

Worldwide Satellite Magazine

July/August 2010

SatMagazine

***Earth Observation
& Imagery***

Satellite image of Iceland's Eyjafjallajokull Volcano Courtesy of GeoEye

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Cover image— this one-meter resolution satellite image features the Eyjafjallajokull Volcano, located in southern Iceland, near the Eyjafjallajokull Glacier. The image was captured by the **IKONOS** satellite from 423 miles in space on March 31, 2010, as it moved from north to south over Iceland at a speed of four miles per second. Image is courtesy of **GeoEye, Inc.**

SatCentric — Eros A + Eros B

On December 5th, 2000, ImageSat international became the first, non-US-based company to successfully deploy a commercial, high-resolution, imaging satellite. This was EROS A, weighing in at 250 kg, which was propelled into its orbital slot by a Russian Start-1 launch vehicle.



EROS satellite

The EROS A possesses a camera with a focal plane of Charge Coupled Device (CCD) detectors to produce a standard image resolution of 1.9 meters

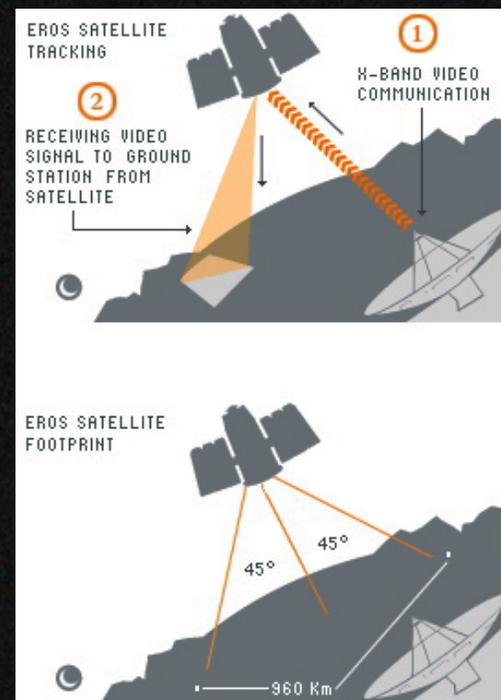
and sub-meter resolution using hypersampling techniques. The swath is 14 km at Nadir (perpendicular to the Earth's surface). The satellite orbits at an altitude of ~500 km, with data transmission at 70 Mbit/s.

The second ImageSat satellite, EROS B, was launched on April 25th, 2006, also aboard a Russian Start-1. The EROS satellites' orbital period, for one complete Earth revolution, is 94 to 96 minutes, with 15 revolutions completed around the Earth every 24 hours. There are two daylight passes each day through the footprint of a typical ground receiving station.

The EROS B is slightly larger in size to the EROS A, but quite similar in appearance. Updated capabilities include the use of a larger camera of the CCD/TDi genre (Charge Coupled Device/Time Delay Integration). A standard panchromatic resolution of 0.70m at an altitude of about 500 km is offered. Plus, the EROS B has a larger on-board recorder as well as improved pointing accuracy and a faster data communication link.



Chaiten Volcano, Chile



25 Successful Years... And Counting...

On June the 11th, **Surrey Satellite Technology Ltd** (SSTL) celebrated 25 years of space innovation. The British company was incorporated on June 11th, 1985, to commercialize small satellite research from the **University of Surrey** and has since become the most successful cash exit from a UK university spin-out when it was acquired by **EADS Astrium** last year.

During the past 25 years, **SSTL** has earned an international reputation for delivering cost effective space missions in rapid timescales with the successful launch of 34 small satellites, together with its contributions to third party space missions, made possible by its committed employees and the continuing close cooperation between SSTL and the Surrey Space Centre. SSTL Executive Chairman and founder Sir *Martin Sweeting* commented,

“As a PhD student in 1985, I was not afraid to take risks — I believed that the costs associated with space could be cut dramatically by taking a new approach to engineering. We have changed the face of space by taking a highly innovative approach to both technology and management of space projects and exceeded expectations by consistently delivering highly capable and reliable space missions. We continue to apply

this principle and determination in everything we do — from producing commercial Earth Observation missions to enabling cost effective interplanetary exploration.”

SSTL has taken advantage of the latest advances such as Solid State Drives (SSD) or powerful microprocessors and rapidly applied them in space, offering more capable satellites at ever more affordable prices. This is clearly shown by today's 2G **Disaster Monitoring Constellation (DMC)** satellites, which have ten times the capability of the original satellites launched just five years ago. In October 2010, SSTL will launch **NigeriaSat-2**, one of the most capable small satellites in orbit. By the end of 2010, a further seven SSTL-built satellites will be in orbit using the best available advances in technology. In 2005, SSTL completed the first **Galileo** program test satellite, **GIOVE-A**, on time and within budget for the **European Space Agency (ESA)**. This satellite embraced SSTL's space engineering principles resulting in a highly cost

effective solution. It soon proved its worth when **GIOVE-A** secured the radio frequencies necessary for the European satellite navigation system, ensuring that **Galileo** could progress. The success of this mission ultimately led to SSTL and its partner **OHB System AG** being awarded a contract to build the first 14 fully operational spacecraft following the validation phase in January 2010.

Also in 2005, SSTL proved that small satellites could provide state-of-the-art high resolution Earth observation for security with the **TopSat** mission, which was built for the **UK Ministry of Defence (MoD)** with support from the UK Government's **MOSAIC** program. This seed corn funding also resulted in the launch of Algerian **AISAT-1**, the first satellite in the international **Disaster Monitoring Constellation (DMC)**. This constellation has since grown to six satellites, all built by SSTL for different member nations, providing countries such as Nigeria, Algeria, Spain and the UK with the ability to map changes in the environment and assist with disaster relief campaigns. From this small initial investment, SSTL has since made £95m of export sales of EO satellites, achieving greater than a 10:1 return on the investment.

What's next? SSTL believes that in the short term remote sensing constellations will continue to develop, improving our knowledge of the Earth, its environment and its resources, with more up to date and cost effective information. Since 1981, SSTL has launched 34 satellites as well as providing training and development programs, consultancy services, and mission studies for **ESA**, **NASA** and commercial customers, with its innovative approach that is changing the economics of space. Based in Guildford, UK, SSTL is owned by **EADS Astrium NV**.



Disaster Monitoring Constellation



Sir Martin Sweeting

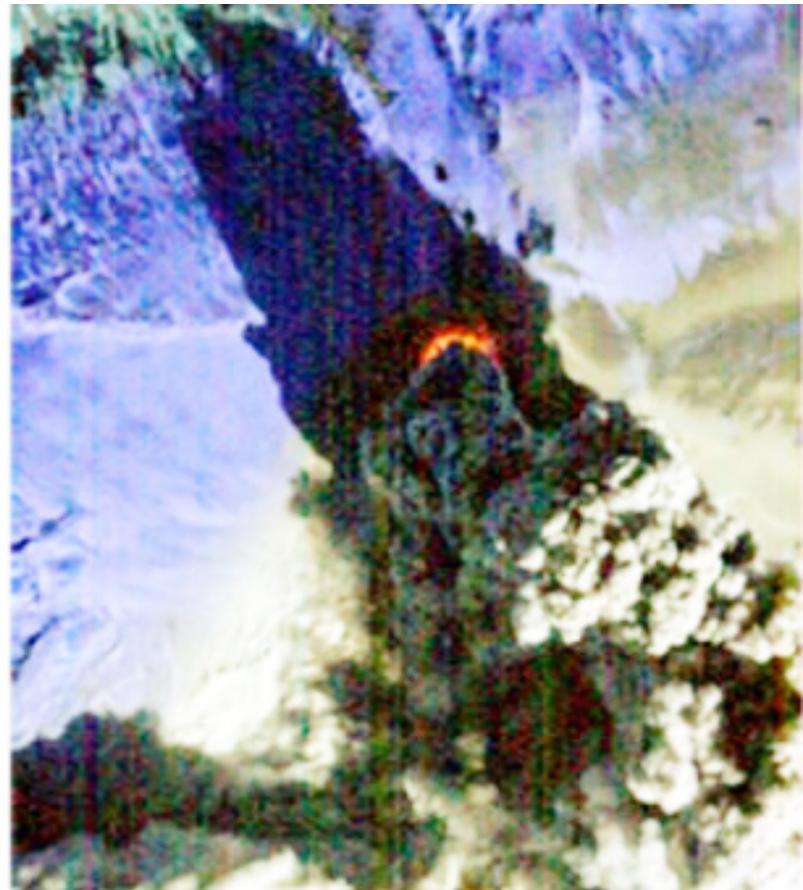


Focus

Volcanic Thoughts...

author: Dr. Christopher Ralph Lavers, Britannia Royal College

As a researcher involved in high resolution satellite remote sensing of both man-made and natural disasters I was very surprised to find myself trapped in southern India in mid-April due to the recent unexpected volcanic eruptions in Iceland by the closure of UK airspace, and indeed most of Northern Europe for the best part of a week. Having just visited the most southerly tip of India, an area badly affected by the tsunami in 2004, and seen the monument to those who died at Cape Comorin ('Land's End'), and researching Internally Displaced People, I found myself an unwitting Externally Displaced Person myself.



Visible (left) and infrared (right) images of Iceland's Eyjafjallajökull volcano, acquired April 17, 2010, from the Hyperion instrument onboard NASA's Earth Observing-1 (EO-1) spacecraft. Image credit: NASA/JPL/EO-1 Mission/GSFC/Ashley Davies

The advances in satellite imagery in the last decade now provide timed sequences of *Meteosat* style data that reveal the gradual spread of the ash clouds after the eruption under the *Eyjafjoll* glacier, to detailed *Ikonos* imagery, E0-1 30m resolution ALL visible imagery as well as other crucial sources of detailed imagery captured by satellites such as **NASA's Aqua** and **Terra** platforms.

Aqua can provide beautiful detailed imagery from its **Moderate Imaging Spectrometer (MIS)**, which showed the changes to the path of the ash plume, which by May 10th had reached as far a field as North Africa, Turkey, and Morocco. However, the scale of the economic impact of the volcanic eruption extended not only to the airlines and stranded travellers (including my family making the most of our extended stay), but to the entire globe, as the financial impact of lost revenue from products such as bananas to a lack of car manufacturing components arriving by air in China struck home. This was quite surprising.

Just as there was a domino effect on subsequent flight delays and flight cancellations that swept across the globe, so the economic consequences were almost as quick to follow, demonstrating how much we really are an integrated, or at least integrating, global community. A relatively small volcanic eruption has had a surprisingly large impact on humanity as a whole, just as when I injure my little finger my whole body (and family) knows all about it.

Clearly one lesson to be learned in the aftermath of this incident is the need for development of a more robust integrated global transportation system better able to deal with a variety of emergency disaster scenarios. The implication of this should not be lost on satellite telecommunication operators who must be able to ensure provision of at least essential traffic if an unforeseen event, such as a repeat of the March 1989 Solar eruption, if the impact on satellite operations, which affected severely both **E1** and **E2** satellites operating over Canada and Northerly latitudes, is to be avoided.



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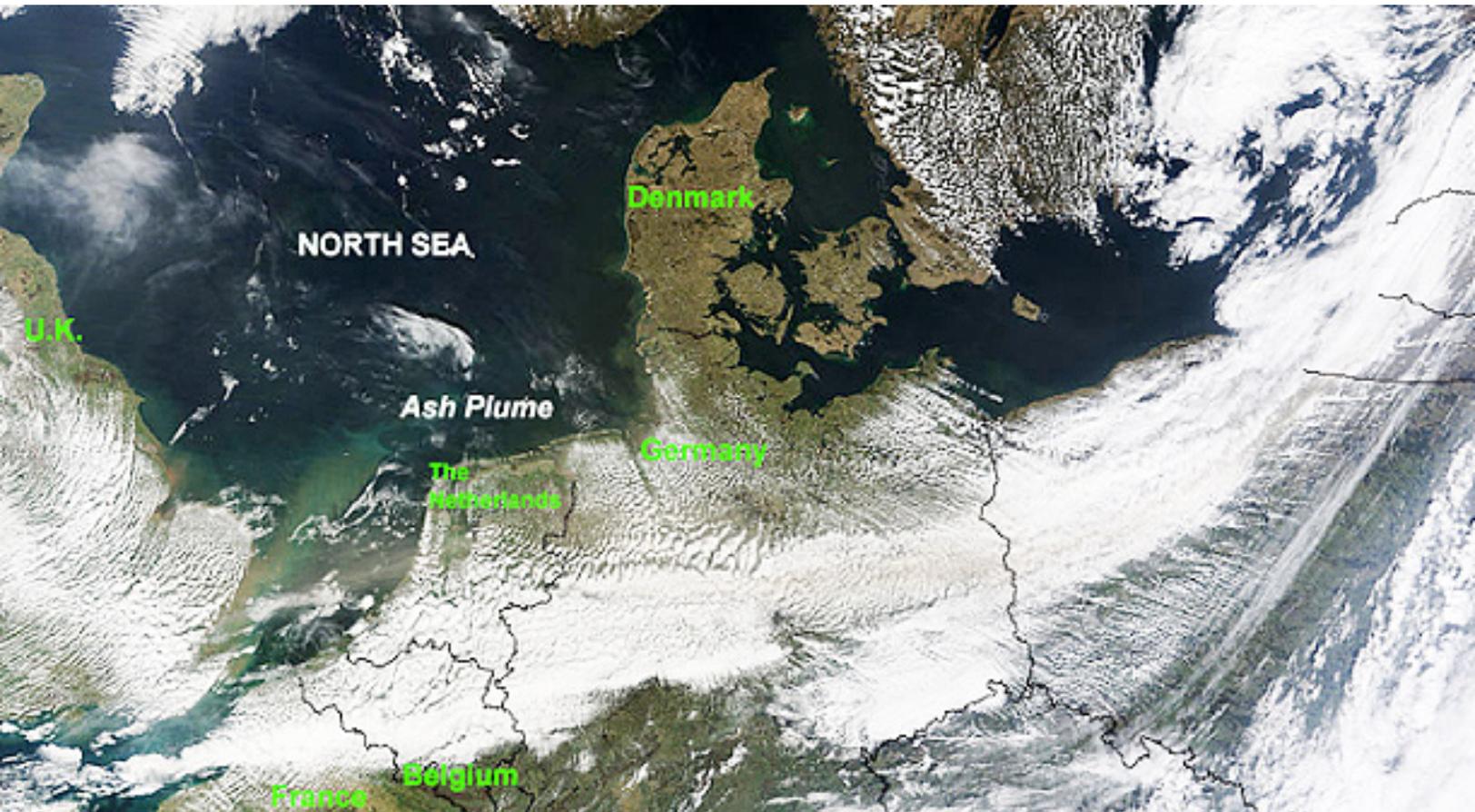
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Above... NASA's Terra satellite flew over the volcano on April 16 10:45 UTC (6:45 a.m. EDT) and the MODIS instrument captured a visible image of Eyjafjallajökull's ash plume (brown cloud) stretching from the U.K. (left) to Germany (right). Credit: NASA/MODIS Rapid Response Team

Fortunately, the sun is currently experiencing a minimum of solar activity — well away from the hyped melodrama enjoyed while watching the 2012 blockbuster in-flight 'entertainment' on the way to India!

There are issues of risk which need to be evaluated and examined with care. It is clearly better to adopt a precautionary approach at the beginning and relax the no-fly zone conditions later than to have half a dozen Airbuses (or is that Airbusi?) go down before anyone takes the situation seriously.

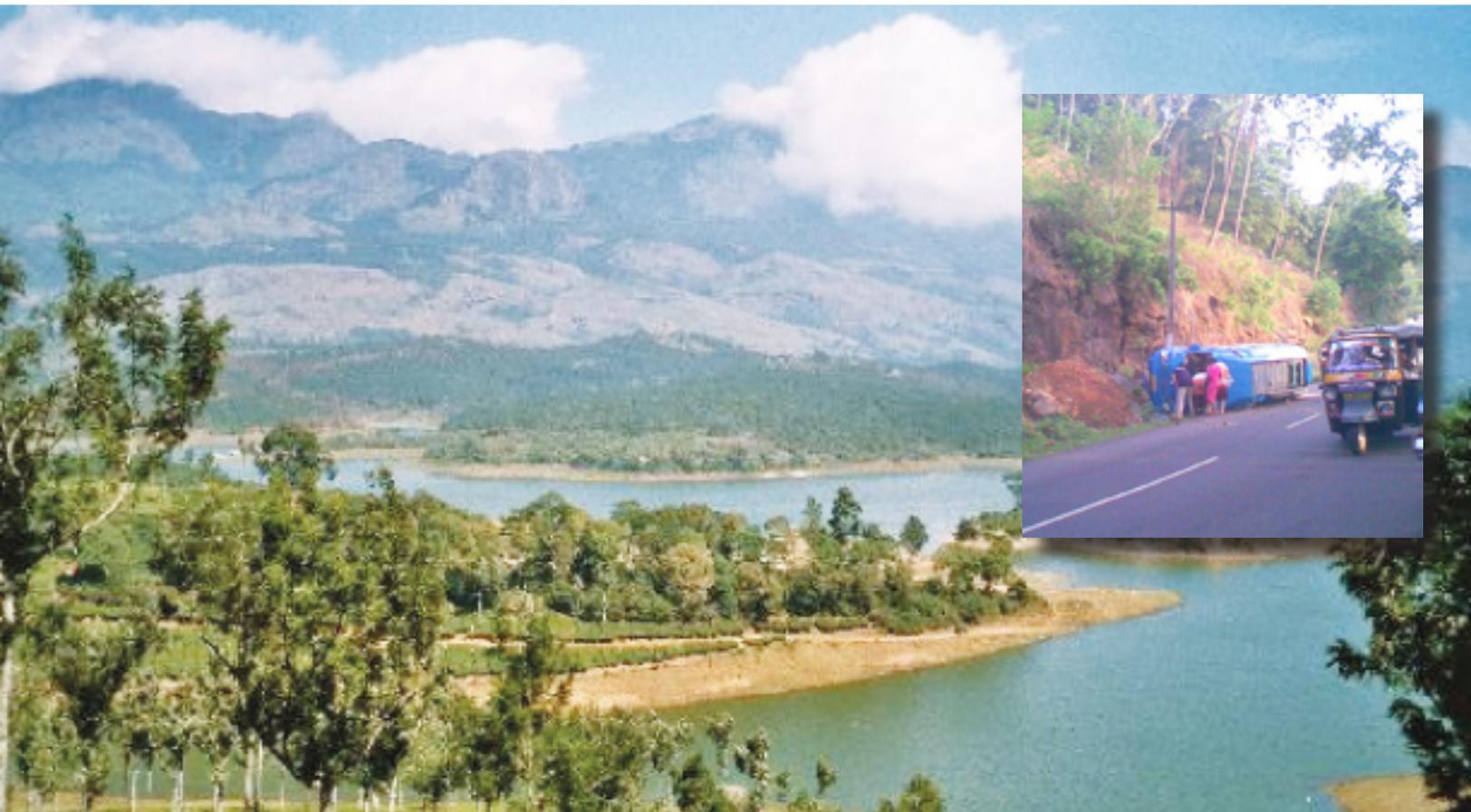
To be fair on both the National and European Air Traffic aviation authorities, there was just no previous precedent for them to draw upon experientially; the last time this scenario occurred, we did not have automobiles, let alone planes, in the sky.

