mass memory device storing the scientific data from seven video units before transferring them to the ground stations.

An elaborate file management system allows flexible and efficient data transfer through virtual channels organized in the downlink.

Gaia is expected to find as many as 10,000 planets beyond our Solar System and hundreds of thousands of asteroids and comets within it. The mission will also reveal tens of thousands of failed stars and supernovas, and will even test Einstein's famous theory of General Relativity.

Once Gaia starts routine operations, around Easter 2014, astronomers will have the challenge of dealing with a flood of data.

Even after being compressed by software, the data produced by the five-year mission will fill over 30,000 CD ROMs.

This data will be transmitted 'raw' and will need processing on Earth to turn it into a calibrated set of measurements that can be freely used by the astronomical community.

The cutting edge computer technology developed at the Cambridge Data Processing Center will be key to this process.

Gaia's first discoveries will be of new sources—supernovae, extreme variable stars and blazars—which will be discovered at the Cambridge processing center, and immediately made available for study by both professionals and the interested public.

Jabiru Satellite Program

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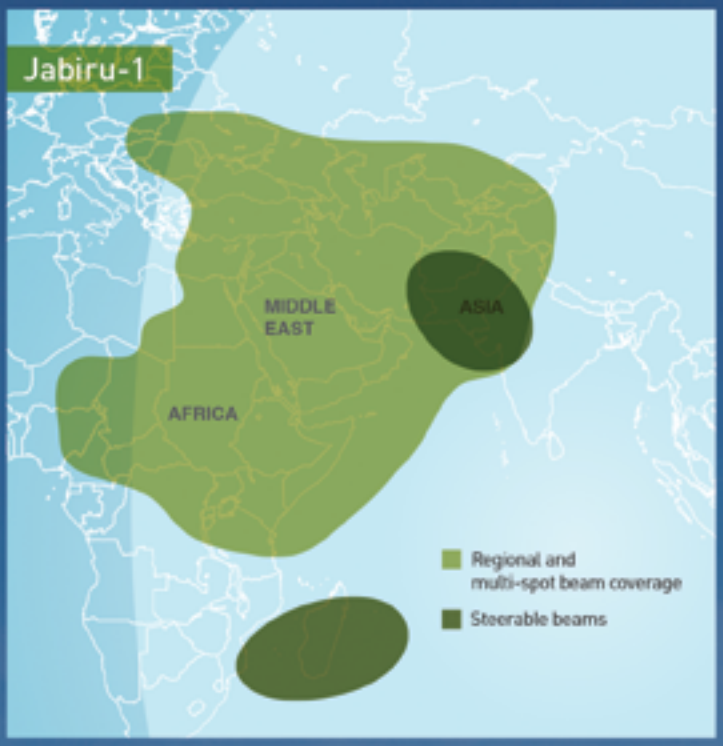

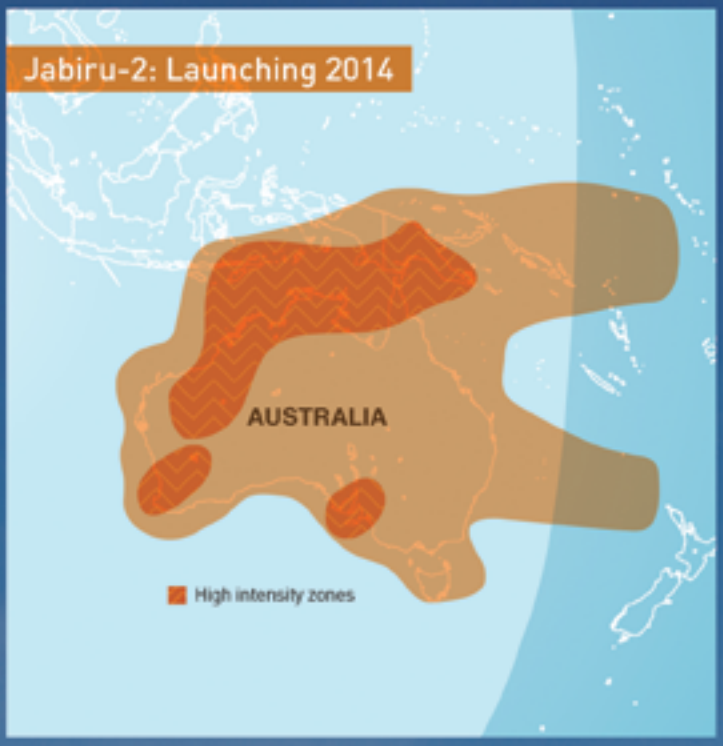

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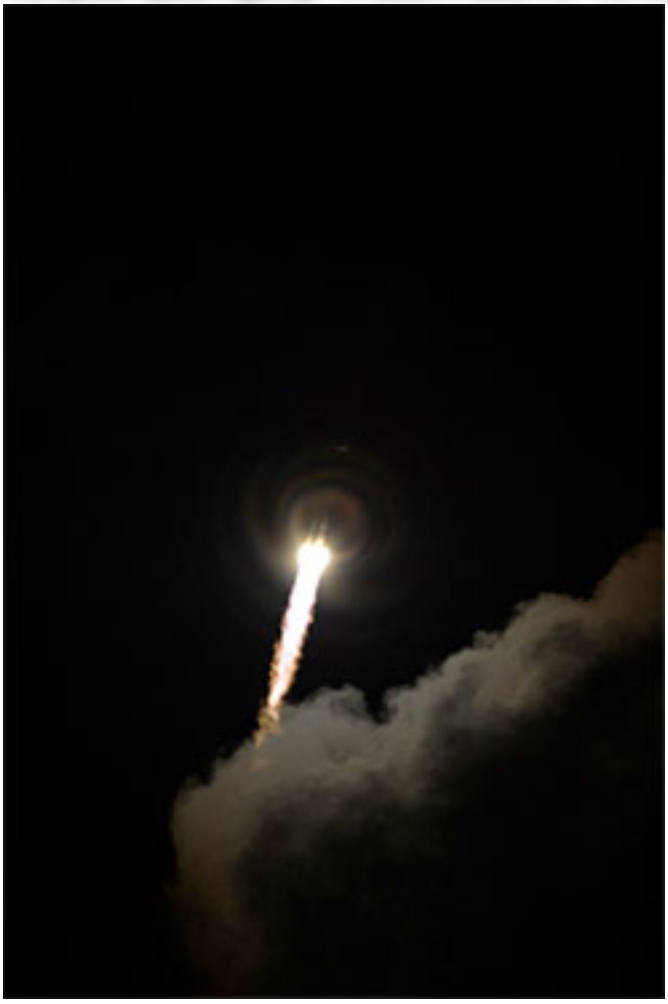
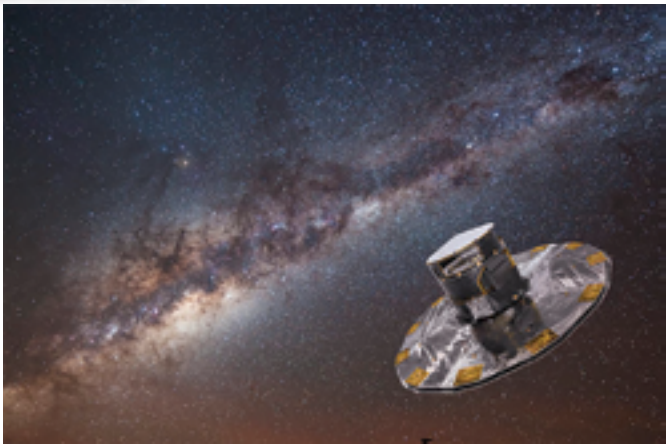
European Space Agency—A Billion Pixels For The Stars *(continued)*



Soyuz with Gaia aboard, reaching for the heavens. Photo is courtesy of ESA.



Artistic rendition of Gaia mapping the stars of the milky way. Image credit: ESA/ATG medialab—background by ESO/S. Brunier

Gaia will discover many new sources which are bright enough for amateurs, and schools with access to public robotic telescopes, to become the first to confirm and obtain more information.

Schools and amateurs will be able to load their data onto the Gaia web site **http://gaia.ac.uk/** where it will be used in scientific analyses, and fully credited.

"A school class can be the first to `adopt a supernova', observe it with robotic telescopes, such as the Faulkes, and provide critically important science information which we need to understand the new sources. That class will be doing original science, and will be credited for their research contributions" said Dr. Heather Campbell, a scientist at Cambridge who is part of the Gaia science alerts analysis team.

"By participating in the Gaia Alerts program, and remotely controlling the Faulkes Telescopes to observe exciting targets discovered just hours beforehand, UK schools will be making real contributions to the research side of this project," added Professor Paul Roche, Director of the FT project at the University of South Wales.

The United Kingdom (UK) had two major roles in the Gaia mission: Building the spacecraft, and delivering the science.

UK industry and science institutes won some 80 million euros of industrial contracts to build Gaia, with leadership roles in building the heart of Gaia, the array of 106 CCDs, the control avionics and the critical micro-propulsion system, as well as playing a critical role in the development of the Gaia spectrometer.

Astrium at Stevenage was responsible for the spacecraft's super precision guidance and control system as well as the powerful on-board computers needed to process the torrent of data it will produce.

The 'eye' of Gaia's camera has the most sensitive set of light detectors ever assembled for a space mission. It is also the largest focal plane array ever to be flown in space and contains a mosaic of 106 large area, high performance Charged Coupled Device (CCD) CCD91-72 image sensors, which are custom designed, manufactured and tested by UK company e2v.

Without these image sensors the Gaia mission would not be possible. These detectors were calibrated with the Gaia electronics at Mullard Space Science Laboratory. SciSys UK Ltd. is responsible for the spacecraft's operational simulator.

Gaia data will be processed and analyzed ready for release to the scientific community and public at six data centers, including one in the UK, operating software developed and tested by a consortium of 400 people across Europe, including some 50 people at 6 Institutes in the UK (Cambridge, UCL-MSSL, Leicester, Edinburgh, The Open University, STFC RAL Space and Bristol).

University College London's Mullard Space Science Laboratory (MSSL) has a major role in spectroscopic science, and in conjunction with The Open University, is involved in software development including architecture, integration and validation, pre-processing development, spectra extraction and calibration.

The UK hosts the Cambridge data processing center, where the Gaia imaging data are processed. These data provide brightness, color, and position information, which enable the core Gaia science, determining distances motions and the intrinsic properties of each star. Gaia also has a spectrograph, to measure the radial velocities of 300 million stars, delivering their complete 3-D positions and 3-D velocities. The spectra will be processed at the French data center, using software in part developed in the UK.

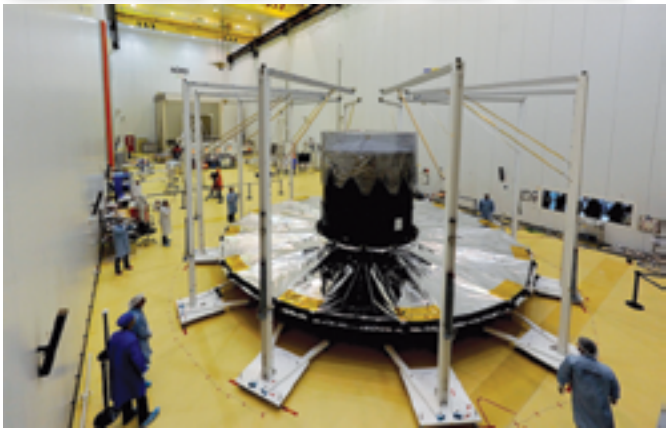
With extreme precision and extreme stability as design drivers, Gaia is a concentrate of technological firsts.

Gaia's astounding acuity—the mission aims to pick out celestial objects one million times fainter than the human eye can see—is achieved by more than 100 light-detecting sensors, like minuscule digital cameras, mosaicked together to form the largest ever space-bound focal-plane array (nearly a billion pixels packed onto a surface of 0.38m2).

Channeling the light onto the focal-plane array are two telescopes with primary mirrors set at an angle of 106.5 degrees to each other for a wide-field view.

Despite the spacecraft's modest dimensions (the payload module is 3.5m in diameter), an ingenious method of bouncing the collected light through a series of 10 mirrors of different shapes and sizes means that the telescopes' effective focal length is extended to 35m. Thus Gaia can 'see' objects 400,000 times fainter than those visible to the naked eye.

Launch-O-Rama: ESA—A Billion Pixels... *(continued)*



Gaia's build work continues at the Centre Spatial Guyanais. Photo courtesy of ESA.

The data from Gaia's three instruments (taking astrometric, photometric and spectroscopic measurements) should provide a pinpoint location for each star mapped with an error margin of only six microarcseconds, equivalent a penny on the surface of the moon, as viewed from Earth.

Rock-steady stability is crucial for making observations of such minute detail, and this dictated Astrium's choice of material—silicon carbide (SiC), a ceramic twice as rigid as steel, ultra lightweight, and remarkably resistant to expansion/contraction under temperature change.

SiC is the only material which can guarantee the stability, durability and lightness of the probe, and Gaia will be the largest ceramic space instrument ever flown.

There are virtually no moving components on Gaia, to avoid vibration. (Even the Earth-antenna points communicate electronically, not mechanically.) As this ruled out 'standard' chemical thrusters, an entirely new type of nitrogen-based thruster for fine attitude pointing which exerts a force as small as a micronewton was specially developed for the mission.

You would need a thousand such tiny thrusters to support a sheet of paper.

Information for this news article was supplied by Astrium Satellites, Arianespace, European Space Agency, the UK Space Agency, and SciSys UK.

Gaia being positioned inside the Soyuz fairing in preparation for the launch. The spacecraft (orange) was attached to the vehicle adapter (yellow) before being installed in the fairing. This work was being completed inside the S3 building at the Centre Spatial Guyanais in Kourou, French Guiana. Photo courtesy of ESA - M. Pédoussault.

Bolivia + China: TKSat-1 Away...

TKSat-1 during its manufacturing process at the CGWIC facility. Photo courtesy of CGWIC.

Unlike the failure of the CBERS-3 launch on December 9th, TKSat-1 made spatial headway on December 20th at 17:02 UTC, as this first telecommunications satellite for Bolivia successfully headed into space via launch by a Chinese Long March 3B/E rocket from the Xichang Satellite Launch Center in the province of Sichuan.

Packing 26 Ku-, 2 C-, and 2 Ka-band transponders, TKSat-1 will offer communications and broadcasting services to Bolivia as well as other support for SatHealth™ data, governmental civil projects, and remote education services.

TKSat-1, also known as Tupac Katari, is based on manufacturer China Great Wall Industry Corporation's (CGWIC) DFH-4 platform, the platform itself built by the China Academy of Space Technology. The liftoff mass was 5,100kg and the satellite has an expected lifespan of approximately 15 years.

Operating from the orbital slot at 87.2 degrees West, TKSat-1's output power is 10.5kW, with a payload capacity of 588kg, and its reach will include Argentina, the areas east of Brazil and north of Chile, Colombia, Ecuador, Paraguay and Uruguay.

The satellite's total cost is estimated to be approaching US$302 million. The project—jointly financed by China's Development Bank and the government of Bolivia—also stipulates terrestrial base stations must be constructed in La Paz and Santa Cruz.

According to Bolivia's space agency (AEB), the investments in the satellite will be recovered over the next 10 years or so, with annual revenues generated of nearly US$40 million.

Aboard the Long March launch vehicle, TKSat-1 awaits the launch sequence.

NAB + JD Events—Showmanship

The National Association of Broadcasters has announced the purchase of the assets of the Satellite Communications Conference and Expo (SATCON) as well as Content and Communications World (CCW) from JD Events, a leading trade show organizer.

SATCON and CCW, held annually in November, are co-located at the Javits Convention Center in New York City. The two events will complement NAB's existing trade shows and events, including NAB Show, held in Las Vegas annually in April.

SATCON offers education and exhibits serving companies in the satellite-enabled communications and content delivery industry.

CCW is a leading media, entertainment and communications technology event held in New York, with a focus on content creation, management and delivery technologies.

The 2013 CCW (which included SATCON) broke all previously held event attendance records with 6,898 attendees, a 22 percent increase from 2012.

"We have made these additions to the NAB event family with the goal of growing both the attendee and exhibitor base of what has emerged as an important East Coast venue for the content community," said Executive Vice President of NAB Conventions and Business Operations, Chris Brown.

"We look forward to developing this event and serving the unique needs of this very important media market."

Joel Davis, founder and CEO of JD Events, said, "The JDE team has worked extremely hard to build these two shows to where they are today. Along the way we have had the pleasure to work with hundreds of wonderful exhibiting companies and thousands of passionate industry professionals. We believe the shows have now grown to the point where they require a larger more experienced owner, with much deeper industry reach and relationships, to take them to the next level. We are excited to place the future of CCW and SATCON into the very capable hands of the NAB."

JD Events was represented by The Jordan, Edmiston Group, Inc., a New York City-based investment bank that specializes in the media, information, marketing services and related technology industries.

NAB information is available at their site: ***http://www.nab.org/***

NASA + Orbital These Cubes Don't Melt Under Fire

The ORS-3 launch from Wallops.
Photo courtesy of Orbital Sciences.

NASA + Orbital These Cubes Don't Melt Under Fire

On November 19th, 2013, a record launch occurred... this was no small task, although much of the payload was small in size... and cubed.

This was an important launch for the USAF, Orbital, and the owners of the 28 small satellites that were also carried aloft as part of the overall payload. (*For additional insight, please see the article on Page 23*).

Orbital Sciences Corporation's teams cheered as they successfully launched a Minotaur I rocket in support of the Department of Defense Operationally Responsive Space Office's ORS-3 mission earlier this evening. Originating from the Mid-Atlantic Regional Spaceport, located at NASA's Wallops Flight Facility in eastern Virginia.

This mission marked the 25th launch for the Minotaur rocket, all of which have been successful, and the sixth Minotaur vehicle to be launched from the Wallops facility.

The primary goal of the ORS-3 mission was to test new procedures and equipment that would allow future missions to be flown at lower cost and with faster response times.

At approximately 8:15 p.m. (EST), the rocket's first stage ignited, starting its flight into Low Earth Orbit (LEO).

Approximately 12 minutes after lift-off, the Air Force's Space Test Program Satellite-3 (STSat-3) spacecraft was deployed into its intended orbit at an altitude of approximately 500km (310 miles).

The Minotaur's upper stage then executed a pre-planned collision avoidance maneuver before starting deployment of 28 CubeSats sponsored by the ORS office, the U.S. Air Force Space and Missile Systems Center's Space Test Program, and NASA's Educational Launch of Nanosatellites (ELaNa) program.

"This mission marks the final launch for Minotaur under the initial Orbital/Suborbital Program-1 and -2 contracts, culminating in the successful delivery of 74 satellites to orbit and 10 suborbital payloads to high-altitude trajectories over 25 total missions," said Mr. Ron Grabe, Orbital's Executive Vice President and General Manager of its Launch Systems Group.

"Orbital's team is absolutely focused on offering the most reliable and cost-effective launch systems to our government customers for their important space missions. This dedication and teamwork with the Air Force has resulted in achieving 25 consecutive successful missions since 2000. We look forward to continuing this collaboration under the OSP-3 contract in the years ahead."

This launch, which was executed under a Federal Aviation Administration (FAA) license obtained by Orbital through the FAA's Office of Commercial Space Transportation, demonstrated a commercial-like approach to government launches in an effort to reduce overall costs.

Through this mission, Orbital also supported the development of new technologies for launch and range improvements including automated targeting, range tracking and flight termination systems.

The Minotaur I space launch configuration combines Orbital's commercial launch vehicle technologies, including upper stage rocket motors, avionics, structures and other elements, with government-supplied lower-stage rocket motors to create responsive, reliable and low-cost launch systems for U.S. Government-sponsored spacecraft. It can place payloads of up to 600kg (1,300 lbs.) into Low Earth Orbit (LEO).

The ORS-3 during its build process. Photo courtesy of Ball Aerospace.

Under the OSP program, which is managed by the Air Force Space and Missile Systems Center's Space Development and Test Directorate (SMC/SD) Launch Systems Division (SMC/SDL) located at Kirtland Air Force Base, New Mexico.

Orbital designs, integrates, tests and provides space launch services with the Minotaur I, IV, V and VI rockets, as well as other suborbital capabilities with the Minotaur II and III configurations.

The rockets are specifically designed to be capable of launching from all major U.S. spaceports, including government and commercial launch sites in Alaska, California, Virginia and Florida.

Orbital's use of standardized avionics and subsystems, mature processes and experienced personnel make Minotaur rockets both reliable and cost-effective for U.S. government customers.

The ORS-3 mission, also known as the Enabler Mission, will demonstrate launch and range improvements to include automated vehicle trajectory targeting, range safety planning, and flight termination; employ a commercial-like procurement with FAA licensing of a Minotaur I; and launch the Air Force's STPSat-3 and 28 CubeSats on an Integrated Payload Stack.

These enablers focus on the ability to execute a rapid call-up mission as well as to automate engineering tasks that once required months to complete and to reduce those timelines to days or hours, resulting in decreased mission costs.

The U.S. Air Force Space Test Program's Standard Interface Vehicle (STP-SIV) project has developed a common spacecraft bus with a standard payload interface to accelerate Department of Defense space technology and ensure future U.S. space superiority.

Payload teams are able to design payloads and specific experiments to be compatible with the flexible standardized vehicle, resulting in lower spacecraft non-recurring costs and increased spaceflight opportunities. By providing such a vehicle, the Space Test Program can shorten acquisition timelines and decrease spacecraft build costs for its defense industry customers.

As for the program, Ball Aerospace is responsible for the overall system including the spacecraft and standard payload interface design and build, payload integration, space vehicle environmental testing, and launch and mission support.

Ball Aerospace's STP-SIV series of satellites, based on the Ball Configurable Platform (BCP) 100 is ideal for a variety of science, technology development and risk reduction missions.

The STP-SIV:

- Spacecraft is approximately 24" x 28" x 28" high and weighs less than 110kg
- Accommodates up to four separate instruments
- Operates in any LEO from 400 and 850km altitude
- Remains easily adaptable for future missions—no design changes necessary for payloads that conform to the standard interface
- Maintains flexibility to launch on a large variety of vehicles, including the EELV Secondary Payload Adapter

The first STP-SIV spacecraft, STPSat-2, launched November 19, 2010, aboard a Minotaur IV from Kodiak, Alaska. That satellite is carrying a relay transponder for data collected by ocean buoys and a space phenomenology sensor.

STPSat-3, the second STP-SIV spacecraft was built in only 47 days. Construction of the STPSat-3 platform was completed before the final payloads had been selected, demonstrating the flexibility of the hardware. Payloads for STPSat-3 include:

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NASA + Orbital Prove Its A Good Thing Cubes Don't Melt Under Fire *(continued)*

Ball's STP-SIV series of satellites is built on the Ball Configurable Platform (BCP) 100. Photo courtesy of Ball Aerospace.

- iMESA-R (Integrated Miniaturized Electrostatic Analyzer Reflight), a U.S. Air Force Academy mission designed to measure plasma densities and energies
- J-CORE (Joint Component Research), a space phenomenology mission sponsored by the Air Force Research Laboratory (AFRL) / EO Countermeasures Technology Branch (RYMW) & Army Space and Missile Defense Commance (SMDC)
- SSU (Strip Sensor Unit), an AFRL Directed Energy (RD) experiment to provide risk reduction through on-orbit testing and operation of a sensor assembly
- SWATS (Small Wind and Temperature Spectrometer), a Naval Research Laboratory (NRL) mission to provide in-situ measurements of the neutral and plasma environment to characterize the Earth's ionosphere and thermosphere
- TCTE (TSI Calibration Transfer Experiment), a NASA/NOAA mission to collect high accuracy, high precision measurements of Total Solar Irradiance to monitor changes in solar irradiance incident at the top the Earth's atmosphere with TCTE instrument provided by the Laboratory for Atmospheric and Space Physics

On June 29th of 2013, the second anniversary of the launch of the ORS-1 satellite, the precursor for the ORS-3 projected, was celebrated, with thanks to all of the launch partners.

The mission of the ORS Office is to plan and prepare for the rapid development of highly responsive space capabilities that enable delivery of timely warfighting effects and, when directed, develop and support deployment and operations of these capabilities to enhance and assure support to Joint Force Commanders' and other users' needs for on-demand space support, augmentation, and reconstitution.

The ORS Office is tasked with establishing the ability to provide rapid end-to-end capability efforts to meet urgent operational needs of the Joint Force Commanders (JFC). The ORS Office plans to stand up this capability over time with a phased "crawl," "walk," "run" approach.

Responsiveness is defined in terms of Tiers. These tiers are distinguished by the length of time required to deliver ORS capabilities. Achieving these timelines are an important goal as the ORS program matures:

- Tier 1: EMPLOY- On-demand use of existing deployed assets in applications that may extend or expand their original purpose. The objective of Tier 1 is to deliver these capabilities within minutes to hours. Other elements of the National Security Space (NSS) community have the primary responsibility for identifying and executing Tier 1 initiatives.
- Tier 2: DEPLOY- Deploying new or additional capabilities that are field-ready; that is, already produced. The objective of Tier 2 is to deliver capabilities within days to weeks.
- Tier 3: DEVELOP- The rapid development, delivery, and employment of a new capability. The objective of Tier 3 is to deliver capabilities within months and less than one year. The ORS Tier 3 strategy comprises the primary office activity focused on maturing the ORS enabling elements.

InfoBeam

Russia—New Soyuz Debuts With Blast-Off

A new Soyuz rocket blasted off from the Plesetsk space center in northern Russia on January 2, after numerous delays earlier this week, the Russian Defense Ministry said.

There were numerous attempts to launch. Originally, a Russian defense official, Colonel Dmitry Zenin, had said later on Wednesday the launch was postponed again and would take place sometime next year. A state commission that gathered on that Saturday morning decided to launch the rocket at 14:00, but it was also cancelled minutes before the planned blastoff.

Finally, the ministry said the launch took place at 16:30 Moscow time (12:30 GMT) on January 2nd. The rocket put into designated orbit a small research satellite built by students and young scientists.

The new rocket, dubbed the Soyuz-2.1v, features a completely reworked first stage powered by a NK-33 (14D15) rocket engine built by the NK Engines Company in the Russian city of Samara.

The rocket lacks the characteristic four boosters that Soyuz and its ancestors have had since the R-7 missile that launched Sputnik in 1957.

The Soyuz, the most frequently launched rocket in the world, has undergone more than 1,700 launches since its debut in 1966. It is one of only two rockets worldwide that are capable of sending astronauts into orbit, the other being the Chinese Long March 2F.

UAE—It's A First

The United Arab Emirates plans to launch the first Arab-built satellite into orbit in 2017, according to the state news agency WAM.

The 'Khalifa Sat' is set to be the fifth satellite owned by the UAE, but the first to be wholly manufactured in the country.

"Khalifa Sat will be the first Arab-made satellite, catapulting the Arab region into a new era of space industry and competition in space sciences," the news agency reported.

Sheikh Mohammed bin Rashid al-Maktoum, Vice President and Prime Minister and Ruler of Dubai, launched the "executive phases" of the project on January first.

"Khalifa Sat is a message to all Arabs that Arab ushering into the space era is neither out of reach nor impossible," Sheikh Mohammed said. "Our doors will remain open for cooperation with all Arab countries in space technology and engineering," he added.

The satellite will be built at the Emirates Institution for Advanced Science and Technology (EIAST) in Dubai, according to WAM.

EIAST previously launched two satellites, DubaiSat1 and DubaiSat2. The Abu Dhabi-based Yahsat currently operates two satellites and has previously indicated the possibility of launching a third.

New Launch Options For Small Satellite Companies

By Curt Blake, Senior Vice President & General Counsel, Spaceflight Inc.

Moore's Law, hardware miniaturization, and terrestrial cloud computing are rapidly expanding into the satellite industry.

The increasing capabilities of small satellites are allowing micro- and nanosatellites to supplant large satellites in traditional roles, and enabling new operating paradigms such as constellations and disaggregation.

For instance, Planet Labs' planned constellation comprises dozens of CubeSats, all about the size of a milk carton. These could eventually provide more comprehensive coverage and better resolution than NASA's 4000lb LandSat spacecraft.

SkyBox just launched their first satellite, a high resolution Earth Observation (EO) spacecraft that provides 80 percent of the capability—at 20 percent of the cost—compared to those operated by Digital Globe.

Nanosatisfi, a company dedicated to making small satellite data consumption as ubiquitous as using a smart phone app that was incorporated in January 2013, deployed their first two spacecraft from the International Space Station 10 months later.

These innovative companies are grabbing the headlines with their incredibly small spacecraft and new technology. However, their business plans are all enabled thanks to the revolution that is occurring in satellite delivery and on-orbit operations.

Launching small spacecraft through ride sharing or "piggy backing" in launch vehicles is not a new concept. However, 2013 will go down in history as the year such became mainstream.

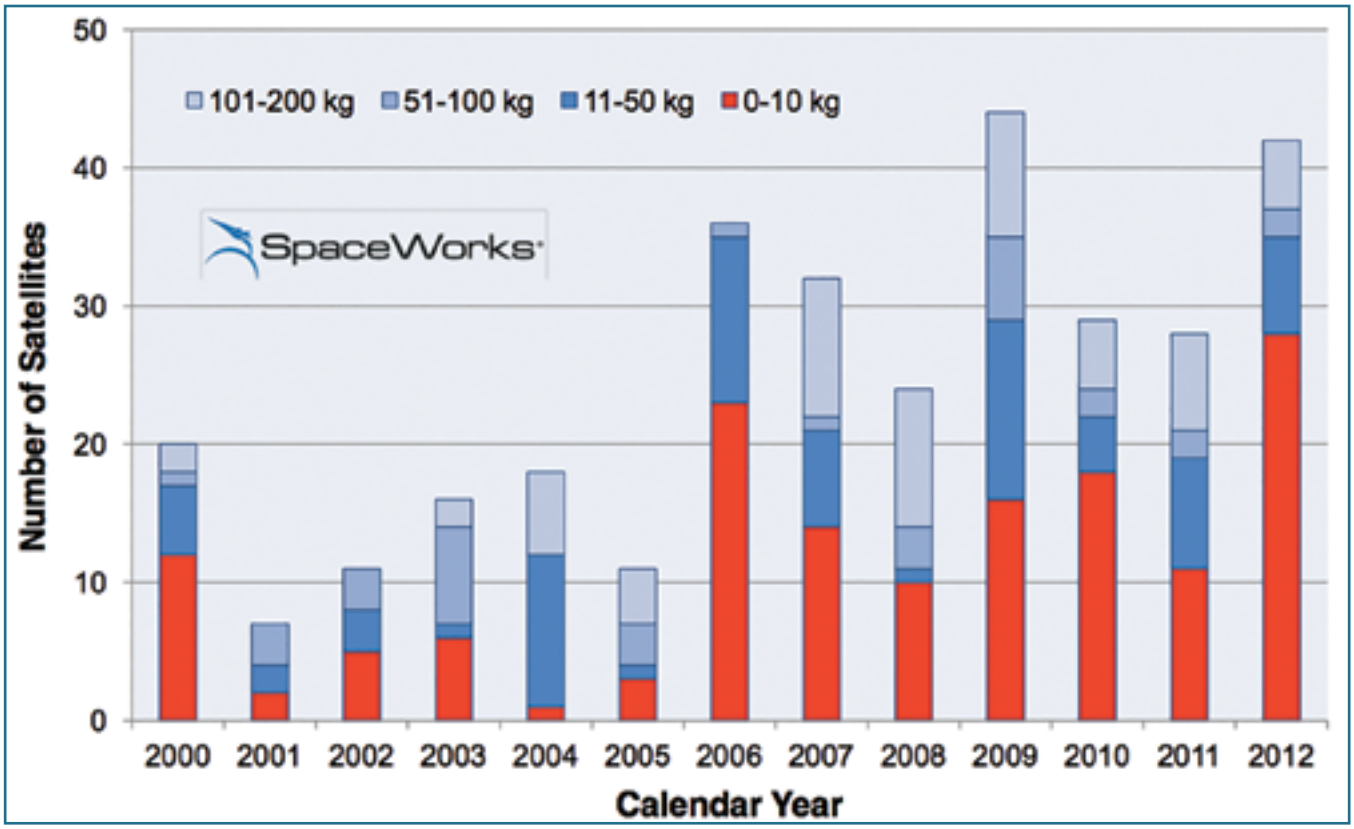
Evidence is provided from two recent launches that set records for the most payloads ever inserted into orbit by a single vehicle. The November 19th record launch of 29 satellites on a Minotaur 1 was immediately bested by a November 21st launch of 32 satellites on the Russian Dnepr rocket. In late December, close to 30 payloads packed aboard an expected Cygnus spacecraft launch will be transported to the International Space Station (ISS) and then later deployed from the Japanese Experiment Module. Is this just a coincidence, or is this a fundamental shift in our industry?

Findings in a 2013 analysis by SpaceWorks reveals an emerging and sustained launch market with a strong showing of payloads in the under 10kg class—primarily CubeSats. Findings such as these lead many to believe that the small satellite market will continue to expand and exceed expectations.

Many organizations have capitalized on fulfilling the launch needs of the nanosatellite-class spacecraft. For example, NanoRacks signed an agreement with NASA that allows them to deploy CubeSats from the International Space Station (ISS). NASA itself has issued a call for a dedicated launcher for small satellites, due to the backlog of CubeSats waiting for a launch vehicle—an initial contract has now been awarded to Generation Orbit for this purpose. However, options are not as numerous for the small satellites that do not conform to CubeSat specifications.

Non-containerized small satellites, which are larger than CubeSat standards but too small to launch as a primary payload, are fighting for access to launch opportunities. While not in the news as often as CubeSats, SpaceWork's analysis shows small satellites (50 to 200kg) continue to occupy a large, and definitely underserved, portion of the market. Microsatellite providers often lack the logistical support required to reserve space on vehicles that serve the traditional launch market.

In an effort to help these underserved satellites gain access to space, Seattle-based Spaceflight, Inc. has specialized in manifesting and



integrating spacecraft between 1 and 300kg on a variety of launch vehicles. Spaceflight oversees all secondary payload integration activities, functioning as the link between the secondary payload and the launch service provider.

Through Spaceflight, small satellite developers can procure a cost effective launch, as opposed to purchasing an entire vehicle. Spaceflight's business plan includes purchasing launch vehicle capacity at wholesale pricing and then reselling the available space to small satellite customers.

This means lower prices for microsatellites as well as it provides additional revenue for the launch service providers, because more of the launch vehicle's available space is purchased and utilized. Small satellite builders can use Spaceflight to obtain the logistical support currently enjoyed by CubeSat developers. Regulatory compliance is often a concern for those planning to deploy small satellites. Issues often encountered include:

- FCC Licensing and its required compliance with space debris mitigation standards
- NOAA licensing for remote sensing payloads, registration of space objects through the Department of State and, ultimately, the ITU
- Navigating disparate country specific liability limitation schemes
- Export regulations, including compliance with the ITAR

Spaceflight works hand-in-hand with clients to ensure payload providers do not inadvertently misstep as they proceed toward launch.

Spaceflight foresees small satellites and nanosatellites providing many of the functions currently reserved for much more expensive spacecraft. To do this, small satellites need to be able to reach a variety of orbits and inclinations to perform these functions. As many small satellites lack a propulsion system, they require hosted deployments.

To fulfill this need, Spaceflight has developed SHERPA, a hosted payload and space transportation solution that adds power and propulsion to the SSPS and provides orbital maneuvering capability for the small satellites. SHERPA helps small satellites expand their functionality by making many orbits available.

Standardized launch interfaces and secondary payload accommodations have enabled the rapid creation and deployment of small satellites. Their capabilities expand every year, with inroads into remote sensing, and, eventually, the telecommunications market.

The small satellite revolution is primed to take off and Spaceflight is prepared to enable small satellites success in the commercial market.

About the author

Mr. Blake brings to Spaceflight years of top-level experience in rapid growth, high-tech companies. His strengths include corporate strategy, intellectual property rights, mergers and acquisitions and public company legal experience. Mr. Blake has held a wide range of Senior Executive and General Counsel positions. He served as CEO of Got Voice from 2007 to 2010, a company focused on revolutionizing voice mail, and negotiated its sale in 2010. From 2000 to 2008 Mr. Blake served on the Board of Directors of SpaceDev Inc. From 1993 until 1999, Mr. Blake served as the COO of the Starwave Corporation, where he managed business development, finance, legal and business affairs, and operations for the world's most successful collection of content sites on the Internet. Mr. Blake negotiated the sale of the controlling interest in Starwave Corporation to Disney/ABC (NYSE:DIS).

Small Satellites — Making Their Way

The inclination to ignore small satellites and the firms that develop them as only a minor segment of the satellite market is no longer an option... companies, large and small, are committing valuable resources into the design, building and launching of small satellites. Additionally, small satellites, from picos to CubeSats, are proving themselves to be highly effective in managing their highly targeted missions.

Small satellites provide cost savings and functionality. With build activity within the commercial and MAG (Military, Aerospace and Government) environs—small satellites are proving their worth. Consider the ability to launch numerous satellites in a single, hosted payload launch... constellations being orbited in a single release, and manufacturing costs drastically reduced withoiut the sacrifice of key solutions.

Alacrity to market is also a serious challenge to the U.S. and allied nation communications, EO and ISR markets: A number of nations who have the wherewithal to invest heavily are now engaging in aggressive missions to dominate spatial environments. Such daring requires indiginous manufacturers be far more nimble in their design and production processes to remain ahead of the ever-increasing compeition.

Readers know all too well the significance that is being displayed by the current U.S. administration at their lack of a unified and aggressive space policy. A marketing adage from the mid-30s best illustrates the reasoning behind the global rush to build and launch more and more satellites and space exploration vehicles—"Find a need and fill it."

If an empty space—quite literally—is evident, rest assured nations with foresight will take the steps necessary to replace the vacuum left by those who once led. A course of prevention is always far better than a lengthy cure, and small satellites can fill the technology amid mission gaps for more frequent launches, while space policy is discussed and re-discussed, re-hashed and argued in halls populated by those who know not of what they speak.

Small satellites are normally categorized by their weight class:

- CubeSat — a cube-shaped vehicle with a total volume of one liter (10cm) and a mass no greater than 1.33kg (*as specified by California State Polytechnic University in San Luis Obispo, California, in their* ***CubeSat Design Specifictions, Rev. 12.***)
- Minisatellie (mini) — 1,100 pounds (498.95g)
- Microsatellite (micro) — 220 pounds (99kg)
- Nanosatellite (nano) —22 pounds (9kg)
- Picosatellite (pico) — 2.2 pounds (997.90g)

Some of the most recent activities and companies involved in the small satellite market are presented in this article, which proves the adage that, for many missions, "smaller is better."

Current Small Satellite Endeavors + Successes:

(NASA is reporting that the agency is receiving confirmation from 11 small CeubeSat research satellites that they are operating as planned. The cubesats were included as auxiliary payloads aboard a U.S. Air Force Minotaur 1 rocket that lifted off from the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility at 8:15 p.m. EST. The cubesats, NASA's fourth Educational Launch of Nanosatellite (ELaNa) mission, deployed from their protective cases into Earth's orbit about 20 minutes after liftoff.)


When You Really Need It To Work... When You Really Need It To Be There...
Type Approved AvL Antennas 85cm, 1.0M, 1.2M
AvL TECHNOLOGIES
TYPE-APPROVED
AVANTI
EUTELSAT
HUGHES
VIASAT
Professional
Developed by satellite antenna engineers with over 300 years total experience
Reliable
Over 18 years of production and 18,000+ units in the field
Versatile & Affordable
FlyAway or Fly&Drive
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designs for ultimate performance
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Last month, one of the most recognizable companies in the small satellite market, Clyde Space, based in Scotland, was pleased to learn that Stephen Greenland, one of the firm's system engineers, had been awarded a major grant—the acclaimed Industrial Fellowship from the Royal Commission for the Exhibition of 1851.

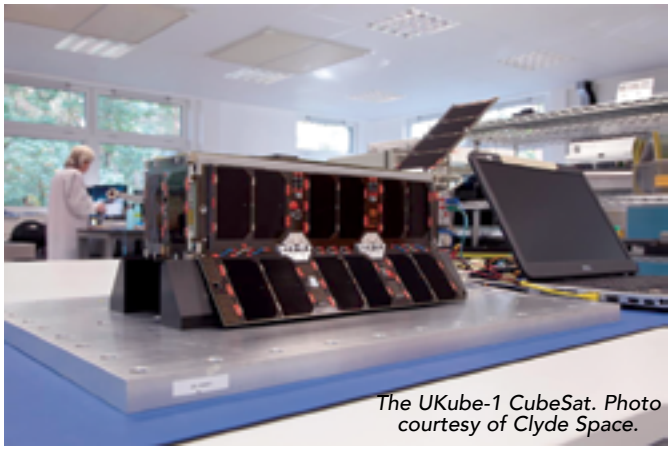
1851? My word, that doesn't sound up-to-date at all. Actually, this fellowship was initiated by Prince Albert in the year 1851 at the Crystal Palace where the Exhibition was taking place. The fellowship supports scientific and technological development and awards £80,000 to the recipient.

This financial reward allows the awardee to pay for tuition and travel expenses, as well as a portion of their salary, while pursuing their Ph.D. as they continue to work in the industry.

For Stephen, that involves his continued work on nanos and the involvement of biosciences, distributed imaging and quantum technology.

His latest efforts surround the development and implementation of the uKube-1 program. The UKube-1 is a CubeSat that is scheduled for a February 10th launch aboard a Soyuz-2 rocket from the Baikonur Cosmodrome. The CubeSat was shipped to the launch facility in October of 2013.

Clyde Space CEO, Craig Clark, said, "The Industrial Fellowship from the Royal Commission for the Exhibition of 1851 is a fantastic scheme, as it opens the opportunity to conduct long term research and capability expansion that we would not normally be able to undertake at Clyde Space. Stephen's contribution to the UKube-1 mission has been outstanding and he fully deserves to be selected for the fellowship and I would like to thank and congratulate Stephen for his hard work on the project."



The UKube-1 CubeSat. Photo courtesy of Clyde Space.

Payloads in the UKube-1 include the first GPS device aimed at measuring plasmaspheric space weather, a camera that will take images of the Earth and test the effect of radiation on space hardware using a new generation of imaging sensor, as well as an experiment to demonstrate the feasibility of using cosmic radiation to improve the security of communications satellites, and to flight test lower cost electronic systems.

The satellite will also carry a payload comprised of five experiments that students and the public in the United Kingdom can interact with. Additionally, an outreach program will also allow school children to interact with the spacecraft.

Clyde Space has been developing components and systems for small satellites since 2005 when it was founded by Craig Clark. One of the facts that continue to showcase the company as a leader in this field is that more than 40 percent of all CubeSat missions flown around the globe possess Clyde Space hardware, which is fully ISO9001:2008 accredited.