The perception of risk alone is also likely to be seriously flawed, especially if we take into account too heavily the views of stranded tourists 5,000 miles away (stuck without

air conditioning due to early monsoons) who are likely to want to fly home no matter what conditions are prevalent.

But how objective can you be when dealing with the unexpected? Our own assessment of risk took a surprising turn as we experienced a coach brake failure (or brake-away) up in the mountains of the Western Ghats a week before our originally planned return home — crazily swerving down a thankfully open road at 50 miles an hour with a 1,500 foot drop on our left — that was until our driver found a wider strip of land to our right, directly next to another ascending rock wall with an electricity pole dead in front of the bus... hope reigned supreme until the bus struck a large rock and barrel rolled left towards the cliff — again!

After rolling 450 degrees (I counted the rolls as I was wondering whether we would go over the cliff, and not that, as a rule, satellite analysts tend to count things), we finally came to a rest. Miraculously, no one was killed or seriously injured, with only the front passenger wearing a seatbelt. Everyone, 18 of us and the driver, from three



Western Ghats, India, near Munnar — The Western Ghats is a mountain range of 1500k which runs from the southern tip of India to Mumbai (Bombay).

years to 70+ in age, walked out of the bus. Actually, my three smallest children were pulled up out of the side-windows that were now facing heavenward, dazed but grateful to be alive (*photo insert, above*).

How do you prepare and evaluate accurately the risk of infrequent, or once-in-a-lifetime events, such as a cometary or asteroid impact? The answer is you can't.

However, satellite imaging and the estimation of gases, such as Sulphur Dioxide, with the help of NASA's **Ozone Monitoring Instrument (OMI)**, and further satellite data alongside 'ground truthing' of ash, are a vital part in ensuring travel by air (and maybe in the future, by coach!) are as safe as is humanly possible.



About the author

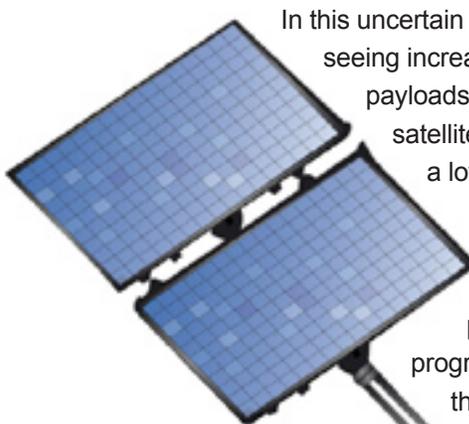
Christopher Ralph Lavers, Ph.D., is a Subject Matter Expert in Radar and Telecommunications, Plymouth University, at Britannia Royal Naval College. He is a lecturer in Sensors and Remote Sensing. His research interests include the use of high resolution satellite imagery for human rights and Earth resource applications. The thermal imagery of wildlife — a recent thermal imaging of wildlife exhibition — was seen by 80,000 people across the South West of England. Dr. Lavers also studies thin film photonics for stealth applications and he has appeared on UK radio several times, including UK national Radio 4, the Material World program, where he discussed stealth warship design. He was also a Research Fellow, Optoelectronics Research Center, Southampton University.



Alternatives To Dedicated Space Platforms

author: Scott Smith, Executive Vice President, Iridium Communications Inc.

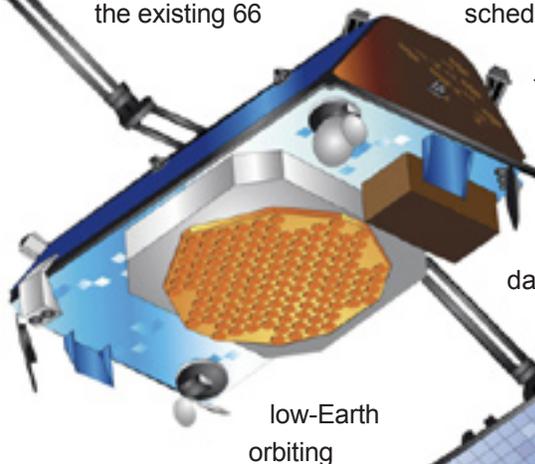
Economic realities dictate that the satellite industry will probably be facing a short-term future characterized by budget cuts and delays in government-funded space programs. There is growing concern among many in the Earth sciences community that this may result in significant gaps in the collection of critical climate observation data in the next few years. Likewise, the government and military sector face the increased likelihood of service gaps in several important mission areas.



In this uncertain climate, we are seeing increased interest in hosted payloads on commercial satellites, which can provide a lower-cost and timely alternative to dedicated Earth observation satellites. Iridium's planned replenishment program to replace the existing 66

On June 2, Iridium awarded a contract to **Thales Alenia Space** for the design and construction of the Iridium NEXT satellites, and announced that **Coface**, the French export credit agency, has issued, for the account of the French State, a "Promise of Guarantee" which commits to cover 95 percent of the \$1.8 billion credit facility for the project. The financing to be covered by the Coface guarantee is being syndicated through French and other major international banks and financial institutions, and is expected to be completed this summer. Launches are scheduled to start in the first quarter of 2015.

Iridium NEXT



(LEO) communication satellites, in particular, poses a unique opportunity for piggy-backing Earth observation sensors as secondary payloads on the new spacecraft. **Iridium NEXT** will be the largest satellite launch program of the decade, creating an unprecedented opportunity that will not be repeated for a long time to come.

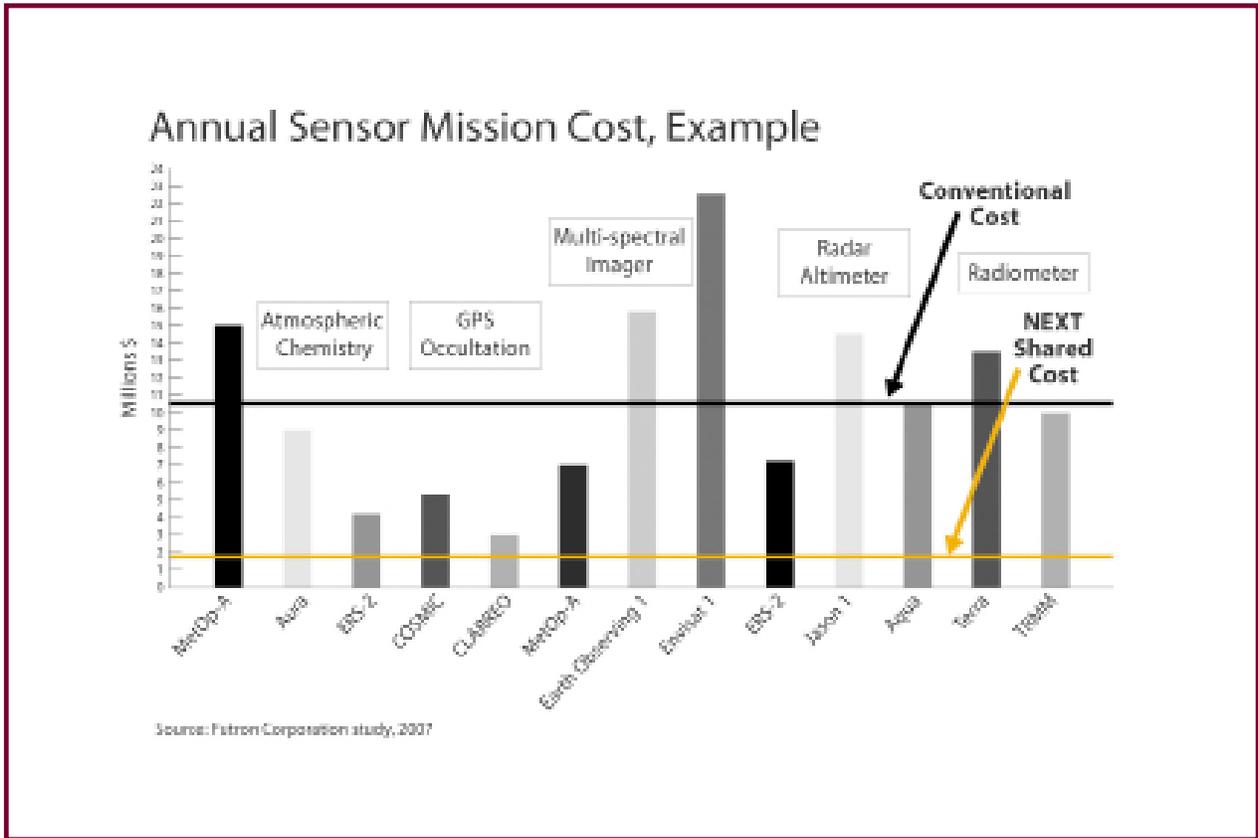
To be certain, the concept of secondary mission payloads on Iridium satellites is not new. The *National Science Foundation* and *Johns Hopkins University Applied Physics Laboratory* have long used magnetometer data from existing Iridium satellites and recently completed initial trials using enhanced samplings of the magnetometers to provide 24/7 real-time acquisition and processing of magnetic field measurements in space. The program, called the **Active Magnetosphere and**

Planetary Electrodynamics Response Experiment (AMPERE), aims to improve monitoring and forecasting space weather to help safeguard technologies, such as GPS navigation and positioning, which can be adversely affected by geospace storms.

Interest in hosting payload on NEXT was affirmed by scientists and space agencies in a meeting that took place in January 2008 at the **Royal Society** in London. It included representatives from Iridium, the international environment and climate science communities, U.S. and European weather and space agencies and the aerospace industry. Concerned by the growing danger of data gaps in key Earth observation programs, they reached a consensus that the LEO constellation, with its global coverage, low latency and cross-linked satellite network architecture, could offer truly impressive temporal and spatial coverage for monitoring critical variables in climate and environment change in a very cost-effective manner.

Since then, various teams of scientists from groups such as the **NASA/Jet Propulsion Laboratory**, the **Rutherford Appleton Laboratory** and **Centre National d'Études Spatiales (CNES)** have conducted independent studies under the auspices of the **Group on Earth Observations (GEO)** validating the feasibility of using the Iridium NEXT satellites to host Earth observation and remote sensing payloads.

Specific feasibility studies have examined radar altimeters for monitoring the height of sea surface, waves and ice; broadband radiometers for measuring Earth's radiation budget; multi-spectral imagers to detect ocean color and land imaging, key measures for monitoring deforestation, desertification and agricultural crops; and GPS radio occultation measurements to provide data on atmospheric humidity and temperature profiles.



Other potential mission areas include ozone profile monitoring, solar irradiance, polar wind observations and forest fire detection. In addition, several national weather and climate agencies have conducted feasibility studies for specific mission payloads on Iridium NEXT.

Importantly, all of these missions support the aims and objectives of the **Global Earth Observation System of Systems (GEOSS)**, which emphasize international cooperation, data sharing and informed decision-making for the benefit of the public as well as the private sector.

In addition to the Earth sciences community, the government and military sectors are also looking to hosted payloads on Iridium NEXT satellites to address a variety of near-term and long-term government and military requirements. Potential missions include dedicated communications, signals collection, space weather and space situational awareness. Iridium NEXT, it is thought, can provide the necessary combination of coverage, persistence and economy that can help fill the critical gap until the next generation of major dedicated satellite programs can be deployed.

By leveraging commercial satellite assets, mission payloads can be sent into space at a fraction of the capital and operational costs associated with developing and deploying mission-specific dedicated satellites and the infrastructure required to support them. A recent study by **Futron Corporation** (see above) compared annualized costs for various sensor missions flown in the past with what they might cost as a hosted payload on Iridium NEXT. The bottom line showed that the average costs of using the commercial satellites were less than 25 percent of the expense for a dedicated mission.

This private-public partnership presents a unique opportunity to deploy a wide range of payloads into space, but there is a narrow window. For payloads to be deployed with the planned first round of launches in early 2015, it will be necessary to make a commitment by next year. Now that the contract has been awarded to Thales Alenia Space, we are moving forward with an aggressive timetable for full design and development — **the time to act is now.**



A Look @ ISU's VAPOR + Volcanoes

authors: SSP Team Project, International Space University

This article summarizes the work performed by the Volcanic Activity: Processing of Observation and Remote Sensing Data (VAPOR) team during the International Space University Space Studies Program in Barcelona, Spain. The objective of the VAPOR project is to improve early warning and hazard tracking capabilities as they pertain to volcanic activity. The main deliverable of this project is a framework for the design of a system capable of integrating data from global providers, standardizing that data, processing it into useful information, and disseminating both data and information to the necessary end-users.

Scope

The mission statement includes the terms “early warning” and “hazard tracking”. Early warning is defined as monitoring and reporting on the probability of an eruption during the period from the first sign of a possible eruption, as provided by existing monitoring systems, up to the point of the eruption. The development of a long term monitoring system is not considered part of this project. Hazard tracking is defined as monitoring and reporting on volcanic hazards during and post eruption.

The framework has implications for policy, law, economics and society at large. Policy and law issues include governance, data collection and standards, licensing and liability. Societal impacts include the potential benefits of such a system and the facilitation of local community awareness of volcanic hazards.

Economic aspects include funding and business models. The framework is not the system itself. The design and implementation of such a system is well beyond the scope of this project. Instead, this project has done the



Left: Mount Pinatubo, The Philippines — Right: Mount St. Helens, United States of America
(Images source: USGS)

To define an integrated framework for early warning and hazard tracking of volcanic activities on Earth using space-based and terrestrial resources."

The VAPOR Mission Statement

preliminary work of identifying a need for this system and establishing a list of requirements that such a system would need to satisfy.

In 1991, the eruption of Mt. Pinatubo in The Philippines killed less than 1,000 people but affected more than one million people. *Table 1* below shows estimated values of volcanic damage according to human impact.

Integrating ground-based, air-borne and space-based sensor technology is a task many organizations have attempted, each with varying levels of function and capability.

Volcano Fundamentals

To propose a framework for volcano early warning and hazard tracking, the basics of how volcanoes work must first be understood. The Earth is composed of three principal layers: the core, the mantle and the crust. The

	Number of Events	Killed	Homeless	Affected	Total Affected	Damage US\$ (000's)
Africa	15	2,213	180,710	318,800	500,353	9,000
Americas	69	67,841	35,680	1,082,150	1,123,587	2,808,697
Asia	80	21,456	97,900	2,565,980	2,668,287	696,549
Europe	11	783	14,000	12,200	26,224	44,300
Oceania	20	3,665	46,000	202,391	248,422	400,000

Table 1: Volcanic damage from 1900 to 2006 (Image source: Bureau de recherches géologiques et minières, 2007)

Why Volcanoes?

Volcanic eruptions are one of Earth's most dramatic and violent agents of change. Notorious eruptions in the past, such as **Mt. Vesuvius**, **Mt. Pinatubo** and **Mt. St. Helens**, have demonstrated the devastating impact a volcano can have on landscapes and communities.

There are more than 1,500 active volcanoes around the world, many of them in populated areas, making volcanoes an important threat to the safety of human lives. Since the beginning of the 20th century, the two most important volcanic disasters in terms of deaths were the 1902 eruption of Mont Pelée in French Martinique and the 1985 eruption of Nevado del Ruiz in Colombia with a combined death toll of over 50,000. However, the number of people simply affected by eruptions (*i.e.* requiring immediate assistance during a period of emergency) must also be taken into account.

lithosphere, consisting of the outer crust and the uppermost solid mantle, is divided into plates. These plates, as shown in *Figure 1*, on the next page, drift very slowly over the mantle.

The activity at the boundary between some of these plates, as shown in *Figure 2* on the next page, causes the solid mantle material to melt, producing magma. A volcano is any place on Earth where magma from the mantle makes its way through the outer crust to the surface of the Earth.

The eruptive products of volcanoes are highly variable and largely dependent on the composition, viscosity and gas content of the erupting magma. Hazards include lava flows, tephra, pyroclastic flows, lahars, landslides and gas emissions. These hazards are represented pictorially in *Figure 3* on page 19.