A major step for Clyde Space is their online CubeSat Shop, where individuals, companies and organizations can purchase their small satellite components directly online. The products range from electrical power systems to ground stations to on-board computers and de-orbi devices to all manner of structures and accessories. The offerings may be viewed at: ***http://www.clyde-space.com/cubesat_shop***

Success for the company's small satellite endeavors can be easily measured... in October of 2013, the firm announced £1.65 million in sales for the previous six months, doubling 2012's earnings.

Additionally, there was a new order from the National University of Singapore for a CubeSat platform, with previous sales to the Massachusetts Institute of Technology, the U.S. Air Force, NASA, SELEX, Raytheon and a number of other global companies.

CEO Craig, who was awarded an MBE in the Queen's Birthday Honors List this year for services to innovation and technology, said, "Most systems used in satellites are very expensive, but what we provide is far more cost effective. What we're doing will enable more missions with more complex objectives and make them more accessible."

Small Satellites — Making Their Way

The ORS-3 enabler launch mission packed the SPTSat-3 spacecraft and a number of CubeSat experiments, all sponsored by the Operationally Responsive Space (ORS) office (*http://www.ors.csd.disa.mil*), the U.S. Air Force Space & Missile Systems Center's Space Test Program, and NASA's Educational Launch of Nanosatellites (ELaNa) program.

The ORS-3 mission headed to the space aboard a Minotaur I launch vehicle from NASA's Wallops facility on November 19th, 2013. ORS-3 is ushering in today the launch and range processes of the future. The ORS-3 mission demonstrates and validates a new launch vehicle flight safety architecture for the future through the AFSS (Autonomous Flight Safety System) payload. This technology uses launch vehicle orbital targeting and range safety planning processes to protect public safety from an errant launch vehicle during flight.

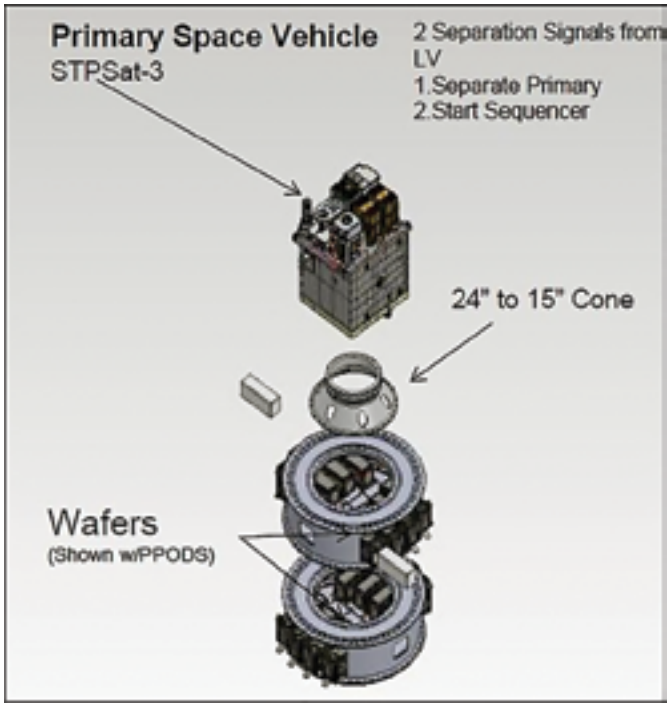
The outcome of this test is of great interest to the military as well as to NASA. The launch is also part of the Federal Aviation Administration's (FAA) certification process for the Minotaur rocket. The FAA has licensing authority over American commercial rockets.

With a near-circular orbit at an altitude of 500km and an inclination of 40.5 degrees, the mission carries 24 secondary technology payloads: The secondary technology payloads on this flight consist of free-flying systems and non-separating components (2 experiments). ORS-3 will employ CubeSat wafer adapters, which enable secondary payloads to take advantage of excess lift capacity unavailable to the primary trial.

NASA's LSP (Launch Services Program) ELaNa-4 (Educational Launch of Nanosatellite-4) will launch eight more educational CubeSat missions. The ELaNa-4 CubeSats were originally manifest on the Falcon-9 CRS-2 flight. When NASA received word that the P-PODs on CRS-2 needed to be de-manifested, LSP immediately started looking for other opportunities to launch this complement of CubeSats as soon as possible.

Approximately 12 minutes after the lift-off of the Minotaur I, the SPTSat-3 spacecraft was deployed at an altitude of some 500km. And then the tricky portion of the mission occurred... a pre-planned collision avoidance maneuver was executed to set-up the CubeSat deployments.

(*The news article on Page 12 reveals the composition of the instruments that are part of the STPSat-3 craft.*)



CubeStack illustration. Courtesy of ORS.

NASA + DoD Operationally Responsive Space ORS-3 Mission

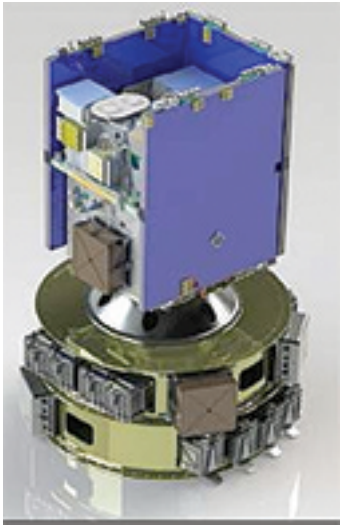


Photo of the ORS-3 launch configuration. The SPTSat-3 rests on the top, with the integrated payload stack situated at the bottom. The photo is courtesy of the Air Force Research Laboratory (AFRL).

The CubeSats were arranged in a CubeStack comprised of wafters, with the CubeStack adpater itself designed by LoadPath and Moog CSA Engineering.

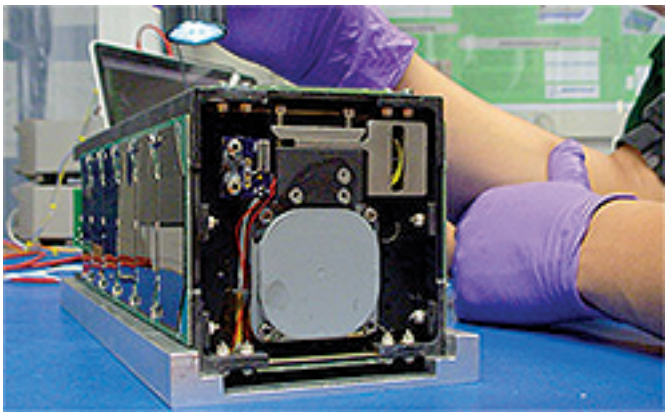
All of the CubeSat developers participating in this mission verified their craft complied with P-POD (Poly Picosatellite Orbital Deployers) requirements. These specs have all been developed by the California Polytechnica State University (Cal Poly) of San Luis Obispo, California, and enable the integration of CubeSats onto launch vehicles.

A CubeSat has to be built to a standard dimension of 10x10x10 centimeters, otherwise known as 1 unit, or 1U. CubeSats may be developed in a variety of sizes: 1U, 2U, 3U or 6U in size, but each unit must weigh less than 3 pounds... the only exception is a 6U CubeSat, which may weigh as much as 12 to 14kg. The final requirement is that CubeSats must be capable of P-POD deployment.

Here's a taste of the CubeSat included in the ORS-3 mission that enabled the small satellite's deployment through the incorporation of eight P-PODs aboard the craft.

University of Hawai'i at Manoa— Ho'oponopono-2 (H-2)

This is the first University of Hawaii (UoH) -built satellite to be launched into space and will fill a critical need by performing radar calibration and performance monitoring for the U.S. Department of Defense and NASA radar stations that track missiles, aircraft, rockets, satellites, asteroids, and space junk.



About 50 students from the UH Mānoa College of Engineering's Small-Satellite Program, established by Professor Wayne Shiroma in 2001, have spent the last four years designing and building the cube satellite, or CubeSat, from scratch.

Dubbed Ho'oponopono 2, or H2, it measures 4 inches by 4 inches by 13 inches, about the size of a loaf of bread, weighs less than 9 pounds and cost $220,000 to build. It replaces a satellite 20 times larger and 40 times more expensive that recently failed in orbit and left the radar community without a dedicated calibration satellite.

Professor Wayne Shiroma and students Larry Martin and Windell Jones of the University of Hawai'i at Monoa College of Engineering watch the launch of the U.S. Air Force rockets carrying the satellite they helped to build.

Ho'oponopono means "to make right" in Hawaiian, an appropriate name for a calibration satellite.

"We have exceptional students at the University of Hawai'i, and I couldn't be prouder of the team," said Shiroma, who attended today's launch. "Creating, building and deploying the first radar calibration satellite in CubeSat form demonstrated the ability of our UH student team to address an urgent operational need at very low cost, and simultaneously provided immense educational value."

"We congratulate Dr. Shiroma and his students on this historic effort," said Interim UH President David Lassner. "The development and launch of Ho'oponopono 2 illustrates how the University of Hawai'i is helping to solve some of the nation's most pressing problems and is training the workforce for the high-quality jobs we are helping to build here."

The UH Small-Satellite Program has trained more than 250 students since 2001 and has brought in more than $1 million in funding, including funding from student-solicited proposals. Graduates have gone on to work for major aerospace companies, including Northrop Grumman, Boeing, Raytheon, Lockheed Martin and more.

Three of the program's students have been recognized as the "Most Outstanding EE Student in the Nation" by IEEE-HKN, the international honor society for electrical engineers. Larry Martin is a UH Mānoa graduate student who received that honor and he is currently the H2 project program manager.

Martin, who also attended the Wallops launch, said, "It is so exciting to see all of our hard work launched into space and now being put to good use. It is also gratifying that the skills we have gained through building H2 are the same skills that major engineering companies are employing today."

H2 is just one of UH's aerospace initiatives. The first space launch from Hawai'i, which will also be carrying a UH student-built satellite, is scheduled for the second quarter of 2014 from Kaua'i's Pacific Missile Range Facility (PMRF). UH's Hawai'i Space Flight Laboratory, a collaboration between UH Mānoa's School of Ocean and Earth Science and Technology and the College of Engineering, is an important partner in that launch. Several UH Community College campuses are also involved in the project.

UH Mānoa Chancellor Tom Apple said, "These projects demonstrate our commitment to working with sister campuses to develop research that matters to the entire State of Hawai'i."

Hawai'i's first space launch known as ORS-4 is sponsored by the U.S. Air Force's ORS Office and is the first launch of the Super Strypi launch system. This mission will demonstrate a new, low-cost launch capability able to deliver 300 kilograms to Low Earth Orbit (LEO). This is the first orbital launch for PRMF and will carry the University of Hawai'i's hyperspectral imager as the primary payload along with 12 CubeSats in an integrated payload stack. This demonstration will enable low-cost launch alternatives and range processes for the future.

The University of Hawai'i team that is building the Ho'oponopono 3 CubeSat, which is manifested for an upcoming NASA launch.

UoH is currently a funded participant in the AFOSR University Nanosat-6/Nanosat-7 Program (UNP-6/UNP-7) and is the only one of 11 awardees that has a CubeSat-based mission. The mission is driven by current operational needs of U.S. radar range facilities: The design, build, test, and operation of a very low-cost radar calibration nanosatellite.

The radar calibration mission now orbiting will supplement two existing, aging spacecraft with the student-built Ho'oponopono 2 CubeSat that carries a C-band transponder and high-accuracy GPS payload.

This mission will demonstrate a university's ability to satisfy an immediate operational need at a low cost, while simultaneously providing immense educational value. Students will learn to operate under customer-driven design requirements, constraints, and schedules to offer a solution to an immediate, real-world need.

H2 and ORS-4 both represent the tremendous possibilities of the Hawai'i Innovation Initiative, in which the university is partnering with the private sector and government to cultivate a $1 billion research industry in Hawaii over the next decade.

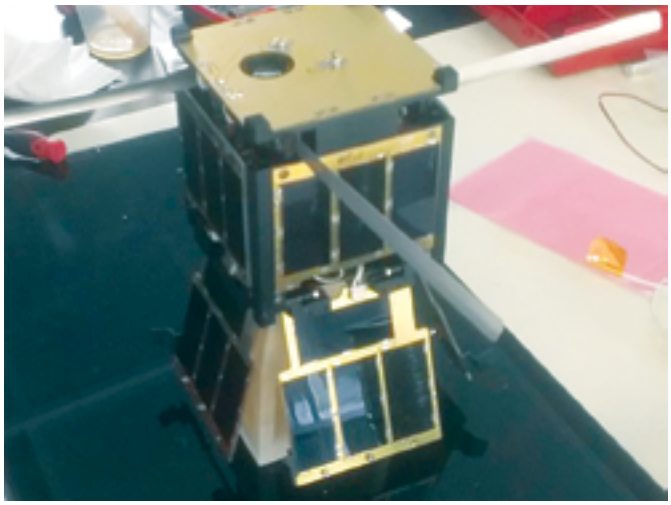
University infosite: ***http://manoa.hawaii.edu/***

Editor's note: Much of the preceeding Information was supplied by Professor Wayne Shroma and Kelli Trifonovitch, University of Hawai'i

University of Kentucky—KySat-2

KySat-2 is the second CubeSat nanosatellite entirely designed, built, and tested by students of the University of Kentucky and Morehead State University.

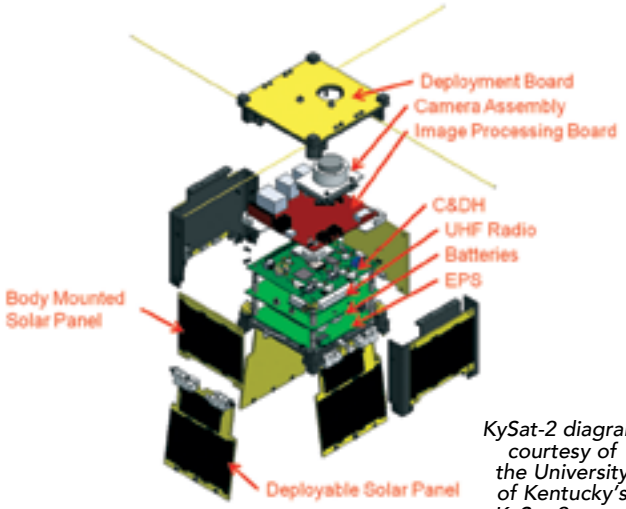
Development of the satellite began in 2011, shortly after the launch of KySat-1. KySat-2 successfully launched on November 19, 2013 out of Wallops Island, Virginia.



KySat-2 is a 1U CubeSat class satellite built by Kentucky Space LLC and includes nine parts that were Additively Manufactured (3D Printed) using Windform XT2.0 from CRP technologies, built by CRP USA based in North Carolina. These parts include:

- Deployment Extensions: Two of these are used on each spacecraft as "extender" of the ON/OFF switches which power the satellite ON when deployed from the rocket
- Battery Holders: These holding "straps" constrain the satellite batteries to structures to ensure no movement during the violent ascent into orbit
- Antenna Holders: These are four surfaces, each one is mounted to the deployable solar panels. When the solar panels are in the stowed configuration these parts hold the UHF antenna within the envelope of the spacecraft. When the panels open the antennas are then released which allow KySat-2 to communicate back to the Earth.
- Camera Structure: The final WindForm XT 2.0 part used was a structure that held the imaging board and lens in place and attached to the spacecraft frame. This part, like all of them, was custom from the start to perfectly fit the needs.

Many of the KySat-2 team attended the annual CubeSat Workshop / SmallSat Conference in Logan, Utah, for a week of productive talks, meetings and get-togethers with the CubeSat community. In the days immediately prior to the conference, the team moved the flight model through all of the environmental testing, which was a huge hurdle cleared.



KySat-2 diagram courtesy of the University of Kentucky's KySat-2 team.

The flight model then entered into a period of long-duration functional testing and the team started the build of a second flight model that could serve as a backup or be used for further testing.

As part of the functional testing, the software team worked with the satellite startup procedure, building in methodology whereby the spacecraft cannot transmit until the solar panels have been extended. This prevents accidental transmission attempts that might damage the radio. The team members then populated the beacons with the electrical power system telemetry to enable ground stations to evaluate the spacecraft's health in real time.

This technology demo CubeSat expands the university's STEM program and also features a new component that determines the three-axis rotation of the satellite using sequences of digital pictures. Called a Stellar Gyroscope, the instrument integrates a "star camera" that collects to measure attitude angles. This device could eliminate the need for the convential gyroscope and offers high slew and update rates.

Further information is available at:
http://ssl.engineering.uky.edu/missions/

Editor's note: Much of the preceeding KySat-2 information was authored by Twyman Clements, Space Systems Engineer, Kentucky Space.

University of Alabama in Huntsville—ChargerSat-1

The University of Alabama in Huntsville's (UAH) Space Hardware Club's ChargerSat-1 is a fully operational, orbital satellite, ~1kg in weight and is a 10cm cube fitting to the CalPoly CubeSat standard. ChargerSat-1 is meant to demonstrate the full capabilities of all of the systems needed for satellite operations. The program involves members from 7+ UH departments exercising their skills in developing a satellite, ground station, and testing program.

ChargerSat-1 is the University of Alabama in Hunstville's first entirely student built CubeSat. The ChargerSat-1 team applied for the third call for NASA's proposal CubeSat Launch Initiative in the Fall of 2011. Acceptance to CLI was announced in February of 2012.

In November of 2012, the team was consulted for launch readiness and the satellite ultimately launched on the U.S. Air Force's Operationally Responsive Space 3 (OORS-3) mission.

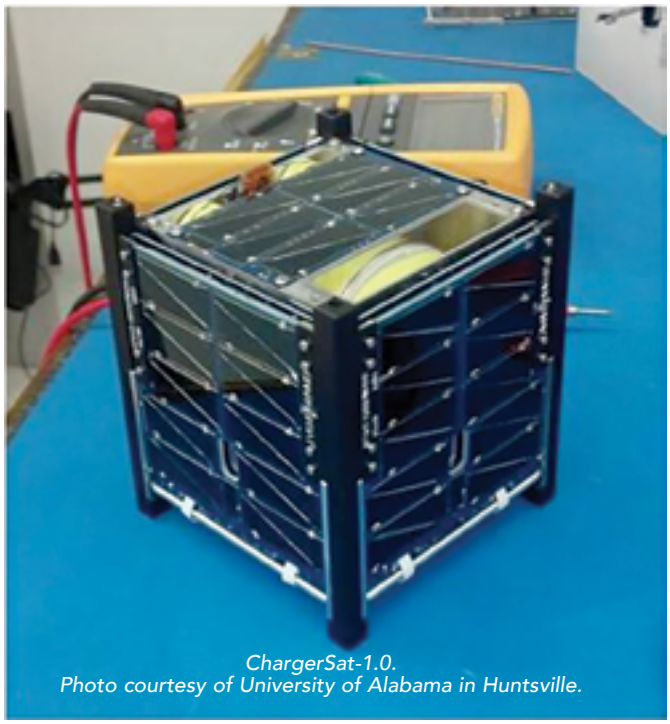
Mission Objectives for the satellite:

- Improve communications for picosatellite operations
- Demonstrate passive nadir axis stabilization for picosatellite attitude control
- Improve solar power collection for picosatellite operations

The program goals for the overall program:

- Design, fabricate, and operate a satellite using the capacities of a multi-disciplinary team of engineering and scientific disciplines to develop a single integrated orbital system. UH hopes to inspire and engage the public in its missions and technical concepts.

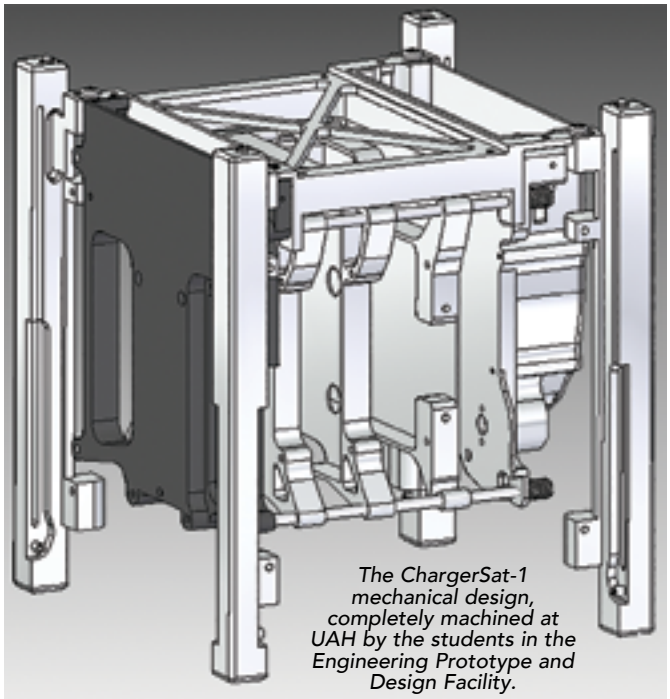
ChargerSat 1.2 is the primary flight unit and is currently in orbit. This unit was built in the clean room and performed all required testing before its voyage to orbit.



ChargerSat-1.0.
Photo courtesy of University of Alabama in Huntsville.

ChargerSat 1.1 was also built in the cleanroom and is ready to initiate launch preparations. This satellite is used for risk-reduction, and has completed the heavy testing of the final design. ChargerSat 1.1 will be stored as a flight-ready unit and ready for launch, if needed.

ChargerSat 1.0 is the prototype satellite. This unit was built and flew as a microgravity experiment in August of 2012 through NASA's Flight Opportunities Program. There have been some changes to the design since this prototype, mostly small corrections.



The ChargerSat-1 mechanical design, completely machined at UAH by the students in the Engineering Prototype and Design Facility.

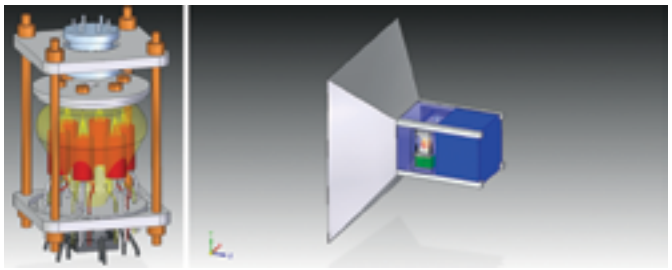
ChargerSat-1's demonstrations present a gravity gradient stabilization system for passive spacecraft stabilization; doubling the power input to the CubeSat via deployable solar panels; and using those same panels to shape the gain pattern of a nadir-facing monopole antenna. The latter will improve the horizon-to-horizon communications.

ChargerSat-1 features four unique deployable systems: A deployable dipole antenna (the primary communications system); a 2m gravity gradient boom (once deployed, for satellite stabilization); and the deployable solar panels (for power input to the spacecraft, and gain pattern shaping).

The team members include team leader Eric Becnel, who has been in this position since May of 2010, leading the team from concept to orbital operations of the satellite.

Matt Rodencal is the electrical lead and has been since the project's inception in 2010, with most of his efforts involved in the development of the EPS, which consists of nine power point trackers, a power management system, and DC-DC converters.

Mason Manning is the software lead, also on the team since 2010. He designed and implemented most of the flight software and also assisted greatly with the electrical design and testing processes.



The initial CAD models of the ChargerSat-2's boiling chamger (left) and the initial concept models of the CubeSat system. Image is courtesy of the University of Alabama in Huntsville.

FYI, the university's ChargerSat-2 project is now underway. The mission of this CubeSat will be to investigate the heat transfer properties of nucleate boiling in extreme gravity, investigating two key aspects: The effects of surface roughness and the effects of convection. Three student-design technologies are being developed that include the boiling instrument and an "aerodynamically" stabilized drag device.

The UAH Space Hardware Club's infosite is — ***http://space.uah.edu***

Editor's note: Most of the preceeding ChargerSat-1 information is courtesy of the University of Alabama in Huntsville.

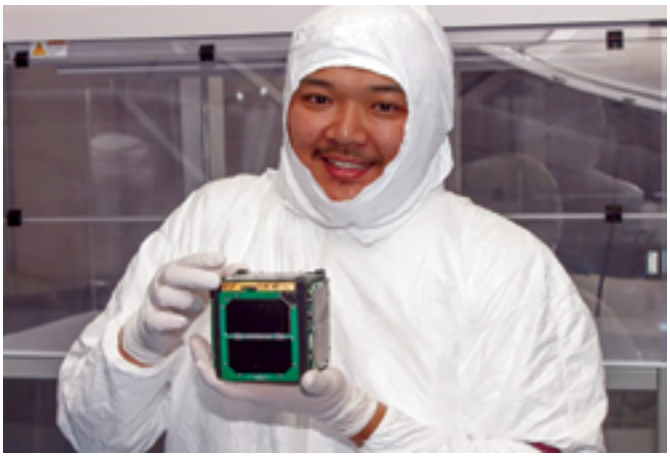
University of Florida—SwampSat

SwampSat, the first picosatellite developed by researchers in the University of Florida's (UoF) College of Engineering, was successfuly launched into space from Wallops Flight Facility in Virginia as a payload with the ORS-3 mission.

Mechanical and aerospace engineering professor Norman Fitz-Coy is the director of UoF's Space Systems Group, which designed and built the 4-inch cube satellit, which is not much bigger than a softball and weighs just two pounds.

However, the "pico satellite" may well hold a key to a future of easier access to outer space—one where sending satellites into orbit is as routine and inexpensive as shipping goods around the world.

"Right now, the way satellites are built, they're all large, one-of-a-kind and very expensive," said Norman Fitz-Coy, an associate professor of mechanical and aerospace engineering and the lead investigator on the project. "Our idea is that you could mass produce these small satellites and launch 10 or 20 from a single launch vehicle."



Student Bungo Shiotani shows off the University of Florida's SwampSat CubeSat.
Photo is courtesy of the University of Florida.

The satellite is the first ever built at UF and may be the first orbiting spacecraft to be built in Florida, said Peggy Evanich, director of space research programs at UF.

"There is a national push to make satellites smaller so that you can provide cheaper and more frequent access to space," said Fitz-Coy.

As part of that push, the National Science Foundation created the Advanced Space Technologies Research and Engineering Center at the UoF College of Engineering. Headed by Fitz-Coy, the center develops "pico- and nano-class small satellites" that can be built and launched for as little as $100,000 to $500,000, according to the NSF. The UoF center will receive NSF funding for five years for the research.

Fitz-Coy said small satellites are not anticipated to totally replace larger ones, but rather to complement them, by adding new capabilities. For example, he said, "swarms" of small satellites could take multiple, distributed measurements or observations of weather phenomena, or the Earth's magnetic fields, providing a more comprehensive assessment than is possible with a single satellite.

"People are looking toward these to not totally replace the big satellites but to supplement what the big satellites are doing," he said.

He said the main impediment to designing small satellites is control: The smaller the satellite, the harder it is to manage its flight path and attitude, or orientation in space—for example, which directions its instruments point, a critical parameter in spacecraft design.

"It's similar to you driving an SUV down the road or a sub-compact," Fitz-Coy said, explaining that while inertia helps large satellites, it is not enough to keep small satellites on track and properly oriented. "The SUV is a lot more stable than the sub-compact."

SwampSAT will test a new system designed to improve small satellites' attitude control. Having precise control is particularly important for such satellites as they have to fly relatively close to Earth in order for their weak communications signals to reach their targets, he said. Due to their proximity to Earth, their instruments must be precisely aimed. "They need to be able to control their orientation and re-orient rapidly," said Fitz-Coy.

The mission is using a pyramidal configuration of control moment gyroscopes (CMG) to afford precision, three-axies attitude control of the satellite in orbit. This is the first technology of its kind and was developed by UoF engineers and, if succesful, will advance the CMG's readiness level for future CubeSats.

Fitz-Coy and 12 undergraduate and graduate students started the SwampSat project, and the recently launched CubeSat is orbiting at an altitude of between 600 and 650 kilometers, or from 373 to 404 miles, and will remain in orbit for several years, Fitz-Coy said.

Florida's Lt. Gov. Jennifer Carroll, standing with, from left, student Shawn Johnson, chairman of the Department of Mechanical & Aerospace Engineering, Dr. David Hahn, Dr. Norman Fitz-Coy of the Mechanical & Aerospace Engineering Department, and student Dante Buckley, visits the Nanoscale Research Facility at the University of Florida to see the softball-sized satellite, SwampSAT. Students designed the CubeSat to be a less expensive and faster way to conduct space-orbiting missions now that the shuttle program has been terminated.
Photo is courtesy of the Gainesville Sun (Gainesville.com)

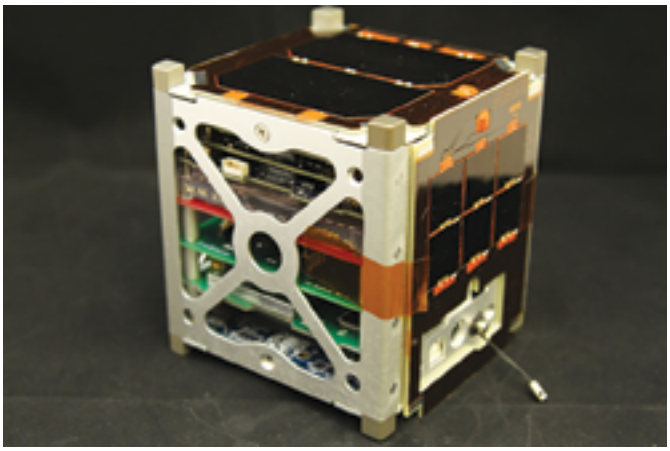
The University of Florida's infosite: ***http://www.ufl.edu/***

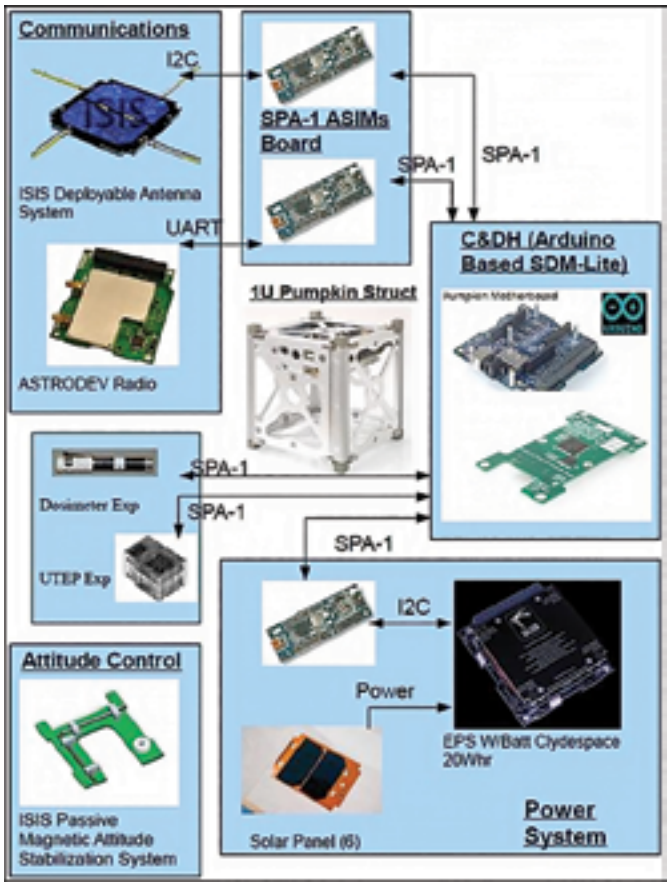
Editor's note: The preceeding SwampSat information is courtesy of the University of Florida's infosite and Aaron Hoover of the university.

University of New Mexico—Trailblazer

On November 19th, 2013, the NASA Wallops Flight Facility launched a Minotaur 1 rocket with 13 small satellites aboard, including one constructed by University of New Mexico (UNM) researchers and students.

UNM's Trailblazer satellite is now in orbit and is sending back information on gamma ray radiation in the ionosphere.





A schematic view of the SPA-1 Trailblazer's various subsystems. Image is courtesy of COSMIAC.

Trailblazer will provide a proof of concept to an Air Force sponsored technology called Space Plug and play Architecture (SPA). The idea is to quickly build satellites for a range of missions, using off the shelf components.

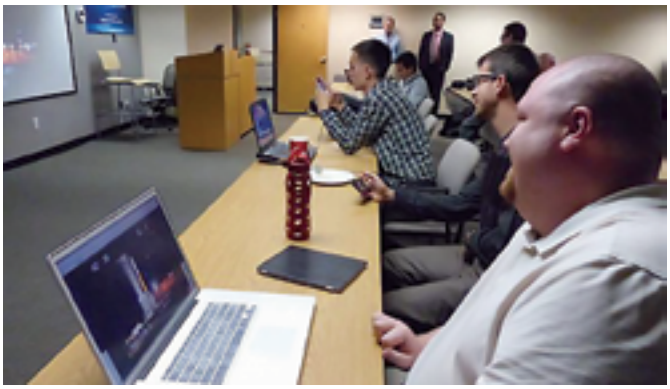
Currently satellites use individually designed components, which must be individually tested and approved for the demanding environment they will encounter in space. That drives up cost exponentially. If Trailblazer works as envisioned, its internal, commercially available components will operate well in a hostile environment within which they are bombarded with gamma radiation and subjected to extreme heating and cooling cycles as the CubeSat orbits.

"Development of this cubesat involved many students who worked on elements of the satellite and the sustained efforts of the research and development team at COSMIAC," said UNM Distinguished Professor of Electrical and Computer Engineering and COSMIAC Director, Christos Christodoulou. "We are thrilled as we move into the next phase of our program."

COSMIAC (Configurable Space Microsystems Innovations and Applications Center) built the Trailblazer. The craft has a mass of 1kg and uses Commercial Off The Shelf (COTS) components.

To reduce the mass of the satellite, COSMIAC used a Pumpkin structure and motherboard, which incorporates the standard 1U enclosure of aluminum and room at the top of the satellite for a deployable antenna system. There are also two separation springs and two separation switches on the four corners of the legs.

Trailblazer is providing radiation exposure measurements from a dosimeter designed by UNM's Configurable Space Microsystems Innovations and Applications Center (COSMIAC) and the Air Force



Researchers and students gather at COSMIAC to watch launch of Trailblazer satellite.
Photo credit: Karen Wentworth

Research Laboratory. The satellite also carries a new additive manufacturing technology designed by researchers at the University of Texas at El Paso.

Trailblazer and UNM are members of NASA's CubeSat Launch Initiative and it's Educational Launch of Nanosatellite (ELaNA) Missions. This program allows students and faculty members an opportunity for hands-on flight hardware development experience.

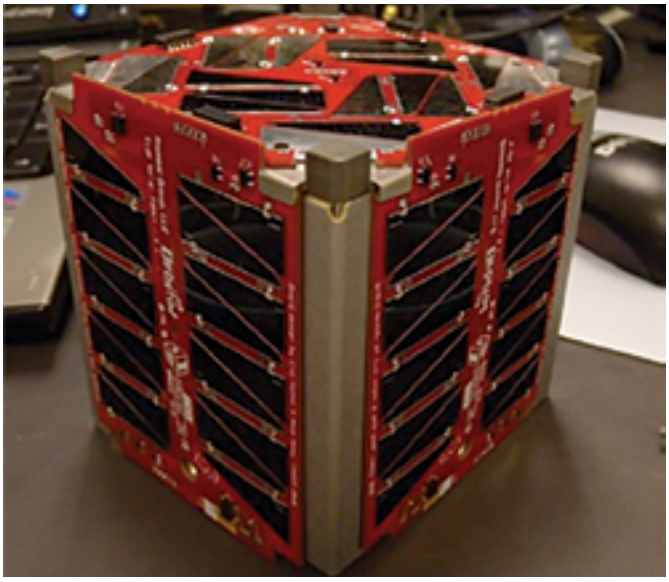
Craig Kief, Academic and Program Support for COSMIAC, and Brian Zufelt, Small Satellite and SPA Development, will lead the team monitoring the information gathered by Trailblazer. GENSO, a European Space Agency initiative, will provide global ground station support to the academic institutions conducting research.

The University of New Mexico's infosite: ***http://www.unm.edu/***

Editor's note: The preceeding Trailblazer information and photographs are courtesy of author Karen Wentworth of the University of New Mexico.

Thomas Jefferson High School—TJ^{3}SAT

TJ^{3}SAT is joint project between the Thomas Jefferson High School for Science and Technology and industry partners to design and build a CubeSat to increase interest in aerospace technology, as part of NASA's Educational Launch of NanoSatellites (ELaNa) program.



TJ^{3}SAT's primary mission is to provide educational resources to other K-12 education institutions to foster interest in aerospace through the successful design and flight of a CubeSat. The school's mission will be successful if it provides resources to other high schools in order that they may also attempt to design and construct satellites, building upon what Thomas Jefferson High School students have learned.

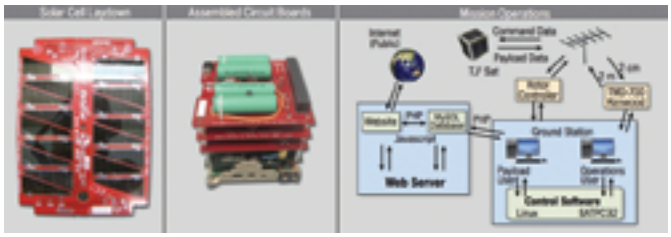
TJ^{3}SAT is the first satellite in history built by high school students and the satellite is currently in orbit.

The primary payload of TJ^{3}SAT helps accomplish the primary mission objective by giving students and other amateur radio users the opportunity to send and receive data from the satellite. Onboard the satellite, a Text Speak module is used to convert text messages into an analog voice signal.

Students and other users from around the world can submit text strings to be uploaded to the TJ^{3}SAT website. Approved text strings will be transmitted to the satellite and the resulting voice interpretation will be relayed back to Earth over an amateur radio frequency using the onboard Stensat radio.

In addition to the voice signals, properly outfitted amateur radio stations can receive state of health telemetry from the satellite. These data exchanges are available to the public and will become the main catalyst for education outreach.

This joint project was started in December of 2006 and offers students an insider's look into the aerospace industry. Students will be able to submit data for transmission to the satellite, with the data relayed back to the student via Amateur Radio frequencies.



Technical specifications chart.
Image courtesy of Thomas Jefferson High School.

The team was led by Energy Systems Lab Director Adam Kemp, with the satellite itself designed, constructed and tested by more than 50 students over the course of seven years. Orbital Sciences Corporatoin funded the purchase of the satellite hardware, engineering consultation, and hardware/software testing facilities. The Stensat Group LLC contributed to the design and construction of the radio and power handling hardware and also assisted with the schematic design and circuit board layout.

The Jefferson High School infosite: ***http://www.tjhsst.edu/***

Editor's note: The preceeding TJ^{3}SAT *information and photographs are courtesy of Jefferson High School and Lead Systems Engineer Rohan Punnoose and TJ CubeSat Program Director Adam Kemp. Special thanks to Carlos Niederstrasser of Orbital Sciences Corp.*

Drexel University + The U.S. Naval Academy—DragonSat

The DragonSat-1 Project is Drexel University's iteration of a CubeSat project and follows the established CubeSat standards, developed by California Polytechnic State University and Stanford University.

The satellite's mission is to photograph the Earth from its orbit at roughly a 350km altitude. The focus will be on the northern and southern lights

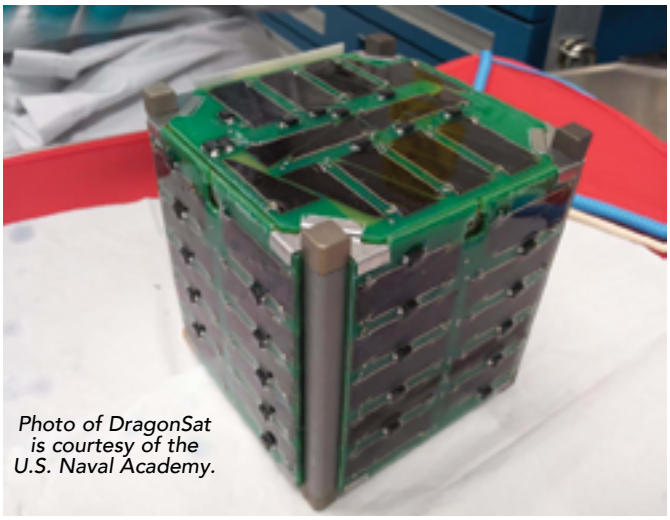


Photo of DragonSat is courtesy of the U.S. Naval Academy.

and to obeserve radiation dssipation intensity during such solar events. In addition, this mission will serve as technology demonstration for many of the components and subsystems flown.

The payload of the DragonSat-1 will consist of a package of various sensors, including one (1) µCam camera, one (1) HMC2003 magnetometer, one (1) MMA7260QT accelerometer, and seven (7) LM335 temperature sensors.

The system will produce 640x480 pixel JPEG image files. These will be transmitted to the ground as well as various telemetry data that include temperature measurements, solar panel voltage readings, and accelerometer measurements.

There is 2GB of starge onboard the satellite in the form of an external SD card and DragonSat-1 is expected to have a lifetime of approximately six months.

Drexel University infosite: ***http://drexel.edu/***

U.S. Naval Academy Aerospace Engineering infosite: ***http://www.usna.edu/AeroDept/***

Editor's note: The preceeding DragonSat *information and photographs are courtesy of Drexel and the U.S. Naval Academy infosites.*

University of Louisiana at Lafayette—CAPE-2

Cheers erupted in the CAPE-2 lab in Madison Hall when the Minotaur 1 rocket lifted off from NASA's Wallops Island, Virginia, facility at about 7:15 p.m. Tuesday.

The launch sent the second small satellite designed and built by Unversity of Louisiana (UoL) at Lafayette students into space.

After the clapping, congratulatory exchanges and high-fives ended, a small group of students headed for their control stations, where they received a signal that let them know the satellite was where it should be: in orbit about 225 miles above Earth.

The CubeSat, a communication device that weighs about two pounds, zips around the globe at about 17,000 mph. That's about once every 90 minutes. The satellite, outfitted with deployable solar panels, is capable of converting speech to text, Tweeting and sending emails.

"It's exciting. We're going to wait for a day or two and be sure the batteries are charged. Next week, we'll start doing some of the experiments," said Nick Pugh, who earned a bachelor's degree in electrical engineering from the University in 1968.

Pugh, a communication industry professional, spends as much as 20 hours per week with students offering technical advice and encouragement. He is also a financial supporter.

Telecommunications expert and team mentor Nick Pugh, seated, left, sits with picosatellite team members Rizwan Merchant, seated, right, and standing from left, Vance Doumit, Alex Wehmann, Nathan Cooley, Travis Loftin and Alex Lanclos at Madison Hall on the University of Louisiana at Lafayette campus in Lafayette. Photo courtesy of Bryan Tuck.

The project leader is Louis Courville, a junior from New Iberia pursuing a bachelor's degree in electrical engineering. Courville said the CAPE-2 launch is the culmination of the efforts of many students. About 50 students have worked on the Cajun Advanced Pico-satellite Experiment-2 project over the last five years.