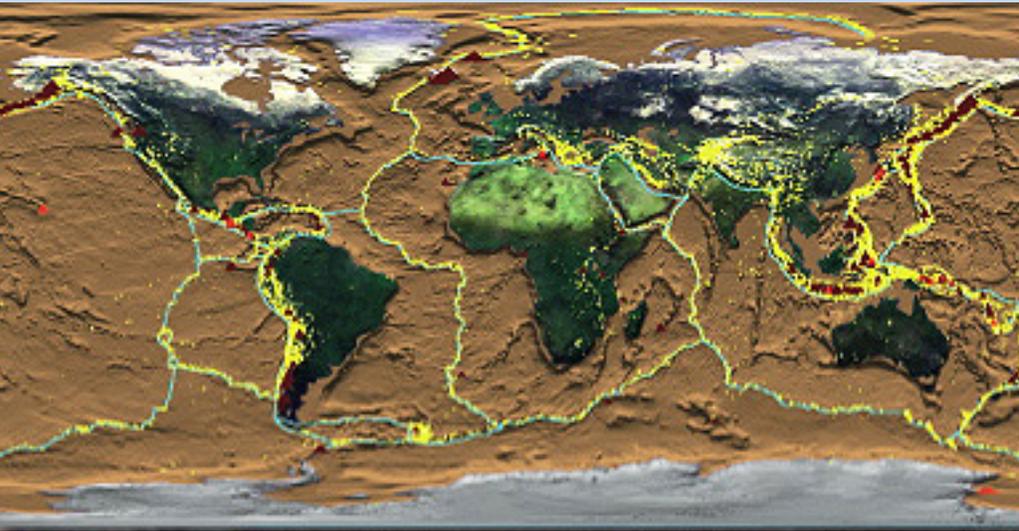


Figure 1 — Plate Boundaries (blue lines), Locations of Earthquakes (yellow dots) and Locations of Active Volcanoes (red triangles) (Image source: NASA)

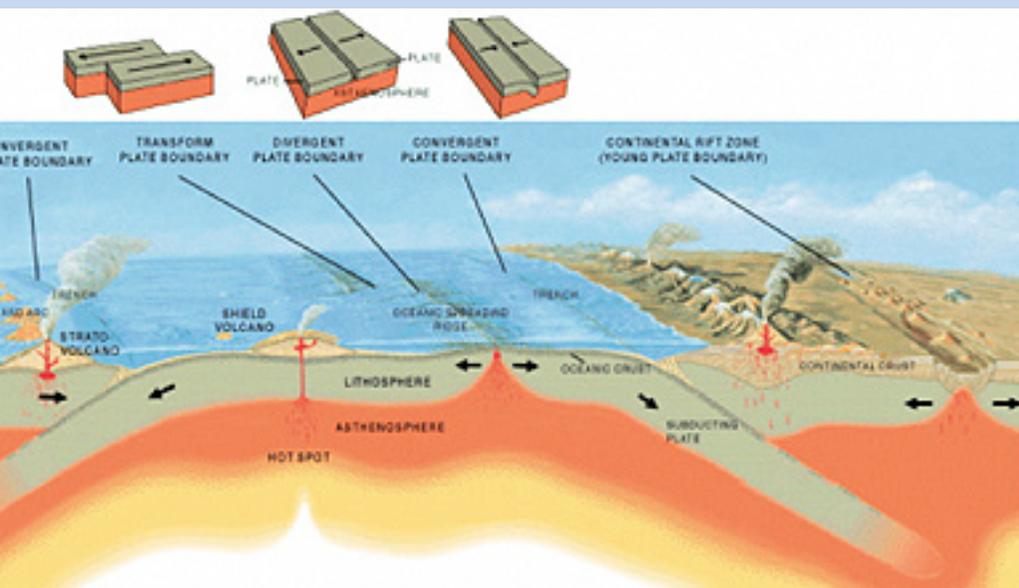


Figure 2 — Types of plate boundary interactions (Image source: USGS)

Lava flows are masses of magma that pour out of the volcano. Tephra are fragments of volcanic rock and lava that are blasted into the air by explosions or carried upward by hot gases. Pyroclastic flows are a mixture of fragments and hot gases that flow down the side of a volcano like an avalanche. Lahars are a mixture of water and tephra that can flow down slopes at speeds similar to fast-moving streams of water. Landslides are large masses of rock and soil that fall or slide under the force of gravity. Finally, gas emissions are the release of hot and toxic gases. These hazards can either be triggered directly by a volcanic eruption or as the result of another hazard.

Volcano hazards can also lead to other natural phenomena such as floods, tsunamis (large sea waves), earthquakes, and storms just as other natural phenomena can trigger a volcanic eruption.

Existing Systems

Various technologies already exist to monitor volcanoes. Many organizations are already actively involved in hazard assessment and early warning systems. It is important to understand these existing technologies and systems to be able to propose recommendations for an integrated framework for volcano early warning and hazard tracking. Existing technologies are classified into three categories: ground-based, air-borne and space-based.

Ground-based sensors include, but are not limited to: seismometers, electronic distance measurements, tiltmeters, borehole strainmeters, spectrometers, magnetometers, gravimeters, acoustic flow monitors, hydrological and electric field sensors, and sensor networks. *Figure 4* shows an array of ground-based sensors.

Gap Analysis

The investigation of current technologies and existing systems led to a gap analysis to identify areas where improvements could be made. Gaps were identified in technological, aviation and policy areas.

Technological gaps include lack of consistent monitoring capability and data format in ground-based and air-borne sensors, and limitations due to available satellite coverage, weather interference and inconsistent format for space-based sensors. Databases that house volcano information from all three groups of sensor platforms are infrequently updated.

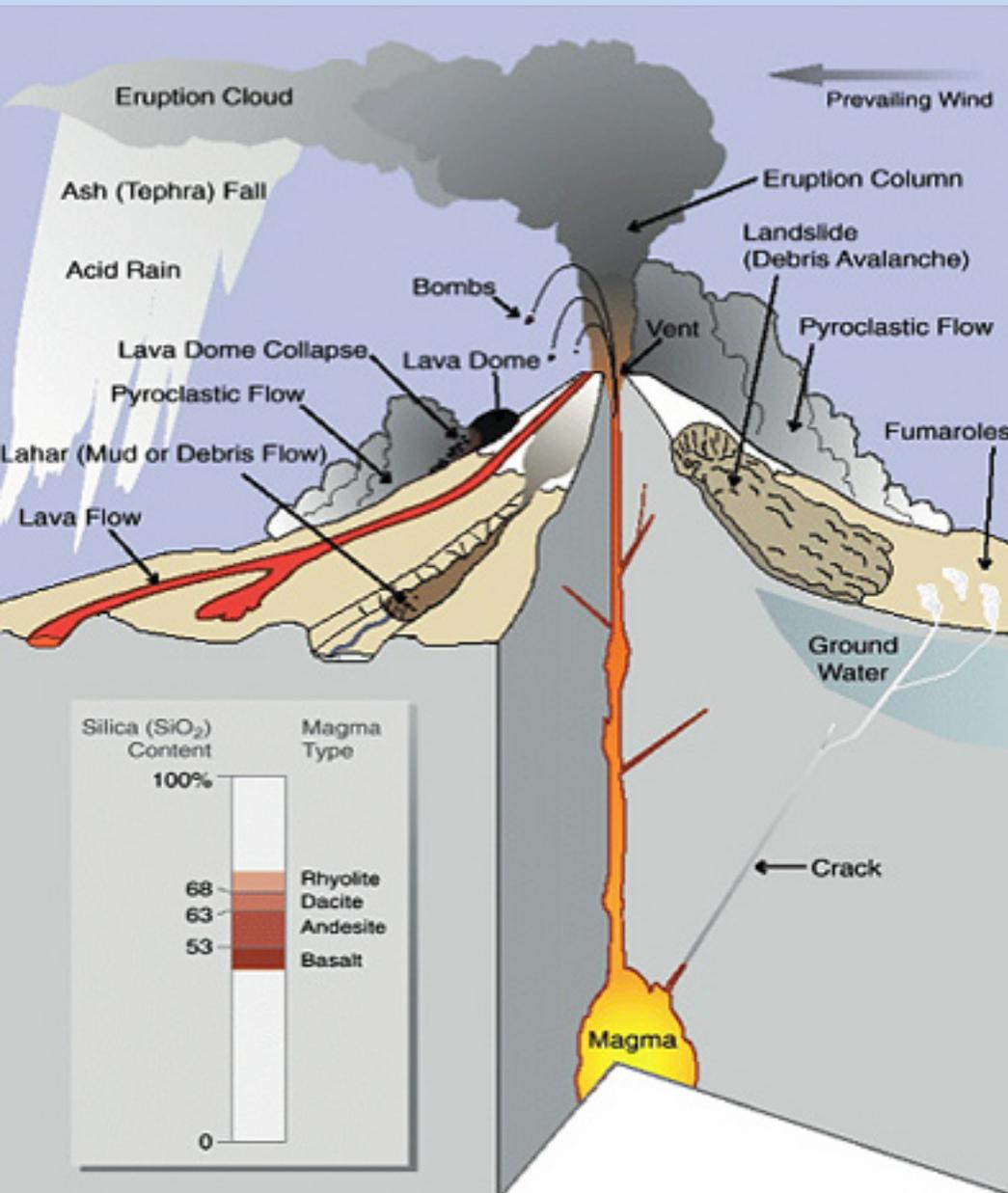


Figure 3 — Volcano hazards (Image source: USGS)

For example, volcanic ash in the eruption cloud, as shown in *Figure 6*, can rise to the height of commercial airliners in as little as five minutes but ash plume tracking information can take as long as 1.5 hours to get to the pilots of those airliners.

Policy gaps primarily pertain to the *International Charter on Space and Major Disasters*, which provides countries that have been affected by a volcanic eruption with space-based processed data products. In the past it has taken as many as 16 days before the Charter was activated (see *Figure 7*).

System Requirements

Before a system framework can be developed, the requirements for that system must first be defined. These requirements are classified into four categories: end-user, early warning, hazard tracking and general system requirements. The requirements for early warning and hazard tracking are defined independently as they represent tasks that the system must be able to carry out separately.

Volcanic Ash Advisory Centers, as well as many individual volcano observatories, use different data formats, different modeling tools and do not communicate effectively between them. Volcano monitoring and early warning systems in developing nations are insufficient or non-existent.

Aviation gaps include a lack of timely delivery of warning to aircraft to avoid ash plumes, lack of understanding of minimum tolerable ash plume concentration that aircraft can fly into, and variations in data based on detection methods.



Figure 4 — Array of ground based sensor (Image source: USGS Volcano Hazards Program)

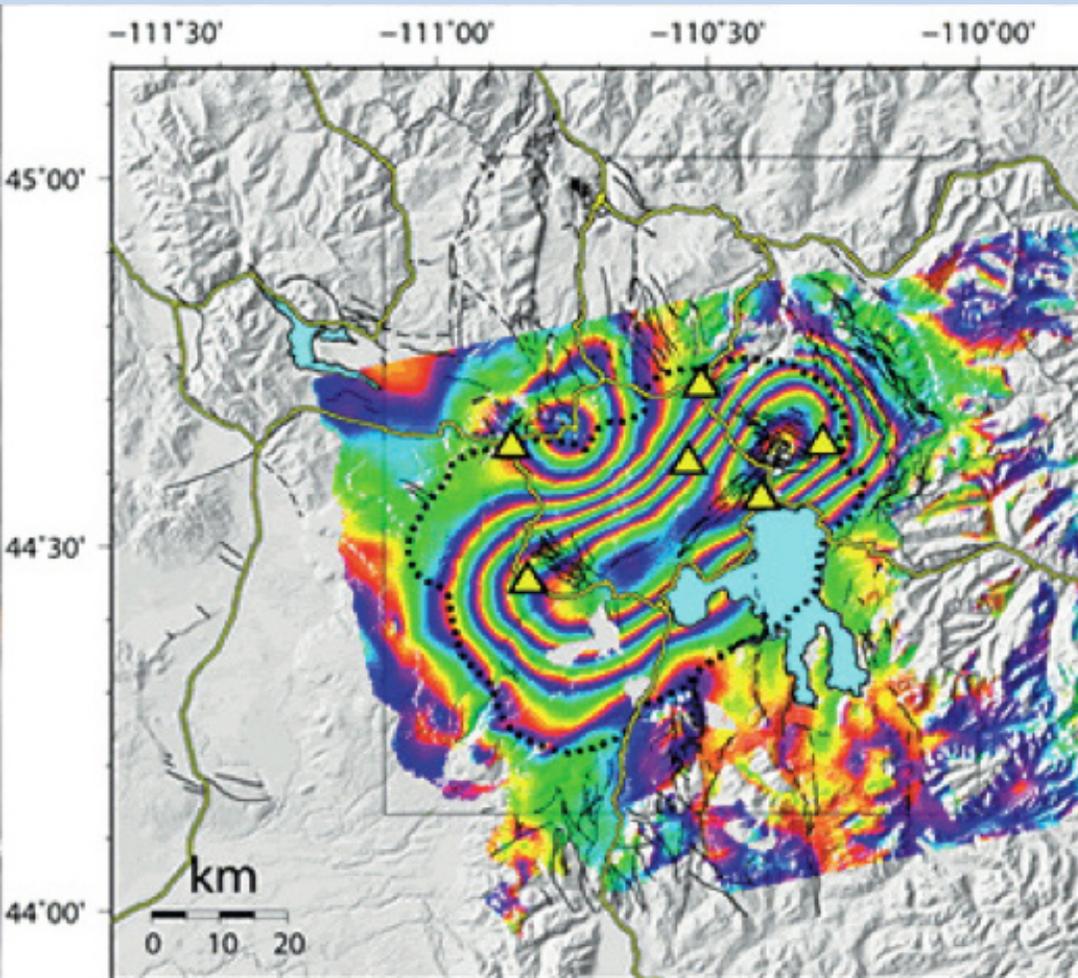


Figure 5 — Space-based InSAR image of Yellowstone National Park (Image source: USGS Volcano Hazards Program)

The system must be capable of accessing data that can be used to forecast volcanic eruptions before they occur. It must also be capable of confirming the occurrence of an eruption or its imminent onset.

For the hazard tracking requirements, the system must be capable of accessing data that can be used to track all hazards associated with volcanic activity.

For the general system requirements, the system must be capable of collecting, processing, storing and delivering data coming from different sources.

VIDA Design Framework

To address the gaps in the current technologies and existing systems, the **VAPOR** team is proposing the **VAPOR Integrated Data-sharing and Analysis (VIDA)** framework.

The VIDA framework will provide uniform storage and easy access to Earth observation data and information. Furthermore, VIDA provides uniform access to services that allow the end-user to process this data and advanced computing facilities for creating knowledge.

The aim of VIDA is not to develop new computing, storing or data providing facilities but rather to integrate existing Earth observation technologies, computing and storage facilities. *Figure 8* shows the architecture defined by the VIDA framework. The organizations shown in the figure are only examples and none of them were directly involved in the requirements definition.

VIDA is composed of three different layers: the interface layer, the access layer and the data and information layer. The interface layer contains the interface tools that are employed by end-users to interact with the

For the end-user requirements, the system must be capable of providing information to at least five classes of end-users: the aviation community, private citizens, emergency crews, authorities, and the scientific community.

The information provided to each end-user should allow them to plan, make decisions and take appropriate actions. End-user requirements have been written with respect to references and not yet in coordination with any specific end-user.

For the early warning requirements, the system must be capable of collecting and analyzing all types of data used to identify potential volcanic activity.



Figure 6 — Alaskan volcano eruption (Image source: USGS Volcano Hazards Program)

system. These can be web-based tools on web-enabled devices (e.g. desktops or mobile phones), tools for Geographic Information Systems, broadcast tools for early-warning, or other specific tools to interface with governmental organizations.

The access layer provides access to the services of the system and is responsible for creating the content that is sent to the end-users through the interface tools. This layer is composed of the content provider, the service provider and the notification server. The content provider creates the content requested by the end-user via an interface tool. One of the important features of the system is that it is able to select different degrees of detail and complexity of information, depending on the end-user's needs and technical skills. It allows many different end-users to access the information in an understandable way. The service provider implements the different functions provided by the system. This component coordinates access to the resources managed by the VIDA system. The notification server is responsible for providing notifications to users concerning specific set of events that are detected by the system.

The data and information layer contains the external systems and architectures that provide uniform input and that are integrated into the overall VIDA system. This layer standardizes and unifies specific data formats and specific access procedures for these other systems.

It is composed of the data provider, the knowledge provider, the storage provider and the computing provider. The data provider ensures uniform access to the external systems that provide raw data. The knowledge provider uses various mechanisms to create information and knowledge from the raw data. To do this, capabilities of other systems will be used as well. These mechanisms can be specific tools, methods or algorithms for data processing.

The computing provider and storage provider supply computing and storing facilities to the system and end-users. Similar to the previous components, they unify access to a set of infrastructures that provide these kinds of resources.

Alarms And Hazard Warnings

VIDA will provide an interface that can automatically trigger alarms when a hazard has been detected. Authorized users will specify the conditions of when an automatic alarm can be triggered. They will also be able to override the system to either cancel an alarm if one has already been triggered or issue an alarm if one has not yet been automatically triggered.

User Cases

VIDA shall be able to provide different levels of services and privileges to different user groups. *Table 3* shows a summary of these services for each of the different user groups.