"It's basically an extracurricular program where we get to accelerate our curriculum here. People really cut their teeth on real world stuff with this project," said Courville, who works at an engineering firm while he pursues his degree.

CAPE-2 is one of 29 satellites created by educational and research facilities from across the nation chosen to participate in NASA's CubeSat Launch Initiative.

Wade Falcon, 36, who earned bachelor's and master's degrees from the University, was one of several students involved with the first project Falcon, an engineer from Lafayette, was at the CAPE-2 lab on Tuesday night to watch the launch. "I mentor students from time to time, so I came to support them," he said.

Emily Gannon, 19, a sophomore majoring in electrical engineering, didn't work on the CAPE-2 project, but still showed up at the CAPE-2 lab to watch the lift-off. Gannon and other students are working on a project to design and build a buoy that will, when finished, relay information to the satellite from a body of water such as the Gulf of Mexico. "It will transmit weather data," Gannon said.

"We're lucky to be to get the chance to be a part of something like this," said Roxanne Bradley-Powell, a sophomore from Murreta, California majoring in electrical engineering.

In 2007, UoL Lafayette became the first university in Louisiana to launch a working satellite into space with the CAPE-1 CubeSat, said Dr. Paul Darby, an assistant professor of electrical engineering. "I think the students are very intensely interested in the project. It lets them get an education while participating in a world-class project," he said.

University of Louisiana infosite: ***http://www.louisiana.edu/***

Editor's note: The preceeding CAPE-2 *information and photographs are courtesy of the University of Louisiana.*

NASA Ames Research Center—PhoneSat 2.4

PhoneSat 2.4, NASA's next generation smartphone CubeSat, has phoned home. The tiny spacecraft that uses an off-the-shelf smartphone for a brain has completed checkout and sent back data confirming all systems are "go" for the spry spacefarer.

NASA Ames engineers are building PhoneSats, demonstrating how "off the shelf" consumer devices can lead to new space exploration capabilities. Image Credit: NASA Ames Research Center/ Dominic Hart

PhoneSat 2.4, a cube approximately four inches square, weighs only about 2.2 pounds, and was developed at NASA's Ames Research Center in Moffett Field, Calif. It is first of the PhoneSat family to use a two-way S-band radio, allowing engineers to command the satellite from Earth. It is confirming the viability of using smartphones and other commercially available electronics in satellites destined for Low Earth Orbit (LEO).

"It's great to hear from NASA's most recent CubeSat spacecraft," said Michael Gazarik, NASA's associate administrator for space technology in Washington. "NASA is committed to opening up the high frontier to a new generation of explorers who can take advantage of these sorts of small satellites to do science and technology development at a fraction of the cost of larger, more complex spacecraft."

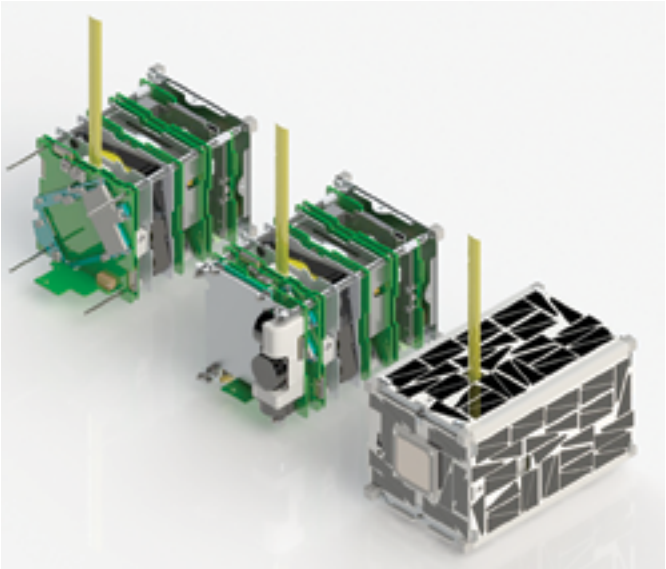
In April, NASA successfully demonstrated a one-week mission with PhoneSat 1.0. With an expected orbital lifetime of up to one year, PhoneSat 2.4 will measure how well commercially developed components perform in space over a long period of time. This innovative application of commercially developed technologies for use in space provides for low-cost, low-risk, highly repetitive missions to meet some unique NASA science and exploration needs.

The spacecraft was among 11 agency-sponsored cubesats deployed on November 19, 2013, by a NASA-built Nanosatellite Launch Adapter System aboard an Orbital Sciences Minotaur 1 rocket for the U.S. Air Force from the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility in Virginia.

PhoneSat 2.4 also will test a system to control the orientation of the CubeSat in space. Like the earlier PhoneSat 1, PhoneSat 2.4 uses a Nexus S smartphone made by Samsung Electronics running Google's Android operating system. Santa Clara University in California is providing the ground station for the mission.

The smartphone provides many of the functions the satellite needs to operate, such as computation, memory, ready-made interfaces for communications, navigation and power, all assembled in a rugged package before launch. Data from the satellite's subsystems, including the smartphone, the power system and orientation control system are being downlinked over amateur radio at a frequency of 437.425MHz.

The next PhoneSat, version 2.5, is scheduled to launch in February, hitching a ride aboard a commercial SpaceX rocket. That spacecraft also is expected to perform in Earth orbit for several months and continue testing the two-way radio and orientation systems. The PhoneSat Project is managed by the Engineering Directorate at NASA's Ames Research Center in Moffett Field, California.



Rapid production and delivery of multiple spacecraft is one of the objectives of the EDSN project.
Image courtesy of NASA Ames Research Center.

The PhoneSat series of missions are pathfinders for NASA's next Small Spacecraft Technology mission, the Edison Demonstration of Smallsat Networks (EDSN). The EDSN mission is composed of eight identical 1.5-unit CubeSats, which are each approximately 4 inches by 4 inches by 6 inches in size and weighing about 5.5 pounds, that will be deployed during a launch from Kauai, Hawaii in 2014.

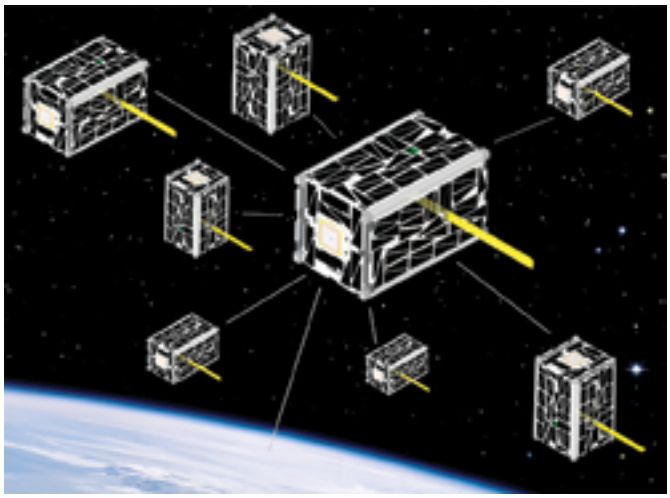
The EDSN mission will demonstrate the concept of using many small spacecraft in a coordinated cluster to study the space environment and space-to-space communications techniques. The eight EDSN satellites each will have a Nexus S smartphone for satellite command and data handling, with a scientific instrument added as a payload on each spacecraft.

During EDSN, each CubeSat will make science measurements and transmit the data to the others while any one of them can then transmit all of the collected data to a ground station. This versatility in command and control could make possible large swarms of satellites to affordably monitor Earth's climate, space weather and other global-scale phenomena.

The PhoneSat Project is one of many development projects within NASA's Small Spacecraft Technology Program, one of nine programs within NASA's Space Technology Mission Directorate. The Small Spacecraft Technology Program develops and matures technologies to enhance and expand the capabilities of small spacecraft, with a particular focus on communications, propulsion, pointing, power, and autonomous operations.

For more information about PhoneSat, the Small Spacecraft Technology Program and NASA's Space Technology Mission Directorate, visit: ***http://www.nasa.gov/spacetech***

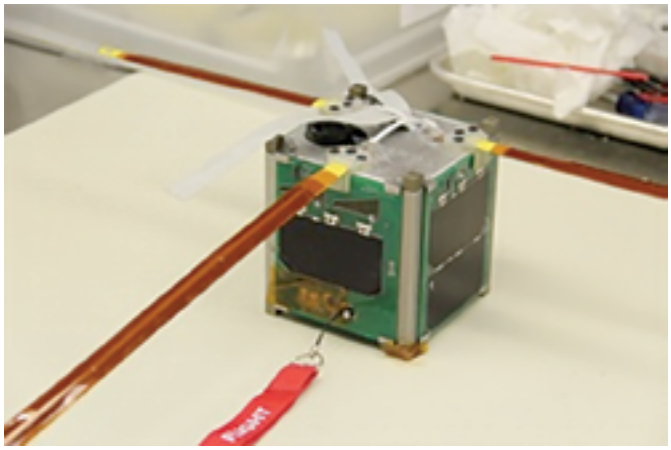
For more information about Ames, visit: ***http://www.nasa.gov/ames***



Artistic rendition of the eight ESDN spacecraft in orbit.
Image courtesy of NASA Ames Research Center.

Saint Louis University—COPPER

When engineering students Steve Massey and Maria Barna were recruited to work on a project in the Saint Louis University's (SLU) Parks College of Engineering, Aviation and Technology a year and a half ago, they said they never expected to be making Saint Louis University history.



Massey and Barna, now seniors, along with several other students, have now experienced the launch of their satellite into outer space as part of NASA's CubeSat initiative. Their satellite, COPPER, which stands for "Close Orbit Propellant Plume and Elemental Recognition," is SLU's first satellite in space.

The COPPER proposal was one of 20 satellite programs in the nation that NASA selected as part of CubeSat, among other universities and organizations, including the Air Force Research Lab and the U.S. Military Academy. NASA selected SLU as the COPPER mission has scientific value and NASA experts said they believe that completion of the satellite is possible.

Michael Swartwout, a professor of aerospace and mechanical engineering, assisted the students with the COPPER proposal, serving as the project's principle investigator who ensures that SLU delivers NASA a functioning satellite.

Sophomore Tyler Olson (left) and senior Richard Henry (right) work on the COPPER satellite.
Photo courtesy of The University News
Shah (Yuqing Xia) / Photo Editor

The COPPER CubeSat's imaging payload.
Photo courtesy of Saint Louis University.

For past 15 months, Steve Massey has been working on the COPPER Payload under Dr. Kyle Mitchell (ECE) and Dr. Michael Swartwout (AE/ME) as an independent study. The team members include Steve Massey, Nidaa bogiss, Gauri Nijsure, Dylan Jones, Tyler Olson and Richard Henry.

COPPER has three main goals. First, it will show the ability of SLU students to design and build a satellite. Barna, who is managing the project, said that although she has reached many technical issues throughout the project, the lessons she learned in the lab are beyond what she could have learned in a course. Even though Dr. Swartwout is an excellent resource for assistance, both Barna and Massey said they have had to solve problems with their own ingenuity.

Massey said that COPPER plans to test a low-cost and low-power infrared camera when it is launched into space. "We think we can use this smaller infrared camera to take pictures of the earth," Barna said. "The CubeSat is simpler due to its small size and reduced complexity."

The project's second overall objective is to launch the CubeSat from a spacecraft. Swartwout explained the process of the launch. A P-Pod, a device bolted to the rocket, will open its doors and send the CubeSat into outer space once the rocket reaches orbit.

Swartout said the launch of COPPER could be beneficial for Earth Observation. "We think it could be useful for science purposes, but especially for engineering purposes to observe the thermal properties of spacecraft to look for damage, heat problems and to figure out what the spacecraft is doing at all times," Swartwout said.

In addition to taking photographs, Barna said COPPER may be able to take video footage so that, after the CubeSat is launched, it will turn around and take videos and pictures of the launch vehicle itself.

The third and final goal of this mission is to test a radiation effects modeling experiment in flight. This test was developed by Vanderbilt University, which is partnering on its second satellite, Argus, with SLU. The proposal for Argus was submitted this week, and results on whether or not Argus will fly on a NASA rocket will be revealed in February of 2012.

Swartout said that the program is always interested in recruiting participants, especially for the upcoming Argus satellite. "This program is such good training for us young engineers," Massey said.

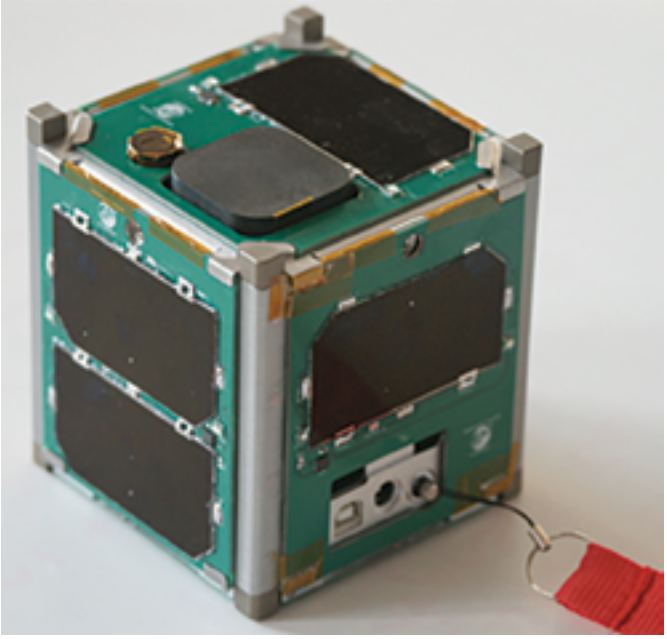
COPPER has an orbit lifetime expectancy of five years and is designed to operate in orbit for six months. The CubeSat will capture approximately 2,000 images during its first eight minutes after ejection. The best theoretical resolution expected of objects on the Earth's surface is around 600 meters.

Saint Louis University infosite: ***http://www.slu.edu***

Editor's note: The preceeding COPPER *information was authored by Anne Marie Beckerle of The University News, Saint Lous University.*

Vermont Technical College—Vermont Lunar CubeSat

The moon is the goal, and the development of a small satellite that can orbit or perhaps even land on the lunar surface is the mission behind this project.

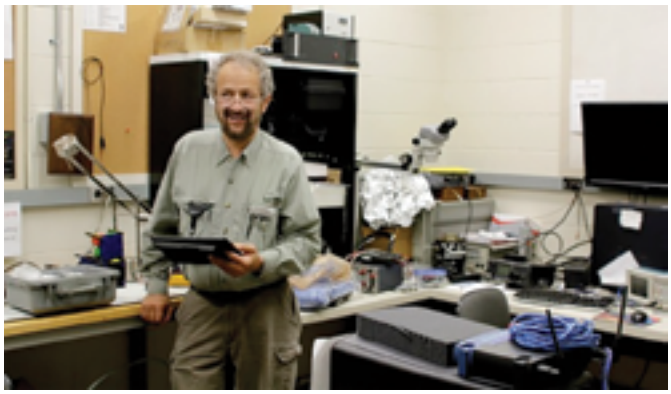


This project's predecessor was the Alaskan Ice Buoy Project, which assisted in learning about the CubeSat Kit™ hardware that is also being used in this project. However, in order for this goal to be reached, many more colleges and other satellite manufactueres would need to be involved to assure the moon landing.

The team built this single CubeSat to test the GPS Enhanced Onboard Navigation System navigation's GPS components that would be of use in reaching the Moon as well as navigation via sun, moon and Earth tracking via optical methods.

The project has seen the director of the Vermont Technical College's CubeSat Lab, Dr. Carl Brandon, involved for more than eight years in the develpoment and build of the four inch cube that was party to the Wallops facility Minotaur I liftoff on November 19th, 2013. The Vermont Lunar CubeSat is equipped with a small radio and the antenna has successfully deployed as signals are being received from the CubeSat. The dual, miniature navigation systems will be able to be thoroughly tested.

Just being recognized by NASA for the ELaNa program was quite exciting." Brandon said, "It's neat that we could get something amazing. And to know how much work goes into it. We're a pretty small school, so we beat out some of the bigger ones," and added that his college even outdistanced the Massachusetts Institute of Technology (MIT).



Dr. Carl Brandon of Vermont Technical College. Photo courtesy of KSE Partners LLP.

In 2009, a grant of $195,000 was awarded to Vermont Tech by NASA to the Vermont Space Grant Consortium. Additional funding was derived from the college itself and EPSCoR. The commercial software to manage the CubeSat and to analyze the orbits were from AdaCore, SofCheck, Altran, Rowley Associates and EPSCoR. The latter (Experimental Program to Stimulate Competitive Research) assists the National Science Foundation in strengthen research and eduction in science and engineering throughout the United States.

EPSCoR's infosite is located at:
http://www.nsf.gov/od/iia/programs/epscor/nsf_oiia_epscor_index.jsp

Dr. Brandon and two Vermont Tech students were invited to travel to Wallops to view the launch of their satellite, with observation of the Minotaur I liftoff from an Orbital Sciences sponsored viewing area, complete with bleachers and complimentary snacks.

Brandon adds that CubeSats are becoming more and more popular, especially within the educational community, due to their lower build costs and their potential for various forms of research. Additionally, those involved with such projects obtain real-world space program experience that many undergraduates simply are unable to receive at most institutions of higher learning.

Previously mentioned was the CubeSat Kit™ and their Pumpkin platform. This kit is now in its fourth generation and has delivered more than 150 such units to customers since 2003. To learn more about the CubeSat Kit, visit: ***http://www.cubesatkit.com/***

The life expectancy for the estimated $50,000 Vermont Lunare CubeSat is two years. Additionally, should readers have a pair of binoculars handy, the CubeSat's bright, light-emitting diodes are visible from Earth.

Editor's note: The preceeding Vermont Lunar Cube Sat information is courtesy of the Vermont Technical College's infosite, VTDIGGER.org, The Herald of Randolph, The Chronicle of High Education and Vermont Public Radio.

To learn more about NASA's CubeSat Launch Initiative, access:
http://www.nasa.gov/directorates/heo/home/CubeSats_initiative.html#.UsRHlfavy3E.

Millennium Space Systems

Millennium Space Systems is a privately held, employee-owned company that was founded in 2001. The company provides alternative and relevant solutions to today's aerospace challenges and designs flight systems and develops project solutions for the Intelligence Community, Department of Defense and National Aeronautics & Space Administration.

The company offers satellite platforms, subsystems and design study services, with every program phase covered for clients, from concept development through to spacecraft operations. Their platforms range in size from 50kg to more than 1000kg. The platforms include:

- Aquilla-XB, the smallest and most affordable bus
- Aquilla-SB, the same bus that's used on the NRO's Rapid Pathfinder satellite
- Aquilla-XG, designed for geostationary and MEO missions
- Aquilla-EO, for LEO Earth Observation

They also bring their branded components into play for incorporation into spacecraft designs. Such items as their 1nm-Sec small satellite reaction wheel, a CMG for highly-agile small satellites, and the Pathfinder-OM, an orbital maneuvering stage that's built into the EELV ESPA form factor.

Last year, Millennium announced that the Defense Advanced Research Projects Agency (DARPA) had awarded the firm a $1.91 million contract for the first phase of the agency's Space Enabled Effects for Military Engagements (SeeMe) program. The first of three program phases, the company will complete the mission specs, satellite design and production planning for six prototype and 24 operational small satellites.

DARPA's SeeMe program aims to give mobile individual U.S. warfighters access to on-demand, space-based tactical information in remote and beyond- line-of-sight conditions. If successful, SeeMe will provide small squads and individual teams the ability to receive timely imagery of their specific overseas location directly from a small satellite with the press of a button—something that's currently not possible from military or commercial satellites. The company sees vertical integration as a means of reducing cost, schedule, and risk for its own satellite programs, while also bringing highly competitive satellite components onto the open market.

Millennium Space Systems and Sinclair Interplanetary announced at the AIAA/USU SmallSat Conference held in Logan, Utah, last year that Millennium is the exclusive U.S. manufacturer and distributor of Sinclair's RW3-1.0 small satellite wheel. This agreement caps a successful technology transfer program under which Millennium has produced a batch of six reaction wheels, and tested two units to full NASA qualification levels. The arrangement also provides small satellite developers an American supplier for Sinclair's high quality, precision mechanism.

The Rapid Pathfinder satellite + Minotaur launch vehicle. Photo courtesy of Millennium.

Taking a National Reconnaissance Office (NRO) contract from order to orbit, the company created the Rapid Pathfinder satellite. The bus was designed, developed, integrated and developed by Millennium Space Systems, who then made the trip to Vandenberg AFB, prepared the satellite, and then aided with its launch. The company now operates the satellite, in orbit, and proved their ability to processes both reduce budgetary requirements and enable expanded schedules for launches.

Millennium Space Systems, developer and operator of the National Reconnaissance Office's Rapid Pathfinder satellite, is currently expanding the scope of its subsystem manufacturing. The Company sees vertical integration as a means of reducing cost, schedule, and risk for its own satellite programs, while also bringing highly competitive satellite components onto the open market.

For further information, the Millennium Space Systems infosite is located at: ***http://millennium-space.com/***

The launch of the Millennium developed Rapid Pathfinder satellite.

One company prefers the term "flock" to "constellation" and one might well ask how this differentiates from the more commonly used term. Both are congregations of technology, a bevy of devices that perform either a specific function or a broader range of services.

When looking at small satellite flocks, Planet Labs of San Francisco intends launching their first flock for Earth Observation/Imagery—28 satellites on January 9, 2014, aboard an Orbital Sciences' Antares rocket 1 from NASA' Wallops Flight center in Virginia.

The satellites arrived at the NASA facility in November of 2013 and, as of this writing, are undergoing pre-flight testing and checking. The company plans to launch 32 satellites on four different launch vehicles in 2014.

This upcoming flock comes after Planet Labs' Doves 1 through 4, their test satellites, were launched earlier this year on three rockets. These satellites were quite successful and, in fact, their test images resulted a number of inquiries from firms that require high-resolution imagery for their operations, such as agriculture and planning companies.

The founders, pictured below, include Mr. Boshuizen who was formerly with NASA Ames and led a variety of partnership projects between NASA and private space exploration companies. He was also the co-investigator for the PhoneSat. He received his Ph.D. and B.S. degrees from the University of Sydney.

Mr. Marshall was a scientist with the NASA Ames team and also worked on the PhoneSat project as well as serving as a team member for the LCROSS and LADEE moon missions. He possesses a Ph.D. in Physics from the University of Oxford and was a Postdoctoral Fellow at Harvard University.

Mr. Schingler was the Chief of Staff for the Office of the Chief Technologist at NASA, managing the exoplanet mission TESS. He led NASA's Open Government activities. He has a B.S. degree in Engineering Physics from Santa Clara University, an MBA from Georgetown and a Masters degree from the International Space University.

There are now more than three dozen employees at Planet Labs, most of them having substantial experience in the space industry, from companies such as SpaceX, SS/L , Pratt & Whitney Rocketdyne and others.

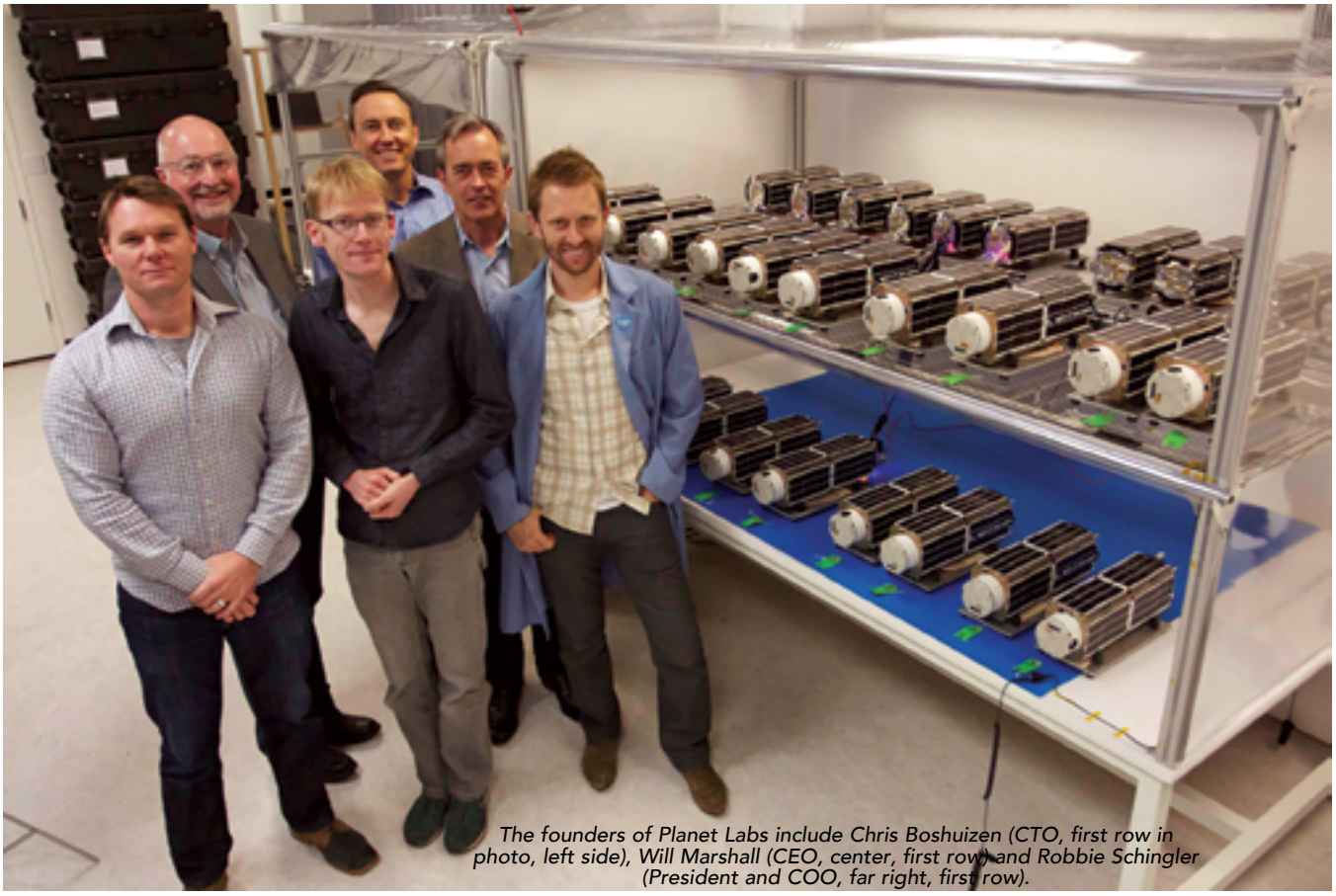
The flock will be orbiting at a much lower altitude than other satellites, with an inclination of 52 degrees to the equator in a circular orbit of 400 kilometers. This low altitude enables the satellites to capture higher resolution imagery with the on-board cameras and the data relay will be far quicker than if they were to orbit at higher altitudes.

Although these nanosatellites (nanos) have a far shorter life cycle than their larger brethren, they are also cost less to build and launch. Plus, the nanos shorter life cycle does allow for far more frequent upgrades of the platform to better the incorporated technologies, which, in turn, attracts additional customer interest.

However, the upcoming launch does require a great deal of money to accomplish the mission. Taking the latter into account, then, is anyone else interested in their goal?

Yes, as a matter of fact, there are... a number of new investors have taken Planet Labs into their pocketbooks, to the tune of some $52 million in Series B financing. Prominent money folk include:

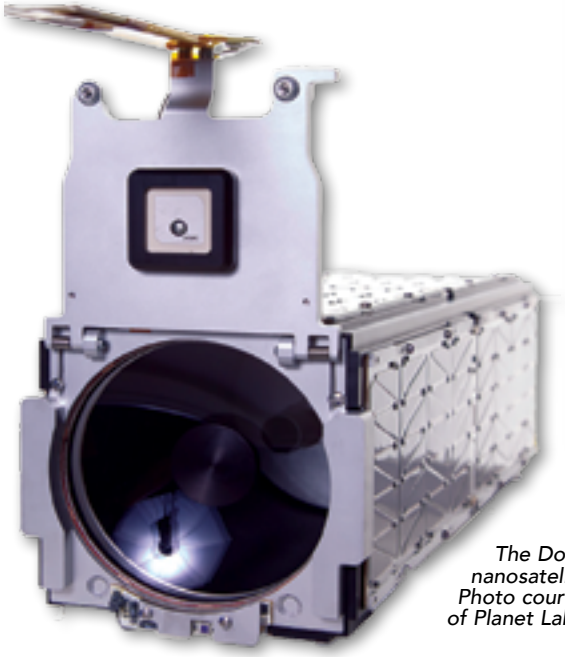
- Yuri Miner is one of a group of billionaires in the U.S., and a co-founder of Digital Sky Technology, a Russian investment fund, to take an interest in Planet Labs. One of his early moves was to recognize that a Facebook play would be extremely worthwhile. He pumped $200 million into that company back in 2009 and then



The founders of Planet Labs include Chris Boshuizen (CTO, first row in photo, left side), Will Marshall (CEO, center, first row) and Robbie Schingler (President and COO, far right, first row).

Image capture by the Dove 2 nanosatellite. Image courtesy of Planet Labs.

poured in another $100 million, followed by another $500 million in a partnership with Goldman Sachs, bringing the investors a 10 percent ownership of that firm.



The Dove 2 nanosatellite. Photo courtesy of Planet Labs.

- Venture capitalist Ray Rothrock has also involved himself, financially speaking, with Planet Labs. A member of Forbes' Midas List in 2013, he has managed some wise and lucrative investments, including one in PGP Corporation, which was acquired for somewhere between $200 and $300 million by Symantec in 2010. His current major thrust is with the Rockefeller-founded Venrock, where he initiated the company's Internet and energy investment strategies. One of his many successes was his work with Imperva, which ended up being the most successful IPO in the technology sector in 2011.

- In 2000, Industry Ventures was formed by Hans Swildens. The focus on the firm was to examine tech companies and then offer the selected companies seed stage infusions of capital. As a leading provider of venture capital liquidity, the firm now has more than a 20 fund portfolio wherein high multiple potential is the expected result. Their portfolio companies include Twitter, Pandora, Alibaba.com, Trustwave, Sojern and Uber. Venture funds include Foundry Group, Lowercase Capital, Madrona Venture Group, true ventures, Costanoa Venture Capital and IA Ventures, among others.

- Boutique venture fund company Felicis Ventures is also onboard the Planet Labs launch pad. More than 90 companies have received the firm's investment capital, with 47 of those firms then acquired by such companies as Apple, AT&T, Disney, eBay, Facebook, Google, Groupon, Intuit, Microsoft and Twitter. The company also has more than $100 million in committed assets and, in 2006, started a $4.5 million Angel fund, a $41 million super-Angel fund in 2010, and a $70 million boutique venture capital fund that was raised in 2012. The company's key focus is on what they analyze as new and groundbreaking technologies.

- Founded in 2000, Lux Capital identifies and backs technology companies, with a focus on helping the firms build their business via their entrepreneurial teams. The three founders — Peter Hébert, Robert Pual and Josh Wolf — have worked together for more than 10 years. Their technology portfolio includes Planet Labs, Cambrios, CyPhy Works, Everspin Technologies, Evolv, Kymeta, Luxterao, Matterport, Molecular Imprints, Nanosys, Shapeways, SiBeam and Silicon Cloks (both of the latter firms have now been acquired).

The new investors join the existing funders that include DFJ, Captricorn, O'Reilly Alpha Tech Ventures (OATV), Founders First, First Round Capital, innovation Endeavors, Data Collective and AME Cloud Ventures. Quite a team of experienced money folk that see the future of small satellites as a most worthwhile endeavor.

For more information regarding Planet Labs, access their infosite:
http://www.planet-labs.com

"It's remarkable that Planet Labs has secured more customer bookings for 2014 than they have raised from investors so far. I have rarely seen a team perform so well," said Steve Jurvetson, DFJ Managing Director and Planet Labs board member.

Skybox Imaging

This company is only the fifth organization that has been licensed to provide high-resolution space-based imagery of Earth. What is most interesting is that their satellite, as of this writing, is this craft is the smallest satellite ever orbited that can capture imagery at better than 1m resolution.

After much anticipation, Skybox Imaging (NSG: SKYB) of Mountain View, California, launched their first satellite (SkySat-1) into orbit in November of 2013. The success of this launch on a Russian Dnepr vehicle led NSG Analysts to improve Skybox's ranking from #12 to #7.

NSG provides the space industry with current analyses that's related to the business of NewSpace, a growing sector that is composed of hundreds of private companies that are involved in space related products and services. Further information regarding NSG is available at: ***https://www.newspaceglobal.com/home***

The launch occurred on November 21st from Yasny, Russia, and contact was made with the satellite on its first pass, with complete bus commissioning occurring within just a few days of the latter's success. The first images were then captured within hours of commissioning. SkySat-1operates in a polar inclined, circular orbit at approximately 450km above the Earth.

The company has also reportedly come to an agreement with Virgin Galactic to use that firm's LauncherOne rocket for future missions.

Leading the team and also a co-founder, is Tom Ingersoll, who has more than 25 years of experience in the space and communications industry. He grew the firm from its development stage to the deployment of the first satellite. Previously, he co-founded and was the CEO of Universal Space Network (USN), a provider of global ground station services to the satellite industry.

Joining Tom in the endeavor is co-founder Dan Berkentstock, Executive Vice President and Chief Product Officer. He leads the vision, implementation and delivery of the products and services that are derived from Earth imagery. He founded Skybox as the CEO and raised $21 million in equity financing from silicon valley VC companies and built the team to 50 in number and also obtained the NOAA operating license. He also oversaw the design and CDR of their first satellite. His prior experience includes that of supporting two shuttle missions at NASA's Johnson Space Center.

Another co-founder is Julian Mann, Vice President and in charge of Product Management. He is an aerospace engineer and was part of NASA's manned space program where he conducted oversight and risk analysis on the agency's Constellation program. He founded Astronautical Development which specialized in nanosatellite engineering and also provided products and services to a number of U.S. government agencies.

The company builds satellites, writes code, and deploys data centers and work toward finding answers to some of the world's most important geospatial problems—regardless of data source—which they call Earth Observation 2.0. Their satellites and software are constantly evolving to address client needs, matching the actual needs of real customers.

Skybox is a privately-held company and has now raised more than $91 million from such firms as Khosla Ventures, Bessemer Venture Partners, Canaan Partners, and Norwest Venture Partners. Specialists from Cloudera, DigitalGlobe, JPL, and Shutterfuly, Joe Rothenberg (former director of NASA's Goddard Space Flight Center) lead the board of directors.

In December of 2013, the company released the first image captures from the SkySat-1 satellite. Three of those photos are presented here, courtesy of SkyBox Imaging.

Further information is available at the company's infosite:
http://www.skyboximaging.com/


Beaton Park, Perth, Australia


Zayed University, Abu Dhabi, UAE


The coastline of Somalia.

Small Satellites – Making Their Way

Small Satellite Conference

Opportunity, demand, and emerging markets have sparked the imagination of entrepreneurs seeking to capitalize on the reality of small satellites to develop new businesses or government services. Supporting these exciting endeavors is increasingly available investment funding from many sources such as high-tech venture capital firms, angel investors, and even crowd-sourcing.

These new funding sources have allowed innovative companies, government administrators, and researchers from within the small satellite community to aggressively pursue diverse concepts such as providing low-cost remote sensing data products at unprecedented revisit rates, prospecting near-Earth asteroids for precious mineral deposits, and manifesting novel sensors as hosted payloads.

During the 28th year of the AIAA/USU Conference on Small Satellites learning more about these exciting entrepreneurial endeavors enabled by small satellites, including the technical and business challenges of this new era, are of utmost importance to this industry.

The conference, sub-titled "The Commerce of $mall $atellites," is going to run from August 2nd through the 7th, 2014, at the Taggart Student Center at Utah State University in Logan, Utah.

Interested parties are encouraged to take advantage of early registration discounts by registering by May 8, 2014. The last day for off-site registration will be July 25, 2014. After that date, on-site registration will be held on the second floor of the Taggart Student Center.

Those who wish to attend are encouraged to register for the full Conference. One-day or Pre-Conference Workshop registrations are available to those participants unable to attend the entire Conference. All speakers and presenters of contributed papers must register for the Conference and pay the appropriate registration fee.

There will be four easy registration methods, with the appropriate forms available by April 8th...

- Register online opens April 8
- Mail a completed registration form and full payment by enclosing a check or credit card information to:

  Registration Services, Small Satellite Conference, 5005 Old Main Hill, Logan, UT 84322-5005
- Fax a completed registration form, with credit card information to (435) 797-0636.
- Or, call Registration Services at (435) 797-0035 or (800) 538-2663.

Registration for the Small Satellites Conference includes:

- Pre-Conference Workshop admission
- Conference admission
- Program materials
- Conference giveaway
- Refreshment breaks
- Munch and Mingle Luncheons
- Campus parking

For further details, please access:
http://www.smallsat.org/conference/

Careers: The Road To The Future What Are Your Adjustments For 2014?

By Bert Sadtler, Senior Contributor

Companies today must re-assess their talent needs in order to remain competitive and drive growth. The satellite communications industry faces challenges but remains ripe with opportunities. Great talent can make a huge impact. Employers need to get it right and make a "great hire."

To assist with career and leadership issues, we asked Bert Sadtler of Boxwood Executive Search to provide his insight.

Slayers Of Dragons

For a business to reach a point of success in today's marketplace, there needs to be an appreciation for change and an ability to make the necessary adjustments.

Many years ago, when dangerous dragons were prominent, dragon-slayers were in high demand. However, this is not much call for

dragon-slayers these days. Did the dragon-slaying businesses evaporate, or did those who slew the beasties make the necessary adjustments to remain relevant and prosperous in the current marketplace?

My comments are centered around the Government Contracting community, which envelops businesses directly servicing the U.S. Government Customer and also businesses who are the suppliers and partners with Government Contractors.

For the Government Contracting businesses who made the adjustments to endure 2013 make it to 2014, will they be able to navigate through the current crop of challenges and make the correct adjustments going forward

Waiving goodbye to 2013, what will be the business trends?

Can these trends be predicted and anticipated?

How much influence will Washington DC have?

- Will we face another round of sequestration early in the year, and will the impact be less distracting as we have already visited this scenario?
- Will our "Healthcare-Revolution" impact the focus of businesses?
- Will the U.S. stock market continue its 25+ percent growth from 2013 into 2014?
- Will our elected political leaders continue to focus on keeping their opposition from winning, or will there ultimately be a spirit of compromise and leadership cooperation?

How do these issues impact best practice recruiting, the opportunity to acquire top talent and the interpretation by business today on which initiatives to pursue and which ones to not pursue?

Making The Correct Adjustments Will Define 2014

In 2013, we witnessed large government contractors making substantial adjustments by shutting down divisions and business units in an effort to "stop the bleeding" and deliver profits through cost cutting. These moves appeared to be driven more by an immediate need to lower fixed labor costs and less about a long-term initiative.

However, this approach was unusual. In traditional circumstances, employers find ways to retain their best talent during a downsizing. In 2013, entire units were shut down, leaving top talent in an unemployed status and leaving the remaining employees feeling uncertain as to their future employment status. Will making the adjustment of shutting down an entire unit prove to be the correct move? Will the dismissal of top talent turn into an opportunity for your competitor to hire that very talent from directly under your nose?

Smaller government contractors have been fighting for every crumb of business in order to remain viable. With sharper survival skills than their larger counterparts, the smaller companies have not been able, nor have they allowed themselves, to add layers of management to their ranks.

Smaller companies have been forced to remain leaner and possibly better positioned for a challenging government contracting marketplace. However, are the smaller companies financially positioned to take on a down period?

A commonly heard theme from the Government Customer heading into 2014 has been, "We know our suppliers have been focused on shaving their costs to us in recent years, however, in 2014 we need government contractors to provide us with more at a lower cost then before."

Webster's Dictionary defines "adjustment" as "Making or becoming suitable."

If government contractors need to be nimble, agile and more competitive than ever before, is this the time for them to add critical talent who possess the expertise to deliver a lower cost to the Government Customer?

Is this the time for business to turn their focus away from Government Contracting and towards the Commercial Sector? Or, do they need to find a way to focus on both markets in parallel, having their oars in both markets?

Through much of 2013, numerous government contractors elected to sit still and not make investments in pursuing new contracts, not adding critical talent to their roles, and not investing in the growth of their organization.

Business culture in the US has historically driven growth through a passion and ambition to succeed. It appears counterintuitive for businesses to have selected the road of stagnation in 2013. Nevertheless, it was a form of "adjustment," or, a means of "becoming suitable." Will there be more confidence and less uncertainty in 2014 and a return to focusing on growth?

One line of thinking is the "Perfect Storm Scenario" which favors businesses with nimbleness, agility and the ability to make the proper "adjustments."

- Fear and uncertainty in 2013 caused many businesses to appear paralyzed
- Opportunistic business may face less competition in 2014 due to stagnation
- Competition could also be lighter since the challenging marketplace may have driven the weakest out of business
- Opportunity alone will not drive success. Execution is required
- Top talent delivers top execution
- As it relates to recruiting and leadership, high quality, top level talent faced layoffs in 2013, making them immediately available
- For the ones currently employed, they are likely to be receptive to a role with another employer as their current employer has left them with concerns about stability of their future employment

As this "Perfect Storm Scenario" plays out, executing on the "adjustments" will be the key to driving success.

Acquiring the correct critical talent is the challenge. Due to a robust quantity of available, professional skill holders, generating interest in a hiring announcement will be the easy step to take in 2014. Abandoning a traditionally drawn out stop and go interviewing process in favor of an effective fast-track approach may prove to be the "adjustment" required.

As stated earlier, smaller organizations are usually more nimble and, as a general rule, are less burdened with red tape and long internal processes. Nimble organizations are able to "adjust" more rapidly and easily.

Could this "Perfect Storm Scenario" reverse the balance of power and position the smaller businesses to out-leverage the larger tier-1 businesses?

While there is available talent, there is also a desire and need for the this talent pool to efficiently move through a hiring process toward an attractive offer. The employer needs to have planned and prepared for the hiring event(s).

If today's dragon embodies the need to acquire the correct critical talent, then the way to slay the beastie involves having the appropriate plan.

For the employer who can "adjust" with a well developed, fast-track hiring campaign, they may find themselves adding great talent and gaining an immediate competitive advantage in 2014.

Good hunting in 2014...

About Boxwood Search and Bert Sadtler
Boxwood is a management, consulting-recruiting firm with offices in the greater Washington DC region as well in Tampa Bay, Florida, and provides solutions for employers needing critical talent. As a dedicated, consulting resource to the employer, Boxwood has designed compensation models that reflects current trends and develops and launches senior level recruitment campaigns to acquire appropriate talent. Position examples include: CFO, COO, Senior Program Manager, Vice President of Sales, Director of Marketing, Vice President of Engineering, Director of Contracts & Compliance and Vice President of Business Development. Examples of industries have included: Government Contracting, The Intelligence Community and the Communications/Technology Sector.