Governance, Policy and Law

The VIDA framework would be set up by a consortium that initially could be publicly funded. This consortium would be comprised of government agencies and satellite companies that specialize in Earth observation, meteorology and hazard tracking. If a VIDA prototype is established, governance will fall to a private entity, which will be governed by a decision-making body called the

Days Before Activation of the Charter Following a Volcanic Event

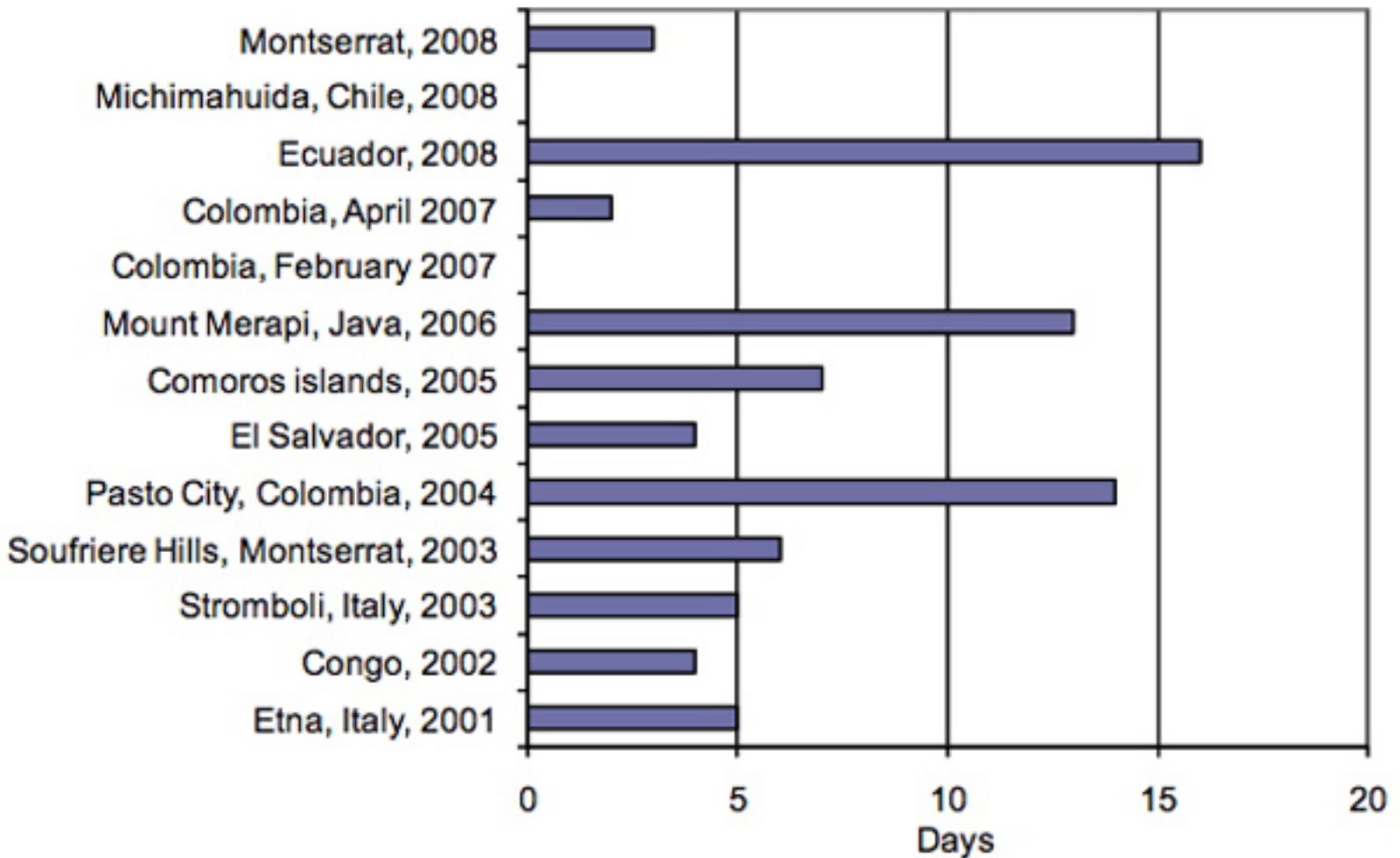


Figure 7 — Days before Charter activation (Data derived from the Charter reports)

Council. The Council would consist of volcanologists and remote sensing experts. Under the Council, a management team would oversee and operate the daily workings of the company.

Currently, VIDA is simply a framework, but in the future, VIDA could potentially participate in a later phase of the Global Earth Observation System of Systems (GEOSS) Pilot Architecture Project within the area of disaster risk management by registering the VIDA system as a GEOSS component and implementing the GEOSS system interoperability arrangement.

VIDA will be able to maintain its own governance structure since GEOSS itself does not have a hierarchical structural system. The success of implementing VIDA will depend on the amount of free data accessible from data providers. However, gaining free data may be complicated by data policies

and sharing restrictions of various nations. One issue that might prevent VIDA from functioning is “shutter control” when a government bars remote sensing of certain areas or dissemination of data derived from it. Restrictions in national remote sensing acts influence data flow between data producers and users.

Licensing schemes must be developed for VIDA to provide value-added services and disseminate processed information. Two types of licenses should be developed: one for the incoming data and data providers, and one for the outgoing information for system users.

Business And Financial Aspects

The major potential stakeholders were identified and their interests are shown in Table 4. The major strengths of VIDA are the rapid access to information, the data sharing capabilities, and the scalability. The major weaknesses are cost, size, and complexity. The most

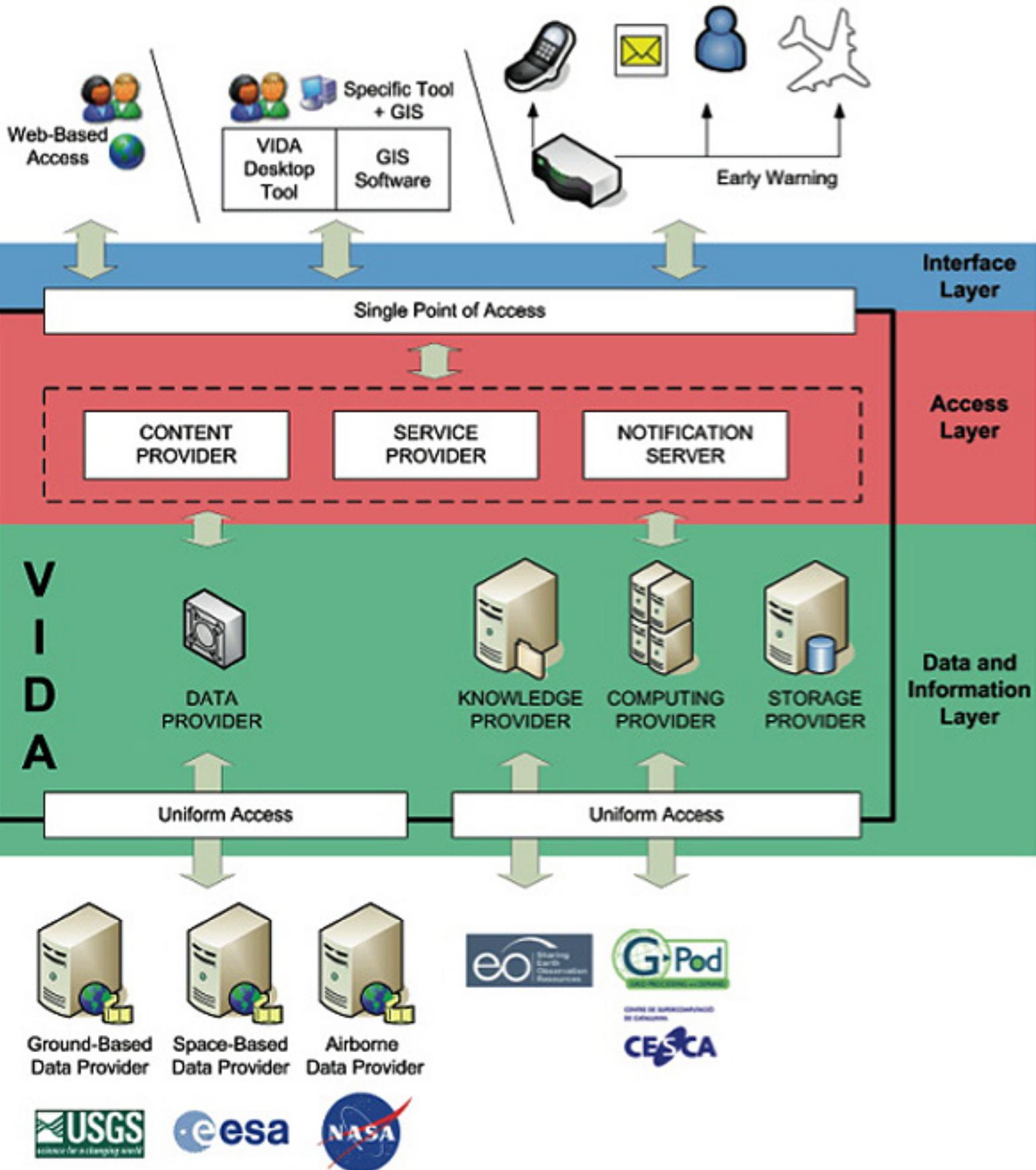


Figure 8 — Architecture defined by the VIDA Framework

	Local Communities and Tourists	Authorities	Emergency Crews	Aviation Community	Scientific and Educational Community
Passive (Only visualization)					
Access to Hazard Information	X	X	X	X	X
Access to Alarms	X	X	X	X	X
Access to Experts Information				X	X
Access to Experts Network					X
Access to Processing Capabilities					X
Active (those with inputting rights)					
Provide Hazard Warnings	X	X	X	X	X
Callbacks on specific monitoring information	X	X	X	X	X
Updating Database		X	X	X	X
Editing Recommendations				X	X
Activating Alarms				X	X
Defining Research Groups					X

Table 3 — Services provided to the different user groups

important opportunity is the potential for saving lives. The major threat is lack of funding.

The major risk was identified as the cost of VIDA and related lack or interruption of funding. This was mitigated by the framework's scalability. Access to data was identified as another significant risk. This was mitigated by accessing readily available free data. Having a false alarm was identified as the final major risk. This was mitigated by having human verification.

VIDA has been compared to *Google Earth*, *Global Earthquake Model*, and *GEOSS*. From this comparison, the start-up cost of VIDA was estimated to be approximately \$5-10 million US. It is expected that funding will come from one or more governments from developed nations that are willing to participate in an

international collaborative project. Once established, the project may have a source of funding and functionality within the GEOSS program.

Potential Benefits

The VIDA framework can improve the performance of a wide range of users including:

- » *The International Charter on Space and Major Disasters*
- » *International aid organizations such as the Red Cross/Red Crescent Movement*
- » *National and Regional Disaster Risk Management Agencies*

VIDA cannot change the framework by which the Charter is activated, but it can potentially speed up the activation

Stakeholders	Interests	How VIDA helps meet these interests
Civil Aviation	Security of people, cost reduction of aircraft assets	Faster access to ash plume information
Space Agencies	Ownership of assets, data providers	Decreased processing time of data through automation
Geosciences Unions, Academic communities, Volcano observatories	Scientific knowledge	Data integration from a wide variety of sources
UN, Governments	Security of people, economic growth	Information to decision makers enabling them to reduce loss of life in the time of a disaster
Remote sensing data processing companies	Business opportunities	Increased business opportunities for data distribution
Insurance Companies, World Bank	Cost estimation, claims verification	Contribution of dynamic data to risk assessment

Table 4 — Stakeholder analysis

process by providing those in decision-making positions with critical information.

By providing a centralized, user-friendly data warehouse of volcano monitoring information, VIDA would give disaster risk management agencies more time to warn the citizens of their countries of an impending eruption. After an eruption event, VIDA data would support the rescue and recovery effort by providing emergency workers with up-to-date information on conditions in the affected region. VIDA could increase the amount of lead-time that agencies have to notify their citizens of an impending hazard, thereby saving lives.

VIDA can also be used as an educational tool. The *United Nations Educational, Scientific, and Cultural Organization (UNESCO)* states that education and information systems will lay the basis for interdisciplinary platforms to manage disaster risks. The VIDA concept of data sharing related to volcanoes is in line with the UNESCO strategy as it will improve information search efficiency, permit the creation of a global knowledge database, and contribute to disaster preparedness and mitigation.

Conclusions

The methods used to characterize and eventually predict the behavior of a given volcano are very data intensive. This data can come in many different forms from an array of sources, sometimes after varying degrees of post-processing. In response to the need for a centralized, user-friendly repository of volcano monitoring data, the VIDA

framework has been defined. Within this framework, users from around the world will be allowed access to salient information from ground-based, air-borne and space-based assets and will be provided with data products that meet their individual needs.

Implementation Challenges

A major risk to successful implementation of the proposed framework is finding a continuous and reliable funding source. The system proposed by the VIDA framework would not be sustainable if, after an initial investment period, funding was lost and those relying on its products were left without assistance.



Photo courtesy of Ecuadorian Red Cross

Another substantial implementation challenge is that of governance. The proposed framework could bring substantial benefits to many organizations throughout the world. However, special attention must be paid to the management structure to ensure successful implementation of the system.

The other major challenge will be collection, standardization, and dissemination of the actual data products. Standardization will require particular attention because the goal set out by the VIDA framework is to provide users with easily-accessed, useful data. Also, proper data formatting must be considered a high priority in order to meet the users' need for timely information.

Future Work

As has been stated many times, VIDA is only a framework. Substantial work must be done in order for this concept to move from paper to reality but this work is feasible. User requirements have been collated in the full report of this project; a further interactive requirements consolidation process is needed in order to establish the baseline system requirements specification. This has fallen outside the scope of the present project. In order to move the VIDA framework to a formal definition phase, the system requirements must be verified by those who will interact with the system.

Numerous tools have been developed to support the education of populations around the world who are

at risk of being affected by natural phenomena such as volcanoes and VIDA could be one such tool. Additional work should be done to develop a web-portal or some other form of mass data distribution by which larger communities can benefit from the products.

About ISU + The Report

This summary and the associated *Final Report* were products of 40 graduate students and young professionals from 15 countries attending the International Space University (ISU) Space Studies Program (SSP) in Barcelona, Spain. The team members included:

Angela ARAGÓN ANGEL
| Oriol BADIA SOLÉ |

Nicola BESSONE | Chris BLAKE |
Daniela CIAMBOTTINI | Karine DIONNE
| Catherine DOLDIRINA | Dohy FAIED
| Yasunori FURUKAWA | Christophe
GIOVANNINI | Francesc GUIM BERNAT
| Heather HENRY | Lynne HOUNSLOW |
Ofer LAPID | Nimal NAVARATHINAM |
Egemen ÖZALP | Saori OZAWA | Assaf
PEER | Laurie PETERSON | Nghi PHAN |
M.R. RAGHAVENDRA | Les RICHARDS |
Aurora SÁNCHEZ FERNÁNDEZ | Sumitesh
SARKAR | Kartheephan SATHIYANATHAN
| Hansdieter SCHWEIGER | Marc SILICANI |
Marla SMITHWICK | Matthew SORGENFREI
| Dani TARRAGÓ MUNTE | Irina THALER
| Diego URBINA | Jeremy WEBB | Luise
WEBER-STEINHAUS | Zongkang WEI
| Jaisha WRAY | Mark WYLIE | Kosuke
YANAI | Lixin YU | Manuel ZAERA-SANZ

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The Chair for the project: Dr. Ed Chester, whose professional background includes ground segment systems architect and integration and test engineer at ESA-ESOC (Germany) for the Herschel and Planck missions, flight operations team member at ESOC (Germany), flight operations and system management for the Beagle-2 Mars lander (UK), I.T. management (UK) and instrumentation/embedded system

design (UK). He is interested in data systems, payload operations, system design, design methods, and operational research. He holds a Bachelor degree in Physics, a Masters degree in Electronics, and a Ph.D. in computer architecture. He attended the International Space University Space Studies Program in 2002, was a lecturer in 2003, Teaching Associate in 2006, Project Chair in 2008, and has been Faculty of ISU since the start of 2009. He is Professor of Space Systems Design at the School of Aeronautics and Industrial Engineering at the Technical University of Catalonia. Ed is currently Head of R&D at CTAE.

Copies of the Report and project CDs may be ordered from the International Space University Central Campus and can also be found on the ISU Web site. Ordering information, order form and electronic files may be found on the ISU web site at <http://www.isunet.edu>.

VAPOR UPDATE... the main activity since this original report includes participation, discussion and promotion at different conferences and workshops. Additionally, a subgroup has been working on the specific

system design for the integration and processing facility that could work on large scale models and data sets. The development of the ideas that emerged during the VAPOR project has continued with a smaller team, who have been hard at work on the challenges of data fusion and integration with global information sources from ground, air, and space.



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Executive Spotlight

Mark Brender

Vice President, Communications, GeoEye

Mr. Brender joined GeoEye in January of 2006 after eight years at Space Imaging as their vice president of Communications and Washington operations. He has more than 25 years of experience in public affairs, broadcast journalism and government relations and is responsible for all communications and marketing. In 2007, GeoEye established its GeoEye Foundation, and Mr. Brender serves as its first Executive Director. In 1998, prior to joining Space Imaging, Mr. Brender was a broadcast journalist for ABC News, spending 16 years at the network as an assignment editor and editorial producer. Before ABC, he served in the U.S. Navy as a public affairs officer and is a retired Naval Reserve commander. Mr. Brender began writing and speaking about high resolution commercial Earth observation as early as 1985 when he established the Radio and Television News Directors Association (RTNDA) Remote Sensing Task Force. The Task Force helped clear the way for high-resolution imagery to move from the defense and intelligence sector to the commercial sector.





SatMagazine (SM)

Mark, how long have you been with GeoEye? What do you think has been your greatest achievement while being a part of the GeoEye team, both for you personally and for the company? What caused you to transition from your previous position to GeoEye? What is it about GeoEye that truly excites you?

Mark Brender

I've been with GeoEye and its predecessor company for 12 years and have over 25 years of experience in public affairs, broadcast journalism and government relations. As GeoEye's vice president of communications, I am responsible for increasing brand awareness, upholding our reputation and managing media relations.

In terms of why GeoEye excites me, let me tell you this: in 1968, the Apollo astronauts took a photo of the Earth suspended in the darkness of space with the moonscape in the foreground. It was the first time humankind was able to see the planet in this way. I believe this single

photo was responsible — in part — for launching the environmental movements of the 70s and 80s. The picture showed how fragile the Earth looked. Now, commercial remote sensing technologies are enabling us to look at Earth in much more detail — we now have the tools to map, monitor and measure our impact on the planet in a very precise manner. Scientists say 30 percent of the world's GDP is affected by our knowledge of what's going on in the environment, so any technology that helps us in this regard will bring value. I left ABC News in 1998 to be part of this growing industry because, as a network television producer, I recognized the value of the visual.