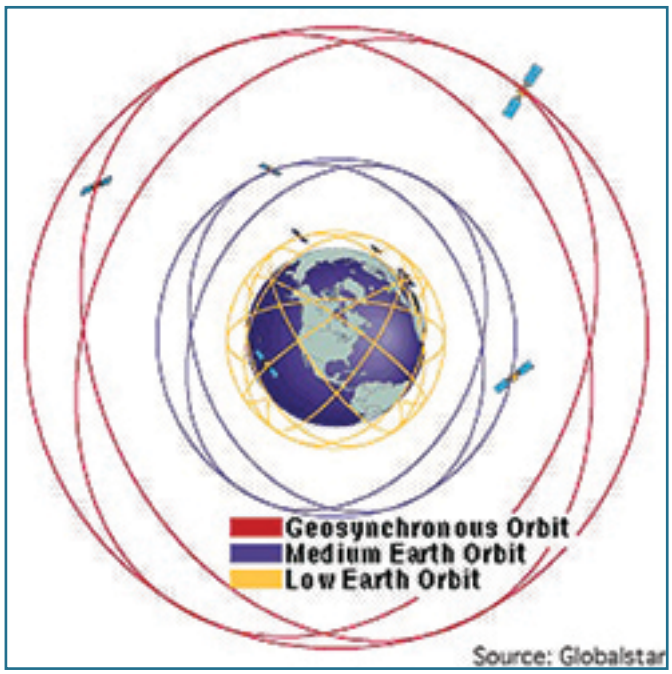
Bert Sadtler is an invited speaker to discuss the shift in the recruitment paradigm toward acquiring critical senior level talent as well as the shift in the employer's performance based compensation model. Bert can be reached at: ***BertSadtler@BoxwoodSearch.com****.*

The LEOs + MEOs That Wouldn't, Couldn't + Didn't...

By Jos Heyman, Senior Contributor

The demand for instant, high speed, global communications services, including cellular (mobile) phones and in particular the Internet, has led to the concept of Low-Earth Orbit (LEO) systems—they would operate at an altitude of 700 to 1400km and possess a polar orbit. At an altitude of 700km, the surface area to be reached by a satellite would be about 3000 x 3000km.

However, to provide global (or, in some cases, regional) coverage from a lower altitude requires more satellites. They must communicate with one another to achieve long distance communications. Moreover, with the satellites moving within their orbit, users must constantly (automatically) switch between satellites, a similar approach used by navigational satellites.



Three separate markets for such satellites have been identified:

- Those providing mobile data messaging and position determination services, referred to a Little LEOs
- Those providing mobile voice and fax services, in addition to the Little LEO services, known as Big LEO
- Those providing wireless video, voice, and broadband, high-speed data services to small satellite dishes, known as Mega LEO

The orbits of these proposed systems vary in altitude, inclination, as well as the number of orbital planes to provide coverage for the desired markets.

Many of the systems that were proposed were merely at a conceptual level, with the stated intent of gaining financing before proceeding to hardware. As such, many of the proposals never moved any further than that crucial money stage. Being unable to obtain financing, these projects disappeared into the waste paper basket before their plans could be preserved for historical purposes.

This article discusses some of the proposals that managed to move somewhat further than just the "this is a good idea" stage and where sufficient documentation survived the route to the disposal bin.

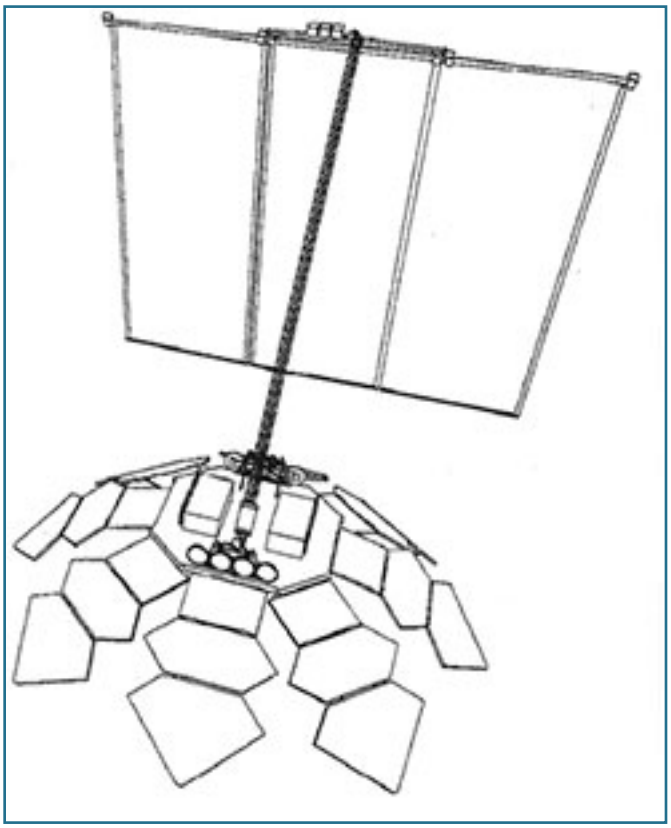
The proposals, especially those requiring large numbers of satellites, were beyond the existing capacity of the space launch industry at the time of inception. This resulted in many proposals for the establishment of additional launch sites around the globe as well as the need for more cost efficient launch vehicles.

It became quite clear that the market was simply not large enough for all of the proposals to result in finished product. Noteworthy is that some leaders used legal processes to hinder potential competitors by challenging competitor licenses, with the objective of handicapping any potential competitors and to place itself in a preeminent competitive position.

Mega LEO Systems

There were three so-called mega systems that relied, initially, upon a large number of satellites. None of these systems ever materialized.

Teledesic



Teledesic, proposed by the company of the same name, was the first of the Mega LEO broadcast constellations and was announced in 1994. At that time, the constellation was to consist of 21 near-polar orbital planes of 40 active satellites each, making a total of 840 satellites, excluding four in-orbit spares per plane. The satellites would orbit at a 700km altitude and all were to be operational by 1999.

In April of 1997, Boeing acquired a 10 percent ownership in Teledesic and would become the prime contractor to build and launch the Teledesic Network. Boeing proposed to reduce the constellation to 288 satellites through the use of new technology. The reworked satellites would have been placed in 12 near-polar planes of 24 satellites each, with three spares in each plane and an orbital altitude change to 1375km.

The major launch vehicle for the network was to be the Sea Launch Zenit 3 vehicle.

Each satellite would have resembled a flower with eight "petals" and a large boom-mounted square solar array. The deployed satellite would have been 12m in diameter and the solar array would have been 12m per side.

Each petal was to consist of three large panels containing the phasedarray antennas. The octagonal baseplate also supported eight pairs of intersatellite link antennas to allow the satellite to link with its nearest neighbors. The baseplate also supported two satellite bus structures that housed the engineering subsystem components and propulsion thrusters. A third satellite bus structure, containing power equipment and additional propulsion thrusters, was mounted at the end of the solar array boom.

The satellites would have operated in the Ka-band and this constellation was scheduled to start operations in 2002.

On February 26, 1998, a 45kg technology demonstrator was launched. The satellite, identified as Teledesic T-1, used a Microstar platform and carried a transponder operating in the Ka-band. The satellite was slotted into a 535 x 580km orbit, with an inclination of 97.7 degrees.

In July 1999, the Teledesic constellation was further modified to eventually consist of 30 Medium Earth Orbit (MEO) satellites as the projected market demand continued to decrease. In July of that year, Lockheed Martin was contracted to provide launch vehicles, either Proton or Atlas 5, and three launches with each of these vehicles were booked, along with five future launch options with each of these vehicles.

By then, Motorola, a company that had merged its Celestri program with Teledesic in May 1998, was seen as the main contractor for the satellites, an arrangement that lasted until October of 2000.

In February of 2002, Teledesic announced that the first two satellites would be built by Alenia Spazio—the assumption was that the remainder of the satellites would also have been manufactured by that company. However, in September of 2002, construction was halted and development was suspended on October 1, 2002. Teledesic's staff was reduced to 10 employees. In July of 2003, Teledesic surrendered its frequency licenses.

While Teledesic may still exist as a corporate entity, there is currently no evidence of any activities.

Sativod/SkyBridge

Sativod (for Satellite Video On Demand) was a 64 satellite system using the Ku-band proposed by Alcatel Espace in 1995. The constellation would have used two overlapping constellations of 32 satellites, each consisting of four planes of eight active satellites per plane. The first 32 satellite constellation were to be placed in orbit by 2001 and the second by 2002.

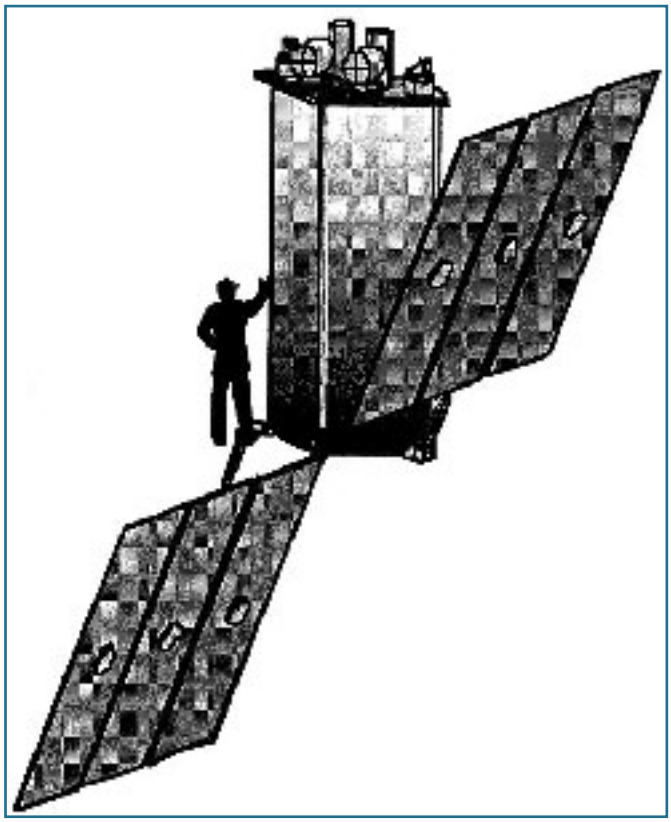
The satellites would have been at an altitude of 1469km with an inclination of 54 degrees. In February of 1997, the system was redesigned as SkyBridge and the number of satellites was increased to 72, with 8 spares.

The launch of the first 40 satellites was to be handled by two Delta 3 launch vehicles carrying four satellites each, and four Delta 4 Medium+ (5,4) launch vehicles carrying eight satellites each. These launches were to occur in 2001.

Alcatel also contracted with Starsem, a Russian-European company formed in 1996, to launch 32 satellites, with ten Soyuz ST/Fregat launchers carrying three satellites each, and an 11th with only two satellites. These would have taken place in 2002/2003. It was envisaged that the system could accommodate the traffic that would be generated by more than 20 million users.

In 2001, Alcatel placed the plans on hold as it was unable to raise sufficient financing for the system. By 2003, the rights to the SkyBridge system were acquired by SES Global. The intellectual property was merged with the SES Satlynx proposal for two way satellite broadband access services.

Celestri



Celestri was a 63 communications satellite system proposed by Motorola in 1997 and was a combination of an earlier LEO constellation of 72 satellites proposed by Motorola as M-Star and a four satellite GEO constellation developed under the name Millenium.

The LEO system would have consisted of nine planes of seven satellites and placed into orbit with an altitude of 1400km, with an inclination of 48 degrees. Up to seven in-orbit spares would probably have been launched, as well. The system would have been supported by nine geostationary satellites.

Through intersatellite links, Celestri would have formed a toroidal mesh network around the Earth. Launches were envisaged to take place in 2001 and the system was to be fully operational by 2002.

The satellites themselves would have been 12.7m in length with a mass of 3100kg—based on conceptual designs. However, on May 21, 1998, Motorola sold the concept to Teledesic and became a prime contractor in that undertaking. There is evidence to suggest that the development of the satellites was outsourced.

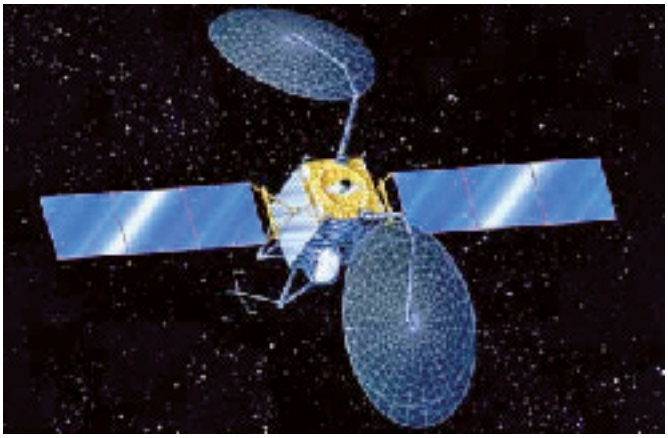
The "Biggies"

Of the proposals for Big Systems, some of which were to operate in the Low Earth Orbit, only two, Iridium and Globalstar, became operational.

Iridium started as a 77 satellite system—when the systems became operational, the constellation had been modified to 66 satellites in six polar orbits to provide global mobile communications services. The first Iridium satellite was launched on May 5, 1997. The Globalstar system, led by Loral Space & Communications, consisted of 48 satellites and the first was launched on February 14, 1998. Both companies still operate, although they have re-structured at various times.

Other systems, some less than successful and canceled, follow…

AMSC



Mention must be made of the American Mobile Satellite Corporation (AMSC) system that planned to have two satellites in geostationary orbit. This system was started in 1989 when AMSC was authorized to construct, launch and operate satellites to provide mobile services to the US and Puerto Rico. AMSC teamed with Telesat Mobile Inc., a Canadian company, and two satellites were launched and placed in geostationary orbit on April 7, 1995 and April 20, 1996. The system has also been referred to as MSat. The company has had various restructures before adopting the name SkyTerra and, ultimately, LightSquared.

Constellation

The Constellation system, proposed by a company with the same name, was to use 46 satellites to provide global coverage and would have consisted of 11 satellites in an equatorial plane to provide continuous service to tropical regions as well as 35 satellites in seven inclined planes for complete global coverage. The satellites were expected to have been built by Lockheed Martin and the system was expected to be in operation by the year 2000. The company no longer exists.

Ellipso

The Ellipso system was to be a 16 to 18 satellite network providing, principally, services to the northern latitudes (above 25 degrees North latitude) for United States, Canada, Europe, the Middle East, the former Soviet Union, China, Korea and Japan coverage. Reduced services would also have been provided down to the 50 degrees South latitude. Ellipso would have achieved this coverage by placing as many as 12 satellites in inclined elliptical orbits of 500 x 1250km, with an inclination of 63.4 degrees, and up to six satellites in an equatorial orbit.

The proposal was advanced by Ellipso Inc. (also referred to as Ellipsat Inc.) in 1997. The first two satellites were to be built by Mobile Communications Holdings, Inc. (MCHI), a subsidiary of Ellipso Inc.—MCHI entered into a construction contract with Boeing on July 17, 1998. However, by 2002, the company was struggling financially and a number of patents that the company held were put up for sale.

ICO

The ICO-2 satellite. Photo courtesy of Boeing.

ICO Global Communications was initially a subsidiary of Inmarsat and was later renamed New ICO, They proposed a constellation of 10 satellites in a MEO orbit of 10,390km with an inclination of 45 degrees, which would have been placed in two planes of five satellites each. The satellites were to be based on the Boeing BSS-601M platform with a mass of 2750kg and fitted with equipment to provide 163 spot beams in the 2Ghz band.

The first satellite in the system (ICO-2) was launched on June 19, 2001 (after a failure on March 12, 2000)

In April 2004, Boeing terminated the contract for the remaining ICO series satellites. Ten of the satellites (ICO-3 to -12) were scheduled to be launched on five Proton M/Briz M launch vehicles between 2009 and 2011, with the remaining three spacecraft, ICO-13, -14 and -15, to be available as spares. By then, ICO Global Communications had changed its approach and, on April 14, 2008, had a Space Systems Loral LS-1300 platform placed in a geostationary orbit at 92.9 degrees West. The 6634kg carried 7 C-band transponders and provided mobile voice and data communications throughout the United States.

The company changed its name to DBSD North America, Inc. in May 2009 and the satellite was, in turn, renamed DBSD-G1. The company failed in August of 2009 but the satellite was kept operational, albeit without usage, until March of 2012, when it was decided to abandon the satellite.

Odyssey

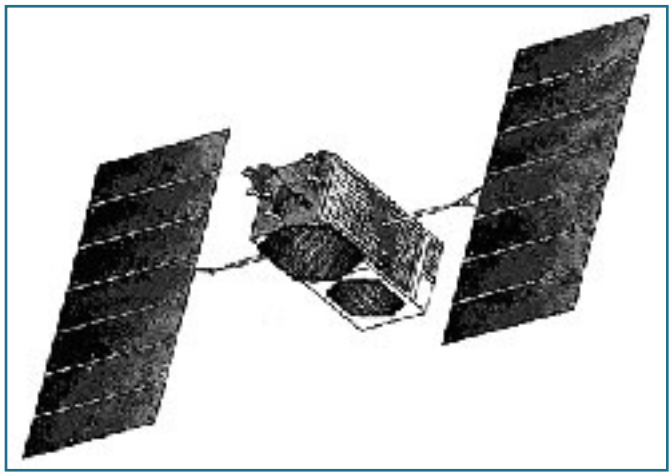
In 1991, TRW Inc. proposed to establish the Odyssey mobile communications satellite system consisting of 12 satellites in a 10,354km circular orbit with an inclination of 50 degrees. The satellites were to be distributed over three orbital planes. An additional two satellites would have been ground spares.

The system was to be operated by Odyssey Telecommunications International (OTI), a consortium consisting of TRW, Teleglobe and several smaller partners. The 14 satellite were to be built by TRW using the AB940 platform. The 2000kg satellites would have been fitted with an L-band uplink for 37 uplinks, and an S-band downlink for 32 downlinks. In addition, three gimbaled Ka-band antennas would have provided connectivity to the ground stations.

The first six satellites were to be launched in 1998 and the last six in 1999. The launch vehicle for the first two was to be a single Atlas 2AS—Delta II, Proton K and Ariane 4 launch vehicles would also have been capable of placing these satellites in orbit.

The project ran into financial problems and the company became involved in a patent issue with ISO. Adding to that were decreasing market prospects and the decision was made in 1998 to cancel the project. OTI was dissolved shortly thereafter.

Signal



In its effort to enter the satellite communications business, the Russian KOSS Consortium, of which NPO Energiya and Polet PO were members, proposed to establish the Signal system to provide communication facilities between small fixed and mobile terminals. The constellation would have consisted of 48 satellites in four orbital planes of 12 satellites each with an altitude of 1500 km and an inclination of 74 degrees.

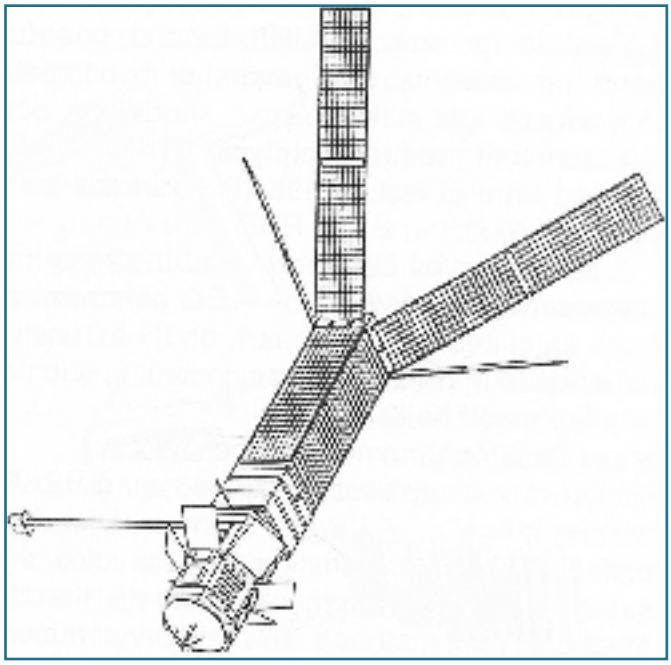
Launches would have been performed by either Kosmos 3 launch vehicles with two satellites each, or Tsyklon launch vehicles with six satellites each—the first of the 310kg satellites were expected to be placed in orbit in 1994.

All major components were based on then-existing hardware and the satellites were to be built by NPO Energia. The system was to operate on the same frequencies as the Iridium system, but the spacecraft would be "silent" when passing over the United States. The proposal never gained ground.

Little LEO Systems

Of the Little LEO Systems group, the Orbcomm system has been the most successful, with their first satellite launched on April 3. 1995. This was preceded by a number of technology satellites.

E-Sat



E-Sat was a constellation of six satellites proposed by E-Sat Inc., a subsidiary of DBS industries and Echostar. The services to be provided by this system were initially targeted at the gas and electric utility industry for the firm's subsidiary, Global Energy Metering Service, Inc. (GEMS). In particular, the service would maintain contact with hard to locate utility meters, such as gas and electricity and transmit usage devices as well as other information to the utility corporation.

For this, E-Sat Inc had a license to provide non-voice operations in the 137-138 and 148-150.5MHz frequency bands using a low-power transmitter fitted with Code Division Multiple Access (CDMA) technology. The 130kg satellites were to be built by Surrey Satellite Technology (SSTL) of the United Kingdom—the first three satellites were to be launched on a Rokot launch vehicle in early 2001. The satellites were to operate at an altitude of 1262 km, with an inclination of 100.7 degrees. E-Sat failed to meet the launch target dates and its license was canceled in April 0f 2003.