I think my greatest personal achievement is bringing my 16 years with ABC — in a variety of editorial roles, most recently as the Pentagon producer — to the GeoEye table. I had direct insight into the mechanics of the military public affairs hierarchy, so I understood the media's need for accurate and compelling imagery to tell their stories. I also served in the U.S. Naval reserve retiring as a Commander. It's hard to believe that in 1985, I established the Radio and



Executive Spotlight

Television News Directors Association “Remote Sensing Task Force” to clear the way for high-resolution imagery to move into the commercial sector. For a quarter of a century, I’ve been thinking about the migration of high-resolution satellite imagery from the world of intelligence to the world of commerce. I understand the vital role our imagery serves across many institutions in both government and business. Open skies and transparency help our customers make better decisions using a technology that was once only in the hands of those who had high security clearances.

SM

Could you provide a brief background on the company’s origins and its timeline so far?

Mark Brender

GeoEye was formed in January 2006, when Virginia-based ORBIMAGE purchased the assets of Colorado-based Space Imaging. In March 2007, GeoEye acquired MJ Harden, which enabled us to expand our offerings to include aerial imagery and specialized geospatial processing services.

Today we sell high-resolution satellite imagery, geospatial information products, image processing services and web-based dissemination and content-management services. Our products and services support defense and intelligence, online mapping, environmental and asset monitoring, infrastructure planning and management, disaster preparedness and emergency response. We provide these services through our constellation of satellites, including the world’s highest-resolution satellite, GeoEye-1, which provides the highest quality and most accurate satellite imagery available. We anticipate launching a next generation system, GeoEye-2, in the 2012-2013 timeframe, to provide our customers with ongoing access to imagery.

SM

Why are Earth observation and imagery so important to the commercial and military / government environments?

Mark Brender

High-resolution Earth-imaging satellites provide a baseline foundation for making

maps. Since 2300 BC, when humankind first etched the lay of the land on clay tablets, people have made maps. Commercial Earth-imaging satellites, such as GeoEye-1, are basically mapping machines in orbit that provide the “ultimate high shot” as well as the metric accuracy embedded in the imagery to make precise and up-to-date maps and render high-quality images. Being able to locate yourself on the Earth using GPS is half the problem; seeing where you are is the other. And GeoEye’s products help you do both.

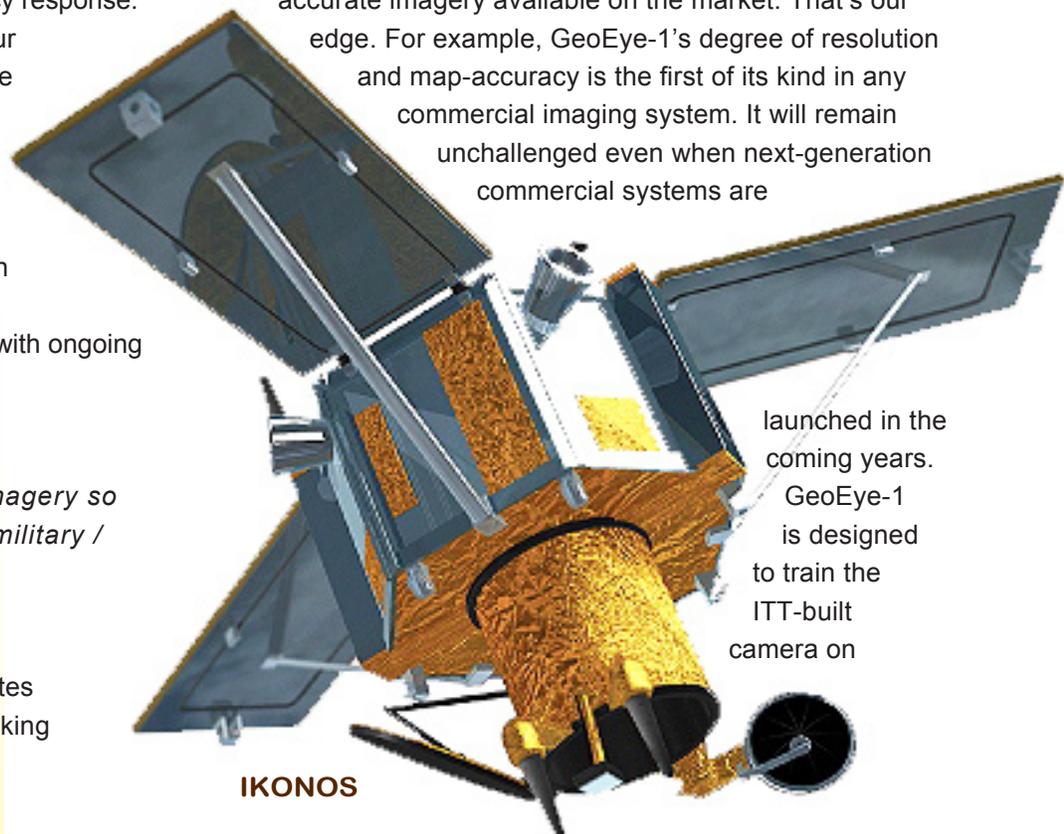
In addition to unsurpassed spatial resolution or the ability to see fine details on the Earth’s surface, our satellites offer customers the best in geolocation accuracy. GeoEye-1 can see an object on the ground 16 inches in size, but, most importantly, map the location of an object that size to within a few meters of its true location on the planet. And that’s hugely critical to both our commercial and our government customers.

SM

How does GeoEye plan on competing in the Earth imagery business against domestic and foreign firms? What makes GeoEye more responsive to imagery requests? How long does it take to retask GeoEye-1 or IKONOS to accommodate those requests?

Mark Brender

We offer our customers the highest resolution and most accurate imagery available on the market. That’s our edge. For example, GeoEye-1’s degree of resolution and map-accuracy is the first of its kind in any commercial imaging system. It will remain unchallenged even when next-generation commercial systems are



launched in the coming years. GeoEye-1 is designed to train the ITT-built camera on

IKONOS

multiple targets during a single orbital pass, and it is able to rotate or swivel forward, backward or side-to-side with robotic precision. So we'll compete on imagery quality and responsiveness to meet our customers' requirements. Feedback from customer service surveys — most recently in May 2010 — tells us that we are meeting their expectations. Ninety-two percent of the respondents said they would recommend GeoEye's products to other professionals.

In addition, we can quickly re-task the satellite to meet the emergency requirements of our customers. When an earthquake struck Haiti in January, for example, we were able to collect 3,000 square kilometers of imagery in and

around Port-au-Prince and have that imagery available to key customers within 12 hours of the earthquake. We have collected tens of thousands of square kilometers of imagery over the Gulf of Mexico and the U.S. shoreline to support efforts to map and monitor the changes that may take place from the oil spill. As of June 1, we've collected almost 80,000 sq km of imagery over the Gulf coast shoreline as well as areas over oil-tainted water.

Many of our competitors lie overseas as more and more governments and commercial companies launch increasingly higher-resolution systems. More than a dozen countries are operating imaging satellites of various types, and increasingly more and more

Executive Spotlight

countries and businesses are seeing the value of using geospatial technologies and satellite imagery in making important decisions. We believe competition is good over the long run; it's good for both our business and that of the industry as a whole, and we know our government likes to have companies that compete since there is no monopoly.

SM

How will GeoEye-2 be different from GeoEye-1? Will it be a game-changer for the industry?

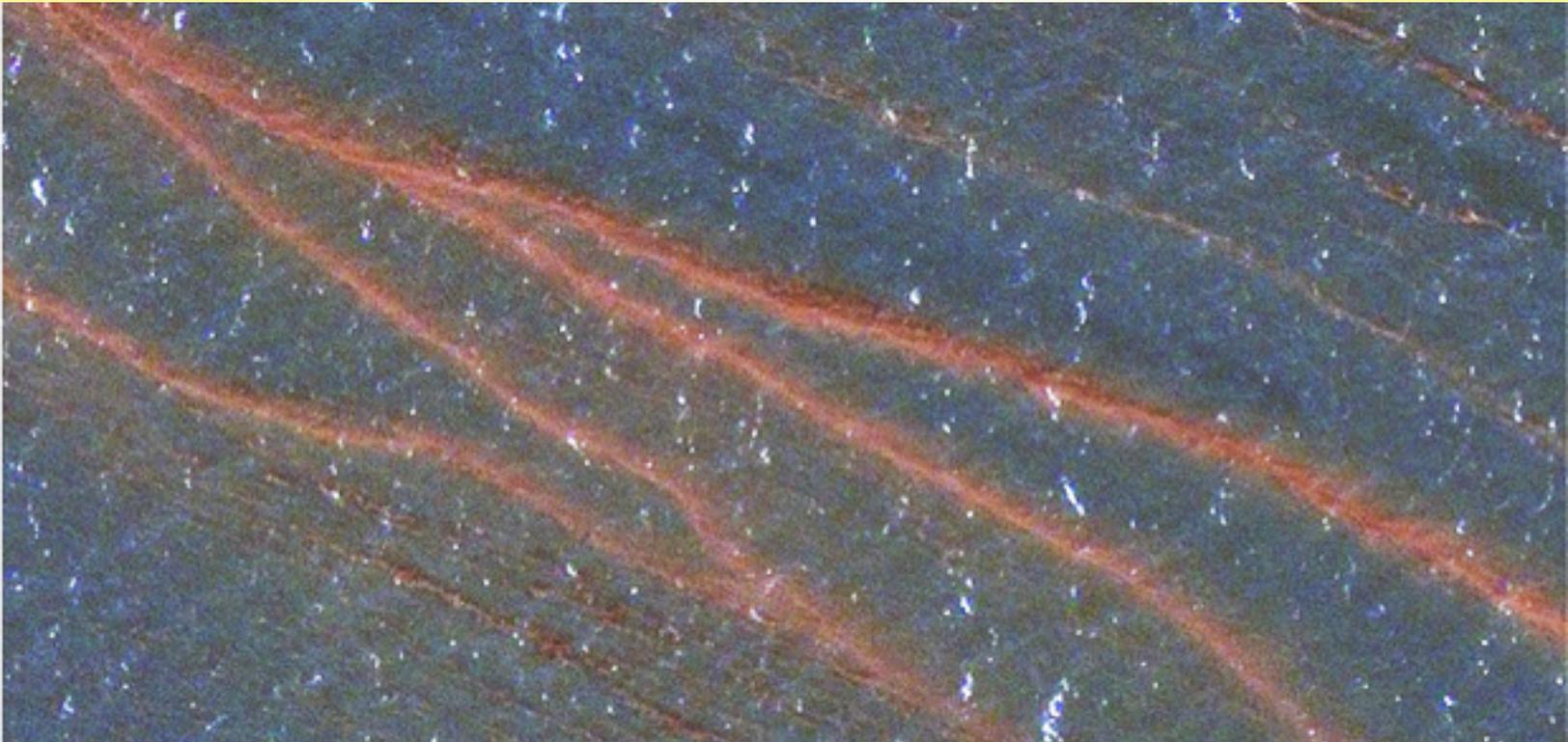
Mark Brender

GeoEye-2 will be the same class of satellite as GeoEye-1, but it will benefit from significant improvements in capabilities to better serve our customers' demands for increased imagery at higher resolution. Some of these improvements include enhanced tasking capabilities and the ability to collect more imagery at a faster rate.

The resolution of the satellite, which will be much higher, was achieved by drawing on the optical and digital camera expertise of ITT. ITT's engineers were able

SATELLITE FEATURE	GEOEYE-1	IKONOS
Resolution	.50-meter	1-meter
Spectral range (pan)	450-800 nm	526-929 nm
Blue	450-510 nm	445-516 nm
Green	510-580 nm	505-595 nm
Red	655-690 nm	632-698 nm
Near IR	780-920 nm	757-853 nm
Pan Resolution at nadir	.41 meters	.82 meters
Pan Resolution at 60 elevation	.50-meters	1.0 meter
Multi-spectral Resolution at nadir	1.64 meters	3.28 meters
Swath width at nadir	15.2 km	11.3 km
Launch date	06-Sep-08	24-Sep-99
Life Cycle	7 years	Over 8.5 years
Revisit Time	3 days at 40° latitude with elevation > 60°	3 days at 40° latitude with elevation > 60°
Orbital Altitude	681 km	681 km
Nodal Crossing	10:30 AM	10:30 AM
Approximate Archive size (km ²)	View Archive	View Archive

GeoEye-1 and IKONOS Feature Comparison



This half-meter resolution satellite image features a portion of the oil slick in the Gulf of Mexico. Streaks of oil blown by wind and currents can easily be seen against the darker colored water. This image was taken by the GeoEye-1 satellite from 423 miles in space on April 29, 2010, as it moved from north to south over the United States at a speed of four miles per second.

to change the “optical prescription” of the telescope, meaning we’ll be able to collect imagery with quarter-meter ground resolution. A final determination on resolution will be made when we know if we win a new satellite imagery contract from the U.S. government. This contract will determine altitude which will ultimately determine ground resolution.

SM

What instruments will be aboard the GeoEye-2 satellite? What are the purposes of each of these crucial instruments?

Mark Brender

Lockheed Martin Space Systems Company is building GeoEye-2, and we’ve spent a little more than \$100 million on the camera, camera electronics and satellite design work over the last few years. Both ITT and Lockheed have a long heritage in building imaging systems for the U.S. government, and we’re taking advantage of that brain trust. The launch could be as early as late 2012, depending on the outcome of the EnhancedView contracting process with the U.S. government.

SM

Why did GeoEye ultimately select Lockheed Martin as the contractor for GeoEye-2?

Mark Brender

Lockheed built IKONOS, which we launched from Vandenberg Air Force Base in California on September 24, 1999. It was the world’s first high-resolution, commercial Earth-imaging satellite. Lockheed has a long history of building and launching high-resolution satellites for the U.S. government, and this new contract will continue to capitalize on that distinguished legacy.

Our decision to select Lockheed Martin for our third-generation imaging satellite was based on the extremely challenging performance requirements we’ve specified for GeoEye-2. We concluded that Lockheed has a flight-proven history of designing, building and operating highly sophisticated and complex satellites. We understand that there’s a premium on the knowledge and experience that go into such systems, and we found Lockheed’s 50-year heritage of design, development and operation expertise to be compelling and convincing enough to team with them for GeoEye-2.

SM

What is the difference between Geo, GeoProfessional, and GeoStereo?

Mark Brender

Geo forms the foundation of the GeoEye imagery product line, and is a radiometrically-corrected, map-oriented image suitable for a wide range of uses. What this means is that, in addition to being useful for visualization and monitoring applications, Geo is shipped with the sensor camera model. It allows skilled users to make their own orthorectified products using standard commercial software and available data sets. Geo imagery products are available in black-and-white or in color.

GeoProfessional products, on the other hand, are orthorectified or terrain-corrected by our staff of experienced production personnel using proprietary processes perfected in our production facilities. The orthorectification process enables us to quickly deliver the most accurate and precise terrain-corrected multispectral products available. These products are suitable for feature extraction, change detection, base mapping and other similar applications.

Finally, our most advanced imagery product, GeoStereo, provides a strong base for three-dimensional feature recognition, extraction and exploitation. It processes two images with stereo geometry to support a wide range of stereo imagery applications, including creating terrain maps, building height extraction, spatial layers and three-dimensional feature extraction. More and more, people are ordering stereo imagery.

SM

What's the latest news for the company? Anything exciting going on recently? Is GeoEye involved in capturing imagery for subject matter expert analysis of the Icelandic volcano and Gulf oil spill?

Mark Brender

Actually, in early April, GeoEye was awarded a contract through the National Geospatial-Intelligence Agency (NGA). The contract is for a new web-mapping service, which provides for rapid delivery to the Department of Defense of near real-time, high-resolution GeoEye-1 satellite imagery of an entire country. We're thrilled to offer the NGA this new integrated service under their RDOG program, which stands for Rapid Dissemination of Online GEOINT.

The best part about this integrated service is that it combines image collection, production and delivery and follows Open Geospatial Consortium compliance standards for geospatial and location-based information and web-mapping services, all through a cutting-edge platform. U.S. military personnel, intelligence community personnel and DoD map production staff have easy access to online, on-demand, geospatial intelligence, so it's a great example of how GeoEye really is on the cutting edge of an industry that's rapidly moving forward.

What's more, we're working on a very similar program for our commercial customers. As our CEO Matt O'Connell likes to say, "It's not just about the pixel anymore, but what you can do with it." We're finding that our customers want the most accurate and highest-resolution imagery, and they want easy access to it over the web. So in addition to our government work, we're currently developing new online tools that will make imagery more accessible to our commercial customers as well.

Since GeoEye-1 became operational one year ago in February, it has collected almost 130 million square kilometers of imagery. IKONOS has collected much more area because it has been operational since 2000. IKONOS was able to capture imagery of the Eyjafjallajokull Volcano in Iceland on April 17. The imagery displayed the plume of ash erupting from the volcano. (*see this issue's cover image*)

SM

Changing subjects, tell us about the NGA's EnhancedView project. What's the plan if you win it?

Mark Brender

The EnhancedView contract is one part of a larger satellite imagery strategy announced by the Director of National Intelligence in April 2009. It will serve the U.S. military and intelligence communities. Under the plan, the government would modernize the nation's satellite imagery architecture by evolving government-owned satellite designs and enhancing the use of U.S. commercial providers, such as GeoEye. The EnhancedView part of this program would allow commercial imagery providers to continue to supply the U.S. Government with unclassified, highly accurate, satellite imagery. The competition for the contract was open to all U.S. aerospace companies, and we anticipate the NGA EnhancedView award announcement in the next few months.

Executive Spotlight

If GeoEye wins the contract, we'll obviously be thrilled. As a company, we take great pride in the fact that we've been a full-mission partner with the NGA for more than 20 years. This is a natural extension of the work we've already done with them. As I mentioned, we've made considerable progress on building the GeoEye-2 satellite, and winning this contract will allow us to move forward aggressively in that regard.

SM

As an industry, how do you see geospatial information moving forward? Broadly speaking, what are some of GeoEye's future plans?

Mark Brender

I'm extremely excited about the industry heading into the future, and for what GeoEye's role will be. In addition, our significant government contracts and robust presence in the commercial geospatial arena, one thing that GeoEye does exceptionally well is work in the non-profit and research-based areas, which we see as an area for growth.

The GeoEye Foundation, for example, is GeoEye's non-profit arm. Its mission is to foster the growth of the next generation of geospatial technology professionals. The Foundation provides satellite imagery to students and faculty at educational institutions to advance research in geographic information systems and environmental studies, and it offers imagery to non-governmental institutions to support their humanitarian support missions.

The Foundation supports a new generation of innovative and diverse users who apply geospatial technology to meet local, national and global challenges. So far, the Foundation has approved more than 100 imagery requests totaling almost 100,000 square kilometers. This is a great example of where I see the industry going as a whole — helping to solve the great problems of our time.



A Case In Point

Accelerating Maritime Research



The R/V New Horizon at sea off central California, summer 2009 — photo courtesy of Scripps Institution of Oceanography

Scripps Institution of Oceanography at University of California, San Diego, is one of the oldest, largest and most important centers for global science research and education in the world.



R/V Roger Revelle, southern ocean 2008. Photo credit: Brett Longworth

Now in its second century of discovery, the scientific scope of the institution has grown to include biological, physical, chemical, geological, geophysical and atmospheric studies of the Earth as a system. The institution has a staff of about 1,300 and annual expenditures of approximately \$155 million from federal, state and private sources.

Challenge

Scripps Institution of Oceanography operates four oceanographic research ships, one research platform for worldwide exploration, and forms part of the **HiSeasNet** satellite network, a dedicated network providing connectivity, basic communications services and real-time education applications for oceanographic research across the **University- National Oceanographic Laboratory System** fleet.

Each ship is equipped with satellite communications systems, which are essential in order for shore-based staff to provide support to on-board scientific colleagues. However, satellite bandwidth covering the world's oceans is not only limited in terms of data capacity, it is also extremely expensive.

Steve Foley is a network engineer at the **Institute of Geophysics and Planetary Physics** at **Scripps**: "Our research vessels need to squeeze every bit of bandwidth out of those fixed satellite links. The more data we can send home, the better. The more satellite images, phone calls, support, etc. that the scientists on the ship can get from shore, the better they can do their science."

Foley had initially been skeptical about the implementation of bandwidth acceleration, on the basis of his investigation of a **Mentat** (now **Packeteer**) solution which had been proposed for the shipboard systems early on. "Satellite communications are notoriously problematic for bandwidth acceleration, and we'd resigned ourselves to sufficing with what we had. It was a case of 'if only network accelerators weren't so ineffective over satellite links.' Then we found Expand."

Solution

Foley looked to re-address the bandwidth issue by evaluating **Expand Accelerators**. "We looked at Expand, and also at others," recalled *Foley*. "By the time the project was far enough along to actually start demoing hardware, we lined up our needs and found that Expand

"With the savings in bandwidth our Expand Accelerators are paying for themselves within nine to 18 months... And will continue their benefits far beyond that."

*Steve Foley,
Network Engineer,
Institute of
Geophysics
and Planetary
Physics at Scripps
Institution of
Oceanography, UC
San Diego*

was the only one that had the features geared towards making our low-bandwidth satellites useful. Our issues aren't about running CIFS across our high delay links, but we really care about things like UDP acceleration, SCPS, and auto fragmentation."

With the unique ability to bolster performance of satellite links, even in the most extreme and remote environments, **Expand** has been optimizing a broad range of afloat environments across the world's largest shipping, naval and maritime organizations since 2001.

Foley continues, "We were really impressed when Expand didn't look at us funny when we said we wanted to put their gear on ships! To them it was the norm, having had many years of experience accelerating maritime environments like ours."

Expand's WAN optimization technology, with integrated **Space Communication Protocol Standard (SCPS)** and TCP acceleration, mitigates the effect of low bandwidth and high latency obstacles that traditionally impede the speed and performance of applications over satellite links.

Combining SCPS with compression, byte-level caching and layer 7 QoS, Expand's technology enables available bandwidth and real-time interactive TCP traffic to be maximized, extending Scripps' existing

A Case In Point



R/V Melville

network infrastructure investments and providing 'virtual bandwidth' capacity to users.

Initial roll-out was accomplished smoothly on the two initial platforms, Scripps' research vessel *Roger Revelle* and the **Woods Hole Oceanographic Institution's** research vessel. Since then, additional devices have proved themselves to be truly 'plug and play'. "Non-IT folks have been receiving Accelerators straight from Expand, popping them in the ship's equipment racks, setting IP addresses, then walking away while we do the rest remotely. The amount of management control we have from shore is very impressive."

Benefits

Scripps is now able to pass substantially more data across its fixed bandwidth satellite links, which in some cases cannot exceed 64Kbps. This in turn requires Scripps to spend less money on satellite space segment leases than they otherwise would. "Bandwidth is costly," stated *Foley*.

"With the savings in bandwidth our Expand Accelerators are paying for themselves within nine to 18 months, depending on the type of satellite service used, and will continue their benefits far beyond that. We estimate we are saving over \$600 per month for each of our large global ships."

In terms of other advantages, *Foley* believes the Expand Accelerators have brought about an unexpected one: peace and quiet. "So far, I haven't received much feedback from the ships. No news is good news, I think. However, I'm sure I'll hear something once they figure out just how fast their bandwidth links are now."

"If we bring more ships into the network, we will continue to consider accelerators as part of the standard equipment set. Beyond that, we are always looking at other projects that may benefit from the technology."

For more information regarding Expand's WAN optimization and other solutions, select the following link...

<http://www.expand.com/Products/products.aspx?URL=ProductsOverview>



R/V Robert Gordon Sproul

Event

Product Uplink

DigitalGlobe's Crisis Event Service

Effective emergency planning and response requires quick and easy access to accurate and up-to date information. DigitalGlobe's online Crisis Event Service provides fast web-based access to pre- and post-event imagery of world disasters for emergency planning, risk assessment, monitoring staging areas and emergency response, damage assessment and recovery.



This is a natural color, 50 centimeter high-resolution DigitalGlobe satellite image featuring the oil spill and associated clean up after an explosion at the Transocean Deepwater Horizon Drilling Slick in the Gulf of Mexico.

QuickBird

When a major disaster is identified, DigitalGlobe's satellite constellation acquires timely post-event imagery of affected areas within 1 to 3 days. DigitalGlobe defines disaster events based on information from the *International Charter of Space and Major Disasters* as well as their own assessment.

For each event, DigitalGlobe will attempt to add at least 3 imagery versions of affected areas to the web service for a more complete story: the latest pre-event image from their ImageLibrary archive, any imagery taken during or just after the event, and an additional follow up image up to 30 days after the incident.

Online Delivery

Organizations can connect to the service in the way that best meets their needs. There are the DigitalGlobe web plug-ins for GIS software, a WMS service, or API's and SDK's for custom map server and Java applications.

Benefits

- » ***Improved Efficiency — Quickly identify high risk areas, monitor the nature and extent of damage, plan access and evacuation routes, and manage recovery and claims efforts. Spend less time and resources managing imagery of impacted areas.***

- » ***Worldwide Reach — World events are constantly monitored so they may be imaged as they occur. The DigitalGlobe satellite constellation helps to ensure that no corner in the world is too far out of a client's needed range.***
- » ***Connect Seamlessly — Connect through a suite of web services that sync directly with desktop and enterprise applications for fast, seamless access.***

Product Uplink

- » **Historical Context** — *More fully understand the extent of damage with images taken both before and after an event. View the most recent pre-event imagery from the offered ImageLibrary as well as new post-event coverage.*

Subscriptions

Flexible enterprise and per-user subscriptions are available, depending on duration and the regions required. This service is not available for free public distribution.

Delivery Method

Distribution and use of imagery at better than .50 m GSD pan and 2.0 m GSD multispectral is subject to prior approval by the U.S. Government.

Some of the industries that could benefit from the Crisis Event Service include...

- » **Insurance and Reinsurance**
- » **Local and Central Governments**
- » **Defense and Homeland Security**
- » **Safety Agencies: Police, Fire, Forest Services, and so on.**
- » **Multinational and Humanitarian Agencies**

A More Informed Response

An example of the service... when a devastating earthquake struck L'Aquila, Italy in April of 2009, DigitalGlobe chronicled the damage and subsequent response efforts (*see the sidebar*).



Left — QuickBird; Center — WorldView-1; Right — WorldView-2



Before: Bell tower in central L'Aquila



After: Bell tower collapsed
Collected April 8, 2009



Response: Relief shelters constructed in the days following the quake



Executive Spotlight

Paul Brooks

Director, Earth Observation & Science, SSTL

An Oxford scholar, Paul joined the UK's Defence Research Agency in 1991 (known as QinetiQ since privatization in 2001), to work on space-based surveillance remote sensing systems, going on to lead the innovative TopSat mission and supporting the launch and operations of four communication satellites.

Joining SSTL in 2006, Paul has managed a team of project managers at SSTL working on a diverse range of missions and studies. In his new role Paul will lead his team in developing business opportunities for SSTL's small satellites, including entry-level geostationary and affordable interplanetary missions.





SatMagazine (SM)

Mr. Brooks, as a youngster, did you always have a desire to become involved in the space industry? If so, how did you prepare yourself for such a career, given the disciplines necessary for success?

Paul Brooks

Like many children I dreamed of being an astronaut and was fascinated by the Viking, Skylab, and other space missions as well as taking up astronomy. Fortunately this interest was matched by an affinity for math and physics, so from the age of 11 on I was pretty well focussed on a physical science future. To actually work in space seemed a little fanciful, so I looked to gain qualifications as a physicist and astronomer. This included attending lectures by Sir *Martin Sweeting* when he was “only” a lecturer at Surrey University, so my links with SSTL go back some way.

SM

After your studies at Oxford University, you joined the United Kingdom’s Defence Research Agency... what role did you play at the agency and how did such prompt your ongoing career in the space/imagery industry?

Paul Brooks

I initially worked on optical remote sensing missions and attitude control systems, working on the designs and equipment and the applications of optical remote sensing as well as working on the launch and operation of four Skynet communication satellites. These early years being closely involved with real kit and applications were critical as they laid the basis for all my subsequent activities. When selling spacecraft or leading the business activities, you tend to attract a reasonable amount of cynicism from the engineers who need to deliver the promise, so it’s critical that you understand the pain and difficulty of actually making things work in orbit.



SM

In 2001, the agency was privatized and became QinetiQ...did that alter the goals of the agency in a positive manner? How did such changes affect your projects?

Paul Brooks

It was a very positive change for me and many other people in the organization as it gave a commercial focus to the activities we were undertaking. By commercial I don't just mean making profit, but rather ensuring that what we do generates value to the customer. This

is a key feature that I have tried to continue and spread in my later work — everything we do must provide a measurable value to the customer. The easiest metric is return on investment in terms of money but I believe that all projects should be clear on how they generate value and how that compares with the cost to the customer, even if the project is for a military, scientific, or exploration objective.

For all of our undertakings in SSTL we develop a "Value Metric" — a simple, numerical statement of why what we are offering is good value to the customer.

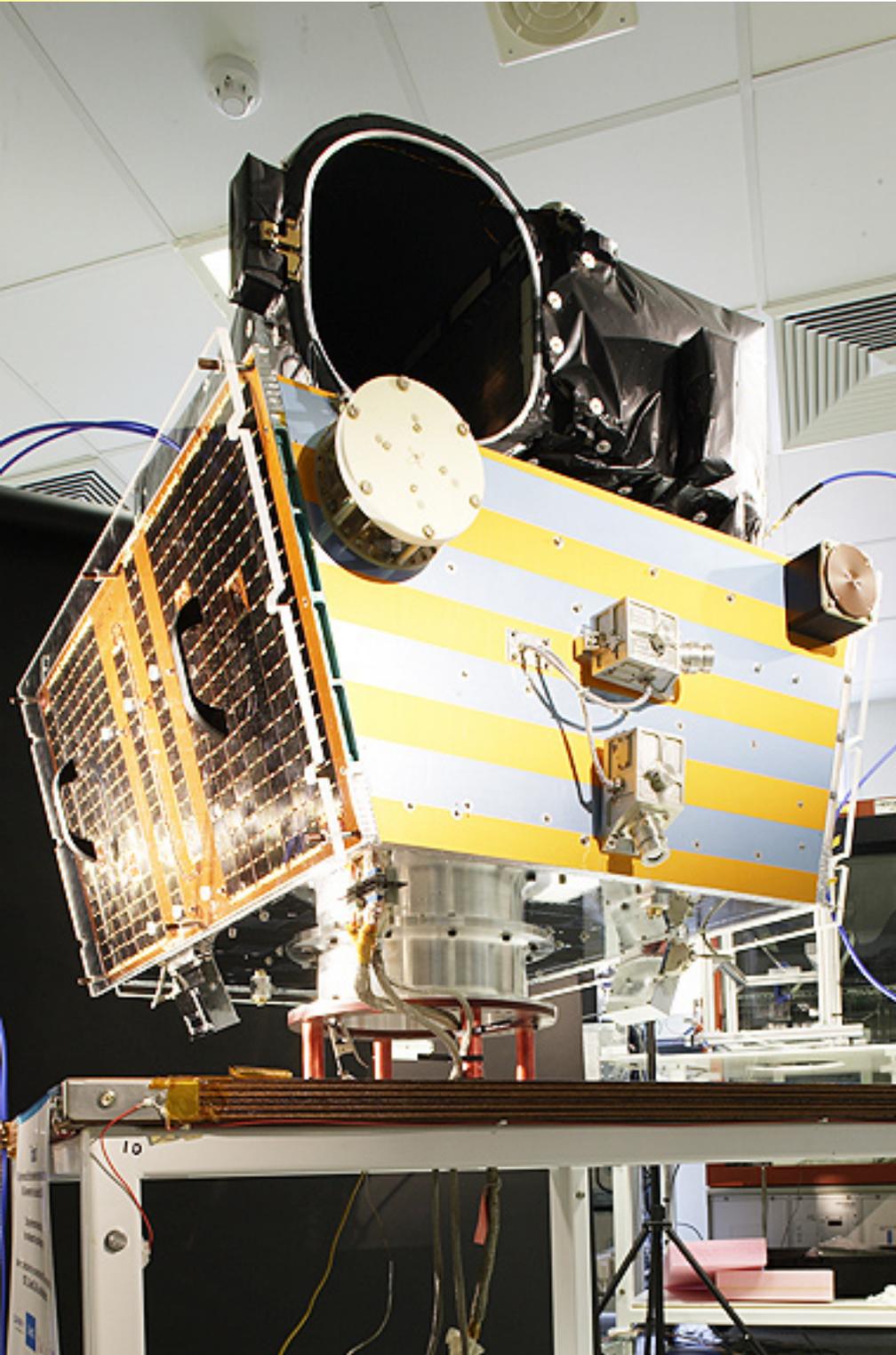
SM

As an instigator of the TopSat satellite mission during your time at QinetiQ, what has been learned about the use of small satellites for security and surveillance missions?

Paul Brooks

TopSat and SSTL's DMC mission were very important as they demonstrated that small, affordable satellites could deliver high resolution imagery at very low cost from Low Earth Orbit. TopSat was developed at the time when the only high resolution satellite in the civil domain was Ikonos. Given that the total cost of TopSat was ~£13M (including launch), and that Ikonos benefited from some \$760M of investment, there was a lot of skepticism that a small satellite could undertake a valuable Earth Observation role.

SSTL had already demonstrated that small satellites provided genuine



TopSat

Executive Spotlight

operational utility and TopSat and DMC demonstrated that this utility was not only of value but of better value (in terms of return on investment) than many large satellites, a case that has been demonstrated by our satellites since then, notably DMC2, Deimos and RapidEye, all of which have been built on the basis of a commercial business case.

TopSat was launched in 2005, and as you would expect since this time our technology has developed a great deal. In fact, we can now offer half meter color imagery at under \$0.20 per sq km! This is possible through ART, a space asset conceived by SSTL that offers a high-accuracy, low-cost optical mapping system ideally suited to providing the fresh, complete and high-quality coverage required for today's location-based services market — and at a price that enables a substantive return on investment. We can be confident that ART can deliver such attractive results as it is so solidly based on the spacecraft we have already launched. This “Heritage

design” philosophy is one of the fundamental reasons for SSTL's success. (See ART diagram on the next page.)