FAISAT

Final Analysis proposed the FAISAT system to provide low rate data and non-voice digital communications, including vehicle tracking and remote meter reading using both Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA), allowing its system to share the spectrum with other users

The constellation was to consist of 26 satellites in LEO. The 115kg satellites would be placed in 1000km orbits, with four planes operating at 66 degrees inclination and two planes at 83 degrees inclination. The satellites would have been placed in orbit on four launches via Kosmos 3 launch vehicles, provided by the Russian AKO Polyot, which, in return for their involvement, would become the service provider in Russia.

Other references have suggested that at one stage, the system was to consist of 38 operational satellites in seven planes, as well as 32 satellites in six orbital planes. Two experimental satellites were launched—Faisat-1 was launched on January 24, 1995, and Faisat-2 was launched on September 23, 1997.

The first two satellites were to be launched before September 2002 and the operational system was to be available by 2003.

However, after a number of corporate restructures, the creditors of the company filed for bankruptcy in September of 2001 and all the company's assets were sold in January 2002. On March 17, 2004, the appropriate licenses were canceled.

GEMnet

The Global Electronic Message network (GEMnet) was a 38 satellite system proposed by CTA Commercial Systems. The system was to provide global two-way data communications to their customers. The planned services include data and message transfer, paging, email, positioning and remote monitoring. The satellites would have been placed in a 1000km orbit. These would have been placed in five circular orbits, of which one was to be polar and the other four with a 50 degree inclination. Proposed in 1993, the system was expected to be operational by 1998.

Meanwhile, CTA had been contracted to build a satellite for the Volunteers In Technical Assistance (VITA). The resulting satellite carried a transponder to test the systems and applications for GEMnet. Known as GEMStar-1, the satellite was launched on August 15, 1995, but failed to reach orbit due to the failure of the first stage of the LLV launch vehicle. The 127kg satellite was to have been placed in a 500km polar orbit.

Following this failure, the association between CTA and VITA came to an end and CTA Commercial Systems was acquired by Orbital and the GEMnet system was canceled. VITA continued its efforts and was involved in the development of the Faisat system and eventually leased bandwidth on the HealthSat-2 and UoSat-12 satellites.

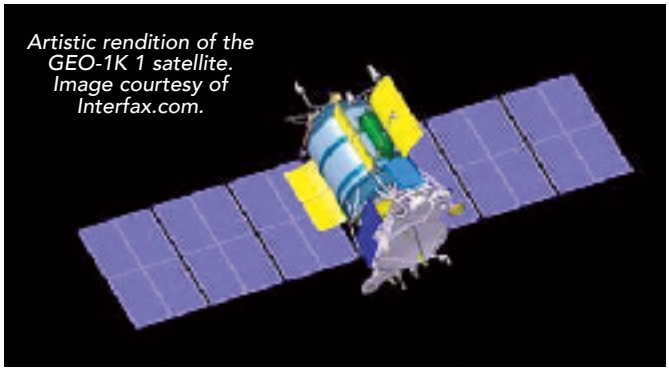
Starsys

The Starsys system, proposed by the company of the same name, was to provide ultra low-cost two-way communications and positioning determination capabilities using a constellation of 24 satellites operating at 137/148MHz. The system, operating in six orbital planes, was to be operational by 1997, but by that time, the license had been surrendered. In 1998, Starsys was purchased by GE Americom who proposed a similar constellation but one that did not materialize. The name Starnet was also associated with that proposal.

Elekon

Russia, in cooperation with Germany, considered a seven satellite LEO constellation that was to be a combined communications-navigation system. The project was seeded in 1993 by a team comprised of Science and Technology International of Russia (STIR) and Elbe Space and Technology of Dresden, Germany. Named the Elekon system, the payload would consist of L-, S-, and C-band transponders. The 900kg satellites would have been in an orbit at an altitude of 1150km.

Part of the Elekon payload was tested on the GEO-IK 1 satellite that had been launched on November 29, 1994. The first operational satellite would have been launched in 1995 and full operations were expected by 1997.



Artistic rendition of the GEO-1K 1 satellite. Image courtesy of Interfax.com.

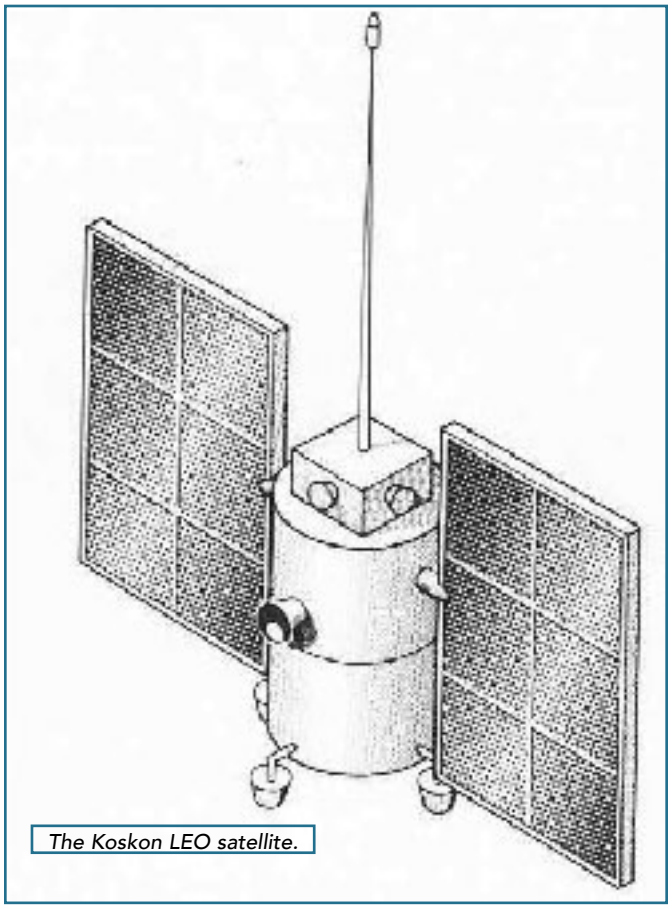
IRIS

Belgium operator SAIT Systems, with the support of the European Space Agency (ESA) to meet the Agency's Little LEO Messaging System (LLMS) requirement, advanced the Intercontinental Retrieval of Information via Satellite (IRIS) system for a world-wide electronic mail and data service using advanced communications technology. Other European concerns were also involved in the development. The system was to be operational by late 1998. The intended orbit was to be 835km with an inclination of 98.7 degrees and the number of satellites was to be dependent upon customer demand. On July 10, 1998, a LLMS payload was placed in orbit on the Russian Resurs O-2 satellite.

Leostar

Leostar was a proposed Italian mobile communications satellite system consisting of 40 satellites located in five different orbital planes and was anticipated to be operational by 1997/98—however, the proposal was not furthered.

Koskon



The Koskon LEO satellite.

Koskon was a Low-Earth Orbit communications satellite system proposed by Russian concerns Polyet and Elas. The constellation would have consisted of 32 to 45 satellites in a 960 x 1010km orbit with an inclination of 83 degrees. The 600kg satellites were to be launched in groups of three using a Zenit 3 launch vehicle. The first satellite in the system, Informator-1, was launched on January 29, 1991. No further launches were conducted.

Kuryer

Kuryer was a constellation proposed by the Russian Elas concern and would have involved 8 to 12 satellites in a 700km orbit with an inclination of 76 degrees. The 500kg satellites would have operated in the 430-470MHz range and were to be launched by the Start 1 launch vehicle.

SPS Sputnik

Proposed by Makayev, a Russian concern, the SPS Sputnik was to provide voice, digital and fax communication services from a 510km orbit with an inclination of 70 degrees—32 to 48 satellites with a mass of 300kg each were to be launched by Shitl N1 launch vehicles from 1995.

WEST

Mata Marconi, a French company, proposed the Wideband European Satellite Telecommunication (WEST) constellation, to consist of nine satellites in MEO and two satellites in a geostationary orbit. The satellites would be based on the Eurostar 3000 platform and would use the Ka-band, with services expected to start in 2001 for Europe and neighboring areas and to then extend to other parts of the world by 2003.

KITComm

KITComm, a subsidiary of the Australian firm Kennett International Technology, proposed the use of eight or nine microsatellites for commercial security monitoring services. The satellites, which would be in a 1000km orbit, would interrogate ground based surveillance devices.

A contract for the launch of the first two satellites was placed with the U.S. firm PacAstro, which would use its PA2 rocket to place the 230kg satellites in orbit. It is believed the first satellite was planned for launch in December of 1993, although the press release was not clear as to the status of the PA2 rocket or the launch site to be used. Eventually, launches were to take place from Darwin, Australia.

The proposal was not acted upon. Later the company considered a 21 satellite constellation with an altitude of 2800km and an inclination of 90 degrees and a mass of 3kg and fitted with L-band equipment. The first launch was envisaged for 1999.

About the author

Jos Heyman is the Managing Director of Tiros Space Information, a Western Australian consultancy specializing in the dissemination of information on the scientific exploration and commercial application of space for use by educational as well as commercial organizations.

*An accountant by profession, Jos is the editor of the TSI News Bulletin (**http://tiros.zarya.info/**) and is also a regular contributor to the British Interplanetary Society's Spaceflight journal. Jos is also a Senior Contributor for SatMagazine.*

As The Earth Turns...

By Philip Miller, Vice President of Operations + Engineering, exactEarth

exactEarth recently announced the successful launch of the company's fifth AIS satellite in our exactView™ constellation. This nanosatellite, EV-5, flew aboard a Dnepr rocket on November 21, 2013 from the Dombarovskiy Launch Facility in Yasny, Russia.

This successful deployment marks a significant milestone as we continue increasing the capacity of our world-leading space-based global vessel monitoring service.

EV-5 is a 25cm CubeSat satellite weighing in at approximately 14kg and carries several advanced electronics payloads that will deliver multiple modes of advance Automatic Identification System (AIS) detection capability. This powerful little satellite will add nearly half a million AIS messages to our service daily. This is nothing short of amazing, that these small 'microsatellites' can survive the turbulence of a rocket launch, operate reliably for years on less power than is consumed by a 20 watt light bulb, and play such a large role in the monitoring of the world's oceans.

Constellation Conversation

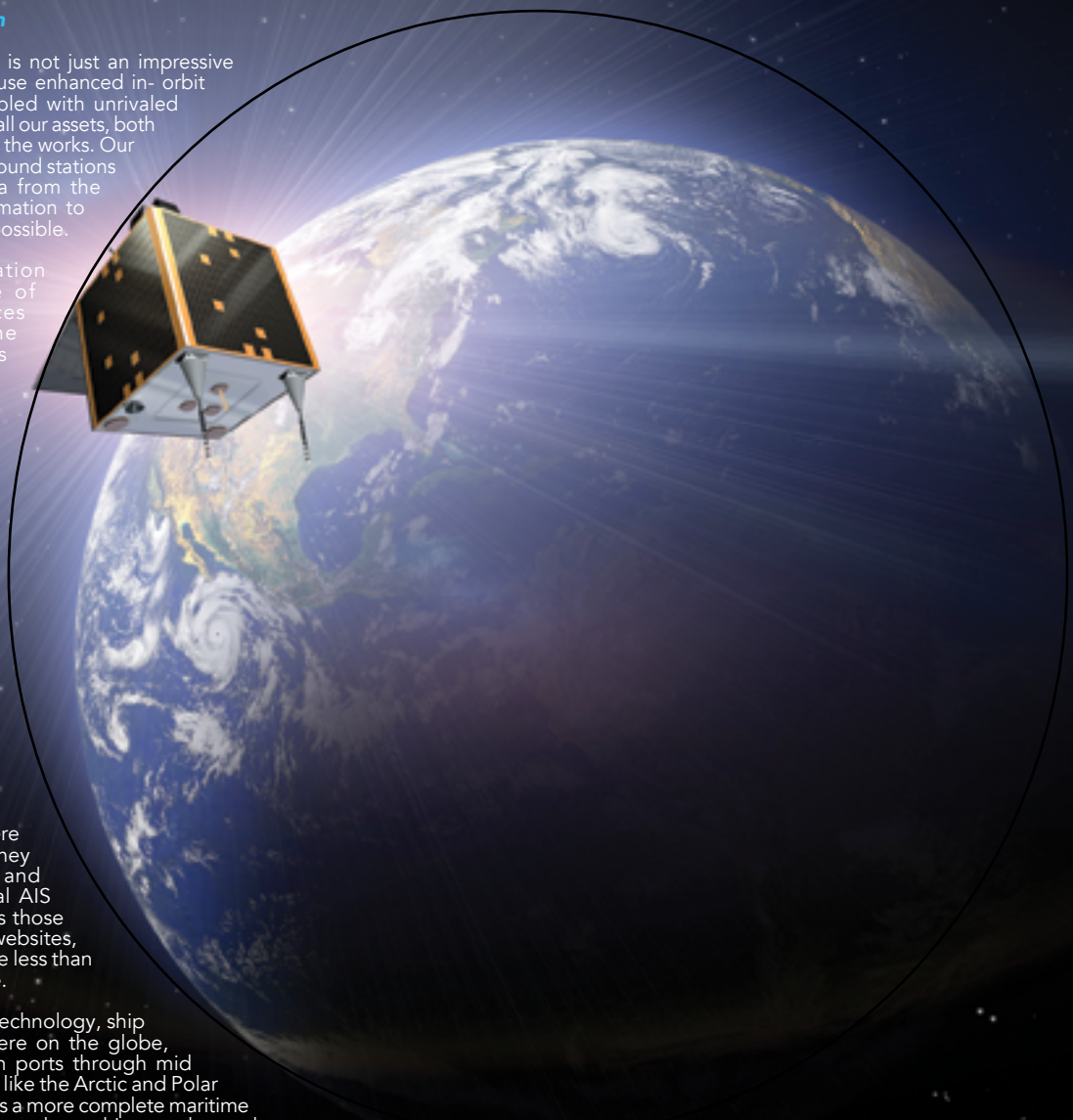
The exactView Constellation is not just an impressive collection of satellites. We use enhanced in- orbit processing techniques, coupled with unrivaled ground based processing, on all our assets, both currently in-orbit and those in the works. Our growing global network of ground stations is used to retrieve the data from the satellites to move that information to our customers as quickly as possible.

The exactEarth constellation serves as the backbone of the complete data services business solution that the company provides to its customers. The collection and distribution of AIS marine vessel information is the basis of exactEarth's cornerstone product offering, exactAIS®.

Once messages are collected, they are then processed and securely delivered to customers enabling the efficient monitoring of shipping on the world's oceans. Our service enables our customers to make critical decisions in areas such as international trade, border security, environmental protection and search and rescue missions.

Before Satellite AIS, ships were essentially invisible when they traveled over the horizon and out of view of land. Coastal AIS surveillance systems, such as those offered through free online websites, can see vessels when they are less than 50 nautical miles from shore.

However, with Satellite AIS technology, ship traffic is now visible anywhere on the globe, from inland rivers, to ocean ports through mid ocean and into remote areas like the Arctic and Polar Regions. This gives authorities a more complete maritime picture, allowing them to see where ships are located as well as to know where they are heading, predict when they will arrive at their destination, and to know exactly where they have been.



The vast majority of ships behave as expected. However, our service provides a new level of information that helps authorities know when ships deviate from expected routes, know when they may arrive late or when they are in difficulty and in need of assistance.

Our 100+ customers have made the benefits of this information very clear and have brought to light the many maritime operational activities that can be aided by our Satellite AIS technology. Benefits like these are the reason we enjoy a 70 percent market share in the global satellite AIS market and why we are working hard to bring our customers new and exciting capabilities and solutions.

The Challenges

The exactAIS service depends upon our satellites being in particular orbits that will maximize the time during which we have one or more satellites covering each area of the world's oceans. To keep costs low, we must hitch a ride as a secondary payload on launch vehicles that are going where we want the satellites to be placed into orbit.

To enable this, our constellation consists of nano- and microsatellites that can be tucked into the available space on rockets "going our way." The exactEarth constellation also includes hosted payloads, which are carried on the bus of a primary satellite going into an orbit in which we have an interest.

In addition, we require sensitive electronics that are difficult to build and integrate, but are the foundation of our world leading AIS detection capability. To achieve this, we have developed an exceptional team of satellite and AIS experts, designed custom tools to ensure that our deployments are able to deliver consistently on our service levels and established the expertise allowing us to work with both traditional large satellite and innovative microsatellite manufacturers. Additionally, we plan, monitor and operate our AIS collection capability, ground station network and ground processing infrastructure with a small but highly competent and dedicated staff.

Looking Ahead

By the close of 2014, exactEarth will have completed its initial Satellite AIS constellation and will be detecting more than 10 million AIS messages per day from well over 100,000 ships, for an average of more than 100 position reports per day per vessel. We will be operating eight satellites in polar and equatorial orbits.

In addition to the growth in our satellite constellation, exactEarth also has plans to roll out more ground stations in 2014 and to make additional improvements in our global ground data distribution network. When combined with other activities currently underway, we will be delivering our highest performing exactAIS service, covering every point on the globe at least once per hour and delivering the information to customers anywhere around the globe in 30 minutes or less.

Even though our initial constellation is coming to completion, we are not slowing down. We are taking the feedback we continue to receive from customers and leveraging the creativity and experience of our exactEarth team and we have already begun to create a next generation that will continue delivering leading maritime monitoring services for the decades ahead.

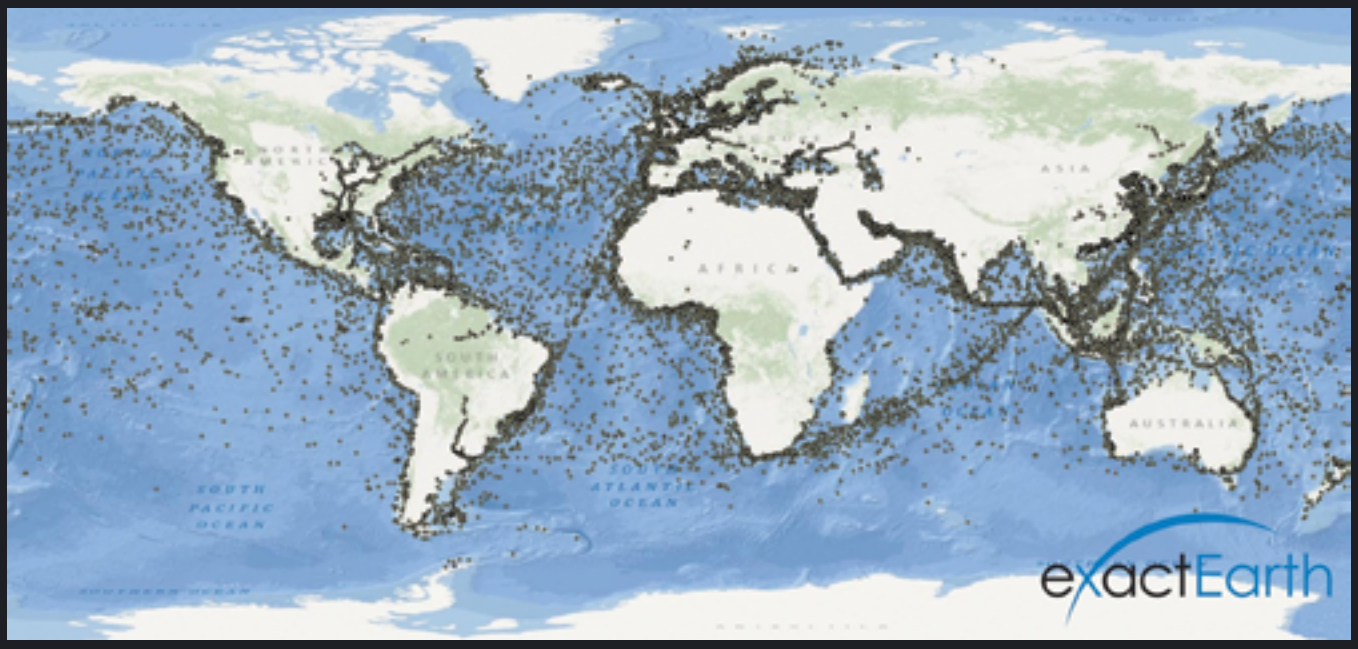
The exactView Data Sheet:
http://cdn2.hubspot.net/hub/183611/file-248885063-pdf/Collateral_for_Download/Rebranded_Collateral/exactView.pdf

About the author

Philip L. Miller is a graduate of Georgia Institute of Technology with a B.S. in Applied Physics. In the 1980's Mr. Miller was a lead systems engineer for Scientific-Atlanta creating the world's first Very Small Aperture Terminals (VSAT). He subsequently co-founded AvData Systems, a provider of satellite VSAT systems, and managed network services throughout the United States.

Mr. Miller then became Vice-President of Product Development for Telemedicine and Informatics at Resmed Corporation leading the successful development and operational commercialization of an enterprise, web-based medical wireless compliance and efficacy monitoring system. Next, Mr. Miller undertook the successful development and operational deployment of a global broadband communications network in the commercial maritime shipping industry.

Mr. Miller joined the founding team of exactEarth in 2009 and has since led the deployment of its satellite constellation, ground station network, data processing and supporting operating staff. Mr. Miller is an expert at designing, implementing and operating the necessary infrastructure, supporting technology, personnel and tracking systems to successfully operate complex integrated technology based services. He has successfully done so in numerous vertical industries including telecommunications, satellite networking, medicine and maritime shipping.



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