SM

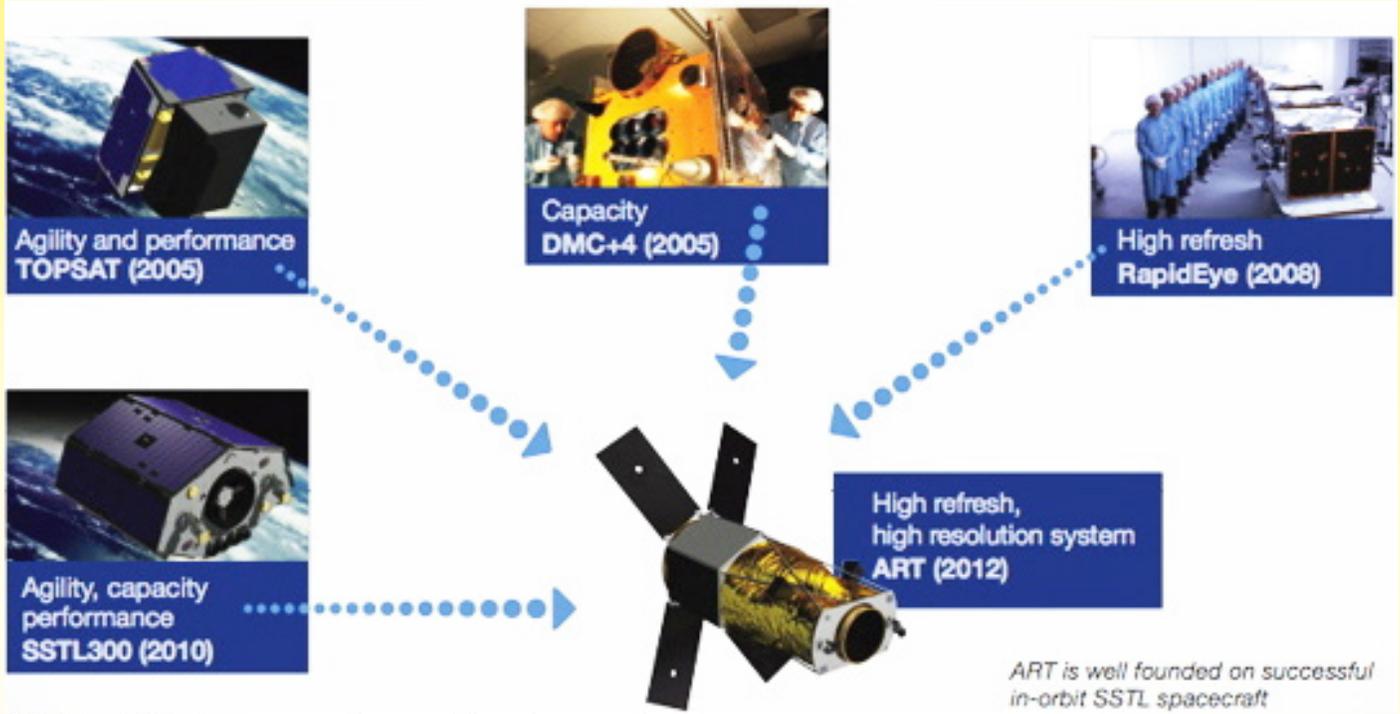
Weren't you also involved in the incubation of a firm that was engaged in the developing and prototyping of a UAV/UAS? Was that goal met?

Paul Brooks

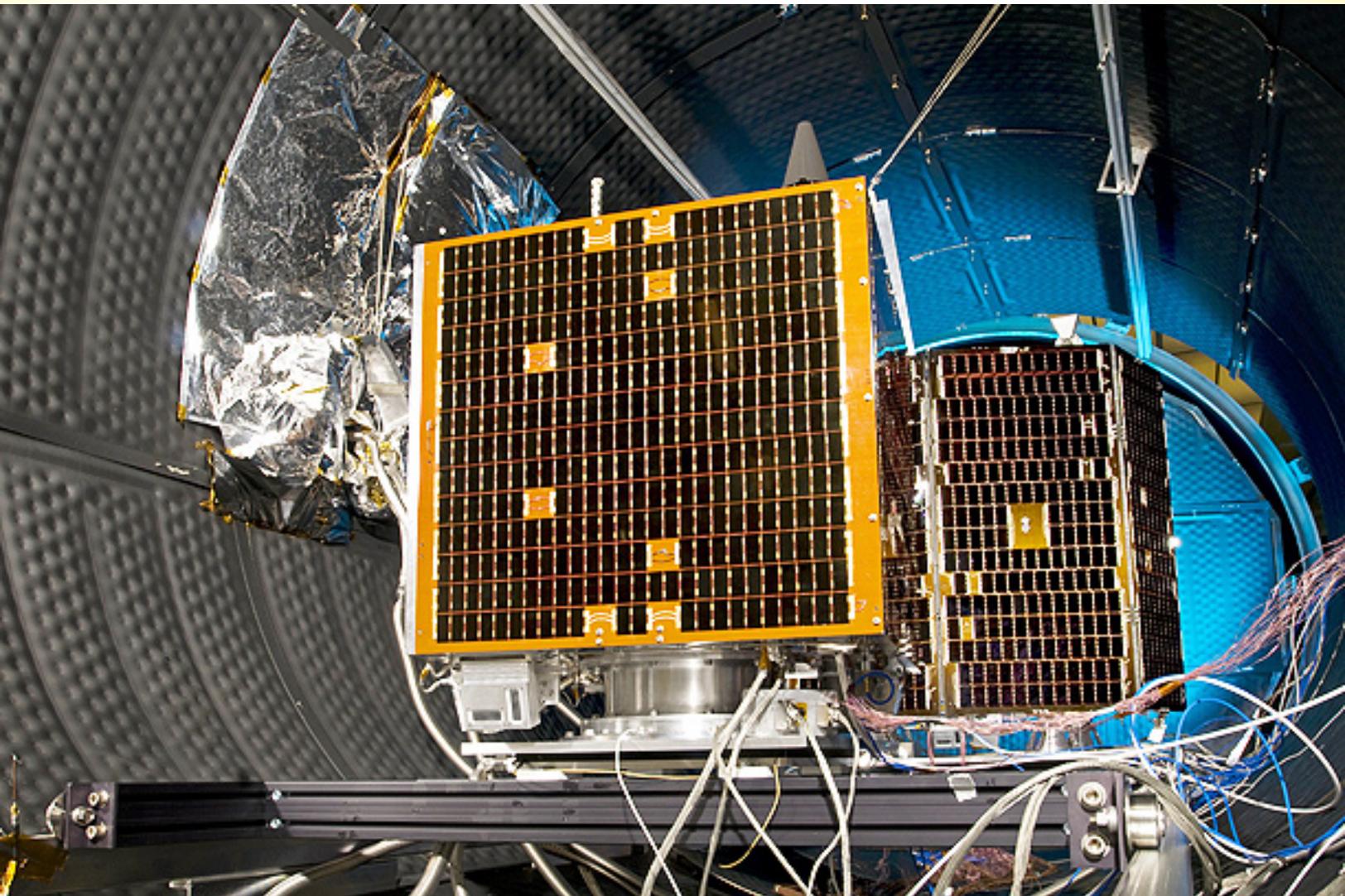
One of the frustrations of spacecraft is that they are doomed to follow orbital paths, regardless of where you wish to look and for how long. While SSTL can deliver constellations of spacecraft that address this issue, they cannot replace the ability of an aircraft or UAV (unmanned aerial vehicle) to circle an area of interest for an extended period.

Back in 2003, I was intrigued to see whether we could use the highly reliable and small electronics used for small satellites, that were already robust against the

Executive Spotlight



SSTL's ART (Accuracy, Reach, Timeliness) diagram



Testing Of NigeriaSat-X and NigeriaSat-2 - Photo courtesy of SSTL

harsh environment found at altitudes above the jet stream (~40,000 feet), to build an ultralight, solar powered UAV that could fly over a region for weeks or months. Fortunately a colleague of mine, Chris Kelleher, was working on a highly efficient airframe and we teamed up to develop the Zephyr project. I'm delighted to say that Zephyr has since broken the flight duration record for an unmanned aircraft, and I believe still has the potential to provide a valuable complement to satellites and more conventional aircraft and UAVs.

SM

What prompted your move to SSTL in 2006?

Paul Brooks

I had long been an admirer of SSTL — both of what they had achieved and how they approached their business and of course I was their customer for the TopSat spacecraft. Having set up a business for the Zephyr programme, I really wanted to work in a small company, one working in space and one that produces real hardware. Simply, SSTL is the best such company that I know and so I was delighted when they asked me to join, and I'm even more delighted to say that it's lived up to all my expectations.

SM

UK-DMC2 and Deimos-1 were launched in July last year — what contribution have these satellites made to the Disaster Monitoring Constellation?

Paul Brooks

For us, these satellites are proof that our innovative, cooperative model works. This is further strengthened by the launch of NigeriaSat-X in October 2010 alongside NigeriaSat-2. These satellites will ensure data continuity and new services for DMC EO data customers.

UK-DMC2 and Deimos-1 were both launched at the same time and are both operating well, providing commercially and ecologically valuable information to governments and companies.

Although sometimes referred to as “Spain” in the context of the DMC, Deimos Imaging is, in fact, a private company and it bought its first satellite to make a return on its investment in the EO data it can provide its customers. With UK-DMC2, SSTL made the same

DMCii Managing Director

Dave Hodgson

EO For Deforestation Monitoring

SatMagazine (SM)

SSTL is well known for the design, manufacture and operation of small satellites. What is the role of DMCii?

Dave Hodgson

DMCii is a subsidiary of SSTL, set up to provide coordination of the Disaster Monitoring Constellation. Although its headline objective is to support the logistics of disaster relief, its main function is to coordinate the daily imaging capability to the partner nations and to provide constellation based commercial imaging campaigns for precision agriculture, land use change and deforestation monitoring.



SM

Deforestation is an issue of increasing international concern. What part can satellite imagery play in monitoring the depletion of this valuable natural resource?

Dave Hodgson

Management of primary forests such as tropical rain forests with high levels of biodiversity is one of the greatest challenges the world currently faces. Maintaining their ability to absorb carbon dioxide from the atmosphere is something we are increasingly concerned about as it relates to climate change.

Most of the CO2 released into the atmosphere comes from a number of sources that are mostly linked to our use of natural resources such as fossil fuels and the ways in which we change and manage our land. Satellite imagery is already playing a key role in monitoring deforestation.

According to the UN Intergovernmental Panel on Climate Change (IPCC) approximately 17 percent of CO2 emissions globally are as a result of deforestation and biomass decay. In order for us to understand how much of the land is changing we need satellite imagery to measure changes of forest cover and state over time. For example, we need to measure the conversion of forest to agricultural use, or for use as a fuel source. Satellite imagery is unique in that it provides a

Executive Spotlight

commitment — this is our own satellite and it will pay for itself through the sale of imagery.

We do not see the value of space for its own sake, but for the return it can make to users and investors. There is a tremendous demand for up-to-date and timely data brought about by the steady adoption of EO data from programs such as LandSat during the past 35 years and the more recent “Google Earth Effect”.

SM

You mentioned NigeriaSat-2 and NigeriaSat-X, which I believe are due for launch in October. What will these satellites bring to Nigeria and the DMC?

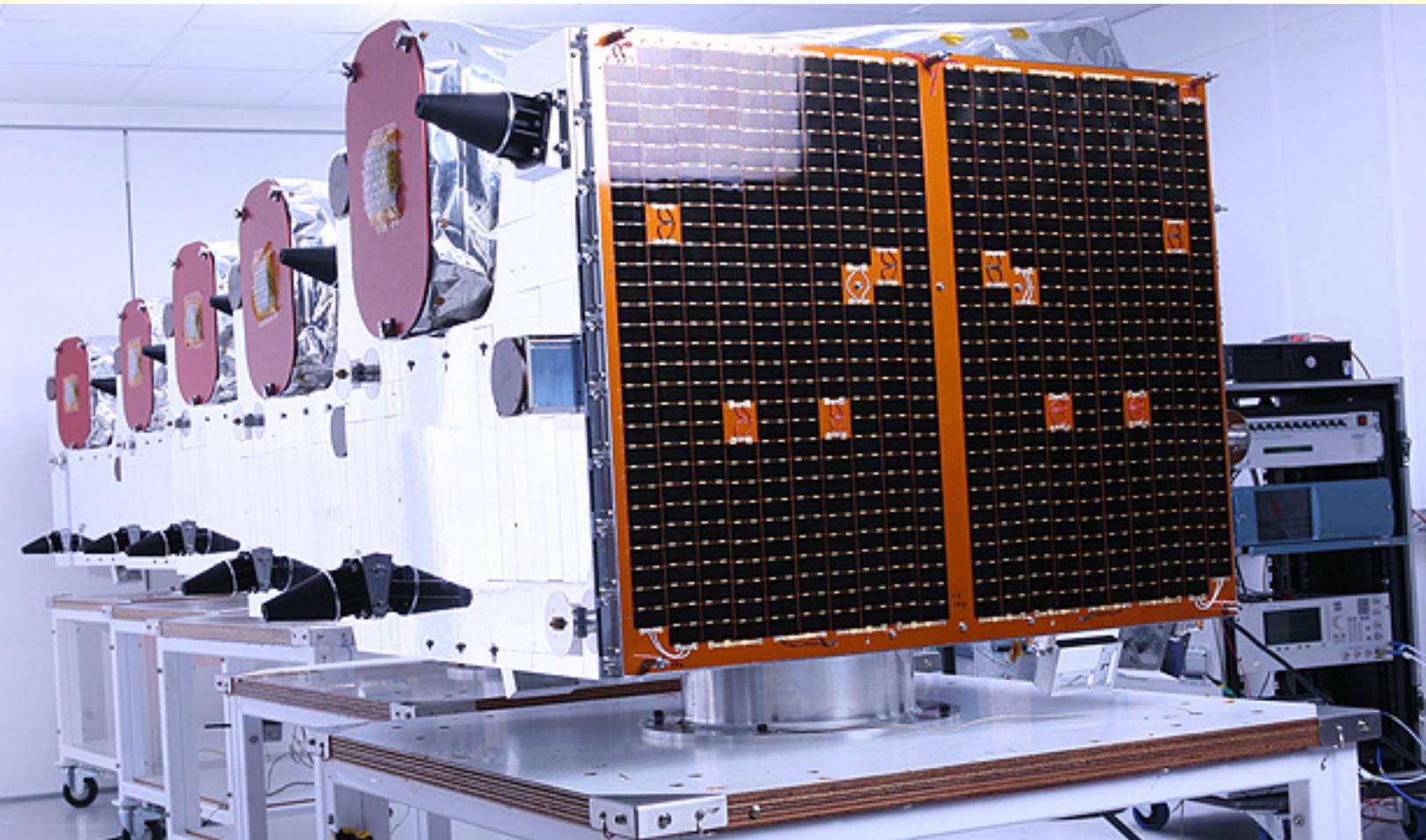
Paul Brooks

NigeriaSat-2 is a state-of-the-art Earth Observation spacecraft, providing not only high resolution imagery but highly accurate geospatial information, tremendously high volumes of data and very flexible modes of operation. These are all required by the need of Nigeria to provide

up-to-date maps of its rapidly growing economy and infrastructure and to take the lead of affordable information services across Africa.

NigeriaSat-X will provide data continuity for users of NigeriaSat-1 and will assist with disaster relief and global environmental monitoring campaigns alongside satellites from other Disaster Monitoring Constellation consortium members ASAL (Algeria), BLMIT (China), Deimos Space (Spain), and SSTL (UK). Of course, the Nigerian strategy does not stop at the provision of a satellite to support its economic growth but is underpinned by the need to develop its indigenous engineering capability to support a future knowledge based economy. NigeriaSat-X, a spacecraft built by the engineers trained at SSTL, was integral to this development of Nigeria’s future space program and engineering economy.

This is something else we believe strongly in — space can act as a beacon to encourage young people into science and engineering, the essential skills for a broad,



Five RapidEye platforms, photo courtesy of SSTL

sustainable economy. The Nigerian government and Space Agency (NASRDA) have combined these two critical elements into an elegant programme that will provide a valuable asset to support its growth and a cadre of engineers to allow its growth to be accelerated and broadened.

SM

Earth Observation seems to be in somewhat of a quandary with the impending Landsat data gap as well as the future of SPOT. What's your impression on the future of Earth Observation?

Paul Brooks

First, I expect the Earth Observation business will follow satellite communications and move away from the government and institutional programmes towards private companies that will provide services to both government and commerce. Organisations such as ESA and NASA will still have a role in undertaking the cutting edge science missions, but operational missions such as Landsat and GMES (the European programme of Global Monitoring for Environment and Science) should be undertaken by industry. This can be done as the principles have been established and it is now a question of driving the cost of such missions down such that a good value service can be provided whilst returning a reasonable profit to industry. SSTL has already demonstrated that both value and profit can be derived from Earth Observation services and it is interesting to note that SPOT is now also working on a private investment basis.

Second, the proven utility of lower cost satellites enables constellations to be affordable. Constellations meet the critical, missing element of Earth Observation — timeliness. This has been demonstrated by DMCii and RapidEye and the move to providing information whenever it is required will continue to accelerate. Looking at businesses such as GoogleEarth, the demand (which is huge and well founded as a business model) will be for current, consistent and accurate information and that requires faster coverage.

Hodgson continued...

global view of the way that we as humans are managing our land. Of course, illegal logging activity and natural events such as wild fires can also be monitored, which are also a significant contributor to CO2 emissions. For example DMCii is currently carrying out a project in Indonesia, which maps changes from deforestation caused by biofuel cultivation and fire.



DMC-2 + Deimos-1 satellites
Photo SSTL

SM

Is the scope of this Indonesian project different from other projects that DMCii has undertaken?

Dave Hodgson

It is interesting that you should ask that question for this project does in many ways “break the mould” of a typical DMCii earth observation project. Typically, we work with Governments and policy organisations. Government and policy bodies have a keen interest in ensuring that their commitment to current and future carbon reduction protocols is met in full. However, in Indonesia we have an active dialogue with foresters and forestry organisations and are working together with other partners that have a commercial interest in monitoring the national forest stocks.

SM

When will the Indonesia project be finalized?

Dave Hodgson

The results of this pilot project will be finalised over the coming months. We are already talking about expansion of this work, but this time with our local partners with whom we have been working so closely over the past nine months.

SM

Do you think the time will come when small satellites will replace larger EO mission spacecraft? Many in the industry believe small satellite constellations are the communication and IRS wave of the future... would you agree with that estimation?

Paul Brooks

Larger satellites will always play their part, for example providing complex scientific measurements from multiple instruments that must be contemporaneous and collocated. However, “small satellites” should not be limited to satellites that are just physically small. It is more to do with approach and use of technology and what I expect to see is that small satellites will take on the commercial and operational activities currently provided by large satellites and then the small satellites will evolve to be physically larger but still utilizing the approach and technology of “small satellites”.

I believe the real “game changer” is when effective EO information is available in a timely and complete manner — and that requires constellations of satellites. We have made it possible to build a constellation by making the cost of each individual spacecraft lower. The five satellite RapidEye constellation launched in 2008 was built by SSTL for MDA and is effectively the first commercial remote sensing constellation and the pioneer of what is to come.

SM

Since EADS Astrium acquired SSTL you have signed a joint contract with Astrium to provide a remote sensing spacecraft to Kazakhstan, what, if any other similar programs have occurred since this contract with Astrium?

Paul Brooks

We’re working closely with Astrium on a number of projects, including Kazakhstan and ESA’s Sentinel 5 Precursor programme. More importantly is that with some of the key technology within Astrium — particularly RADAR — and the service led business they have pioneered through SPOTImage, Paradigm and InfoTerra we have a unique combination of low cost approach and service understanding to develop the new commercial business opportunities that we have at SSTL have always thought would be the next big thing in Earth Observation.

SM

Given your expertise in this area, how can such challenges be overcome to ensure EO continues to play its most crucial role in assisting NGOs, first responders, governments, and commercial firms in protecting both the planet and its citizens?

Paul Brooks

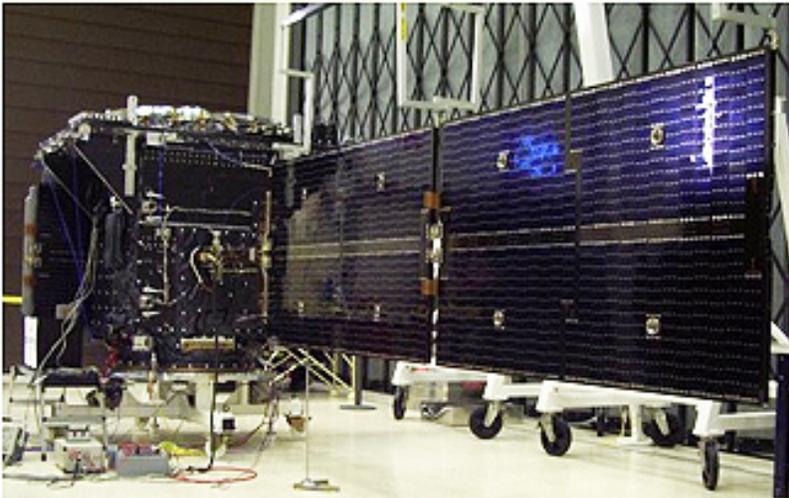
The first requirement for addressing the global challenges we face is providing accurate, consistent and unambiguous information about the state of the Earth and how it is changing. The data provided over the past decades by LandSat and SPOT has been critical in providing a traceable record of global change and this information is now required at a greater refresh rate and with even higher resolution to support the mitigation activities such as emission reduction and improved utilisation of resources through precision farming.

Again, we know this is all possible, the applications have been successfully demonstrated many times. The key is to provide the information on a service basis such that everyone can be confident that they can rely on the service. This requires a sustainable approach where the costs of providing the service are well below the value that can be assigned to the service.

I would say that the key is for the governments and agencies responsible for ensuring the future safety and security of citizens to specify what information and services they require to fulfil these obligations and then allow industry to put in place the systems and provide the service. This is not revolutionary, Paradigm (part of the Astrium group) has been providing the communications service for the UK’s armed forces for many years now, and if a service based approach works for military communications it can certainly work in other sensitive and critical areas such as environmental protection and sustainability.

SM

For youngsters and students considering a career in the space and satellite environs, what course work would you recommend to assist them gain the education needed to enter these industries? How can our industry assist in ensuring there is a competent core of specialists to grow our various endeavors?



GIOVE-A deployable panel, photo courtesy of SSTL

Paul Brooks

These are excellent questions and ones that are critical to the future of the UK and SSTL. I have no doubt that if the UK is to maintain a strong economy it must be based on a strong foundation in education. The first issue is making science and engineering an attractive option for young people. Unfortunately, and rightly, these are hard subjects to follow so people need to see that it is worth the effort to become an engineer rather than settle for a softer option. We can help here by showing the excitement of space and the benefits that spacecraft can give to the critical issues of the day. We also need to show a working environment that is energetic and demanding, such that people want to work in engineering and that once they succeed in this goal they realise that they are part of an elite group. SSTL has such an environment and few people visit us without going away with a desire to work here.

In terms of courses, I'm a bit of a traditionalist, so stick with the fundamentals — math, physics, chemistry — leading to degrees in math, science and engineering. There are some excellent masters courses in space science and spacecraft engineering, including the courses at Surrey University that we use regularly with our professional customers. The critical aspects are a sound scientific approach to problems, a solid base of knowledge and an early immersion into real hardware, so one other feature I would look for in new recruits is someone who has built something in their shed or garage!

SSTL website: <http://www.sstl.co.uk>

Hodgson continued...

SM

What future challenges do you see for deforestation monitoring?

Dave Hodgson

We see two major challenges. The first is at least a three year shortfall in high resolution imagery data until new satellites are launched. Many government and scientific research organisations are dependent upon this data. Fortunately, we are able to offer multi-spectral data that is directly compatible with Landsat spectral bands, but with the added benefits of more timely and up-to-date data that are made possible by our using a constellation. The EC Global Monitoring for Environment and Security (GMES) program also offers huge potential to improve our knowledge of forest resources, land use and food security.

The second big challenge is the Congo rainforest — it's the second largest area of dense tropical forest in the world after the Amazon rainforests, but satellite imagery of the region is old and not frequently updated. As such little is known about where and how fast the forests of the Congo Basin are degraded. We used our experience monitoring the Amazon rainforest, Indonesia and sub-Saharan Africa to develop a system that can rapidly acquire high resolution cloud-free images of the Congo Basin to help the world improve its knowledge of this valuable resource.

STEM Supports All

author: Carol Hively, Public Relations Specialist, Space Foundation

In keeping with its mission to “advance space-related endeavors to inspire, enable, and propel humanity,” the Space Foundation believes that future success in space depends on an educated and well-trained workforce, and now is the time to build that workforce through Science, Technology, Engineering, and Mathematics (STEM) education.

We focus on teachers because by training teachers we reach a much larger audience year after year,” said **Space Foundation** education vice president *Iain Probert*. “The lessons we teach educators are integrated into their classrooms for lasting effect on their students.”

Lessons in STEM can begin as early as preschool, and the Space Foundation instructs teachers to deliver STEM lessons to children in preschool through grade 12. With an interdisciplinary approach that fortifies all content areas by linking lessons across the curriculum, the Space Foundation approach is highly replicable and a model for schools across the country.

This summer, the Space Foundation is presenting teacher professional development classes in its home city of **Colorado Springs, Colorado**, and across the country in **Charles County, Maryland**, the suburban **Chicago** area, and, for the first time, at **Colorado State University - Pueblo**. The Space Foundation has

entered into a partnership with CSU - Pueblo to deliver a professional development class for teachers of very young children, “**PreK-2 Early Childhood Space Exploration**,” held on the Colorado State University - Pueblo campus.

Chicago-Area Professional Development

Also for the first time, **Aurora (Illinois) University** is offering graduate credit for those enrolled in this summer’s Space Foundation teacher professional development class, “**Astronomy Principles for the Classroom: Kinesthetic Astronomy**,” delivered to seven school districts in the suburban **Chicago Lyons Township Consortium**.

The program is taught in a “two classrooms” approach for 24 teachers and 24 students. Teachers and students are taught similar content in rooms adjacent to each other and then brought together several times a day for key hands-on activities and design challenges.

In addition to Aurora University certification, Space Foundation education programs are also certified by the **University of Colorado at Colorado Springs** and by **Regis University**.

2010 Space Across The Curriculum Classes

In 2009, 17 *Space Across the Curriculum* sessions were conducted in Charles County, Maryland, Colorado Springs, Colorado, and Omaha, Nebraska. This year, in addition to the educator professional development classes held out of state, four Space Across the Curriculum classes are offered in Colorado Springs at the **Space Foundation Discovery Institute**, which houses the Space Foundation education programs.

These week-long, intensive, graduate-level courses provide Pre K-12 educators with space-related STEM education knowledge and content that is instantly transferable to the classroom.

Participants can earn continuing education credits, graduate credits, or work toward a master's degree in multiple related disciplines. Master's degrees are offered to elementary, middle, and high school teachers through the **Space Foundation Educator Professional Development, Regis University**, and the **College of Education** at the **University of Colorado at Colorado Springs**.

This summer's Space Across the Curriculum classes at the Space Foundation Discovery Institute include:

- » ***Rocketry: The Future of Human Space Exploration***
- » ***Biological and Physical Research: Long-Term Space Travel***
- » ***Space Technologies in the Classroom: Imagery and High-Tech Science***
- » ***Earth Systems Science: Our Earth Revealed***

Jack Swigert Aerospace Academy and the AGI Space Missions Simulator at the Space Foundation Discovery Institute

The Space Foundation Discovery Institute occupies two buildings on the campus of the **Jack Swigert**

Aerospace Academy, about seven miles east of the Space Foundation headquarters in Colorado Springs. Jack Swigert Aerospace Academy is a Colorado Springs public middle school that opened August 2009 with an aerospace-based curriculum. The Academy is a joint project between **Colorado Springs School District 11** and the Space Foundation, and is named in honor of Colorado native and Apollo astronaut *John L. "Jack" Swigert*. The adjacent Space Foundation Discovery Institute provides targeted professional development, on-site teacher support, and student programs for the Academy.

Teachers attending Space Across the Curriculum classes this summer are among the first to use the new AGI Space Missions Simulator at the Space Foundation Discovery Institute. Thanks to a multi-million dollar donation from **Analytical Graphics, Inc.**, (AGI), teachers and students have access to a state-of-the-art space missions simulator.

Students at the Jack Swigert Aerospace Academy have used the new missions simulator to complete their multi-curricular study of the **International Space Station** (ISS), programming a simulation predicting when the ISS would be visible over Colorado Springs.

Said *Bryan DeBates*, Space Foundation senior aerospace education specialist, "The students were able to do in two class periods what aerospace engineers do."

AGI, headquartered in Exton, Pennsylvania, donated software, licensing, and new computer equipment valued at more than \$3 million to establish the education lab, which simulates launch, flight, and landing of a variety of space missions. The lab runs AGI's STK, **Orbit Determination Tool Kit (ODTK)** and STK/**Astrogator** software, allowing students and teachers to learn about satellite orbits, design their own satellite orbits, track their satellites, and, eventually, help plan a simulated return mission from Mars.

The simulator includes 30 student stations and one teacher station and may be used by any school district, when available.

"AGI is honored to be part of this exciting opportunity to educate the next generation of space enthusiasts," said AGI CEO *Paul Graziani*. "We applaud the Space Foundation



Teachers build robotic arms, later to be used in competition during the 2009 Space Technologies Space Across the Curriculum course.

for the important work it has done over the years, and look forward to the success of the new space education lab.”

Educators National Science Standards Lesson Bank

Another resource available to teachers is the **Educators National Science Standards Lesson Bank**, providing free Pre K-12 national science standards-based lessons, with around 10,000 lessons downloaded annually. The Space Foundation provides the free lessons at www.sciencestandardslessons.org/.

Space Foundation Teacher Liaisons

Serving as advocates for space science education, Space Foundation Teacher Liaisons represent all disciplines and use Space Foundation-provided training and resources to further integrate space curriculum into the classroom.

The highly regarded Space Foundation Teacher Liaison program is in its seventh year and has more than 320 active participants. Selected by a panel of experienced Teacher Liaisons and representatives from the space industry and the military, they

participate in workshops and education programs at the annual **National Space Symposium** and receive Space Foundation training and resources to further integrate space into their classrooms, such as: **NASA** workshops with optional graduate-level credit; exclusive STEM professional development experiences with optional continuing education credit; and special space-oriented student programs created just for Teacher Liaisons.

The Space Report

The Space Foundation provides previous-year editions of **The Space**

Report: The Authoritative Guide to Global Space Activity as a resource to teachers and students. Certain non-profit organizations, schools, and libraries may qualify for donation of past editions as long as quantities last. These books contain valuable information that is still relevant for research, as well as diagrams, photos, and articles that can be used for classroom projects.

Published by the Space Foundation, *The Space Report: The Authoritative Guide to Global Space Activity* is the definitive overview of the global space industry and is the result of extensive research by the Space Foundation’s Washington, D.C.-based research and analysis group and a team of independent research organizations, thoroughly examining the state of the space industry. The methodology, which is refined every year, involves identifying, gathering, analyzing, and synthesizing data from publicly available sources, as well as industry publications and reports.

The current 2010 edition is available for sale at www.thespacereport.org/store/.

To explore eligibility for donated past editions, contact Space Foundation Education Partnership Manager *Margo Hatton* at mhatton@spacefoundation.org.

For more about Space Foundation education partnerships and Space Across the Curriculum programs, see www.SpaceFoundation.org/education/.



The RADARSAT Promise

article credit: Canadian Space Agency

The RADARSAT Constellation is the evolution of the RADARSAT Program with the objective of ensuring C-band data continuity, enhanced operational use of Synthetic Aperture Radar (SAR) data and improved system reliability over the next decade.

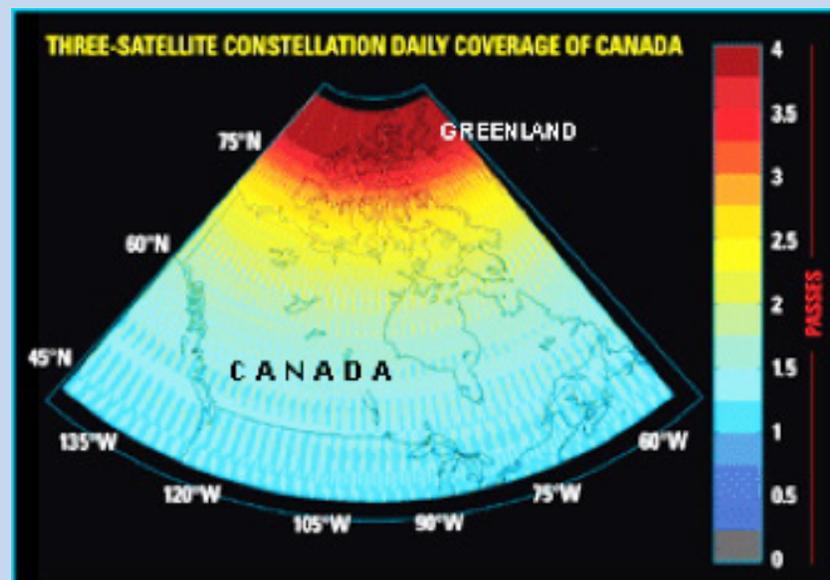
Characteristics

The baseline mission includes three satellites, but the constellation is designed to be scalable to six satellites. This allows the system to address future requirements as they arise with greater flexibility. For example, new functionality could be added to a fourth satellite and these functions could be made available to all constellation users. In this fashion, RADARSAT Constellation is a paradigm shift from earlier RADARSAT missions. Instead of launching a single satellite, the capabilities of the system are distributed across several satellites, increasing revisit, and introducing a more robust, flexible system that can be maintained at lower cost and launched into orbit using smaller, less expensive launch vehicles.

The greatly enhanced temporal revisit combined with accurate orbital control will enable advanced interferometric applications in between satellites on a four-day cycle that will allow the generation of very accurate coherent change maps.

Design and Development

The RADARSAT Constellation mission will ensure C-band data continuity for RADARSAT users, as well as adding a new series of applications enabled through the constellation approach. The first satellite of the



constellation will be launched to ensure that there is no data gap at **RADARSAT-2** end of life. The system does not aim to reproduce RADARSAT-2, but rather to meet core demands at better value for money, and enable new applications. The mission development was started in 2005, with satellite launches planned for 2014 and 2015.

Main Applications

The RADARSAT Constellation mission is being designed for three main uses:

- » ***Maritime surveillance (ice, wind, oil pollution and ship monitoring)***
- » ***Disaster management (mitigation, warning, response and recovery)***
- » ***Ecosystem monitoring (forestry, agriculture, wetlands and coastal change monitoring)***

In addition to these core user areas, there are expected



to be a wide range of ad hoc uses of RADARSAT Constellation data in many different government applications, federally and provincially, and in the private sector, both in Canada and internationally.

For example, while the mission design initially focused on maritime security requirements, land security, particularly in the Arctic, will be dramatically enhanced. The system offers up to four passes per day in Canada's far north, and several passes per day over the Northwest Passage.

The increase in revisit frequency introduces a range of applications that are based on regular collection of data and creation of composite images that highlight changes over time. Such applications are particularly useful for monitoring changes such as those induced by climate change, land use evolution, coastal change, urban subsidence and even human impacts on local environments.

The following points list the main areas where the Constellation system will be different from RADARSAT-2:

- » ***The Constellation is conceived as a government-owned system, providing a large amount of data to government departments for operational monitoring over wide areas.***
- » ***The ground segment is driven by requirements for fast data delivery of***

images acquired over Canada, and for fast tasking over international areas.

- » ***The majority of acquisitions in Canada concerns large areas to be covered on seasonal basis and therefore most of the acquisitions can be pre-planned.***
- » ***Conflicts between main users can be resolved in advance.***

Insight

Beam Modes	Approximate Incidence Angle	Nominal Swath Width Gnd Rg x Az	Approximate Resolution	Number of Looks Rg x Az
Low Resolution	19° - 54°	500 km	100 x 100 m	8 x 1
Medium Resolution (Maritime)	19° - 58°	350 km	50 x 50 m	4 x 1
Medium Resolution (Land)	20° - 47°	30 km	16 x 16 m	1 x 4
Medium Resolution (Land)	21° - 47°	125 km	30 x 30 m	2 x 2
High Resolution	19° - 54°	30 km	5 x 5 m	1 x 1
Very High Resolution	18° - 54°	20 km	3 x 3 m	1 x 1
Ice/Oil Low Noise	19° - 58°	350 km	100 x 100 m	4 x 2
25 m ship mode	19° - 58°	350 km	variable	variable x 1

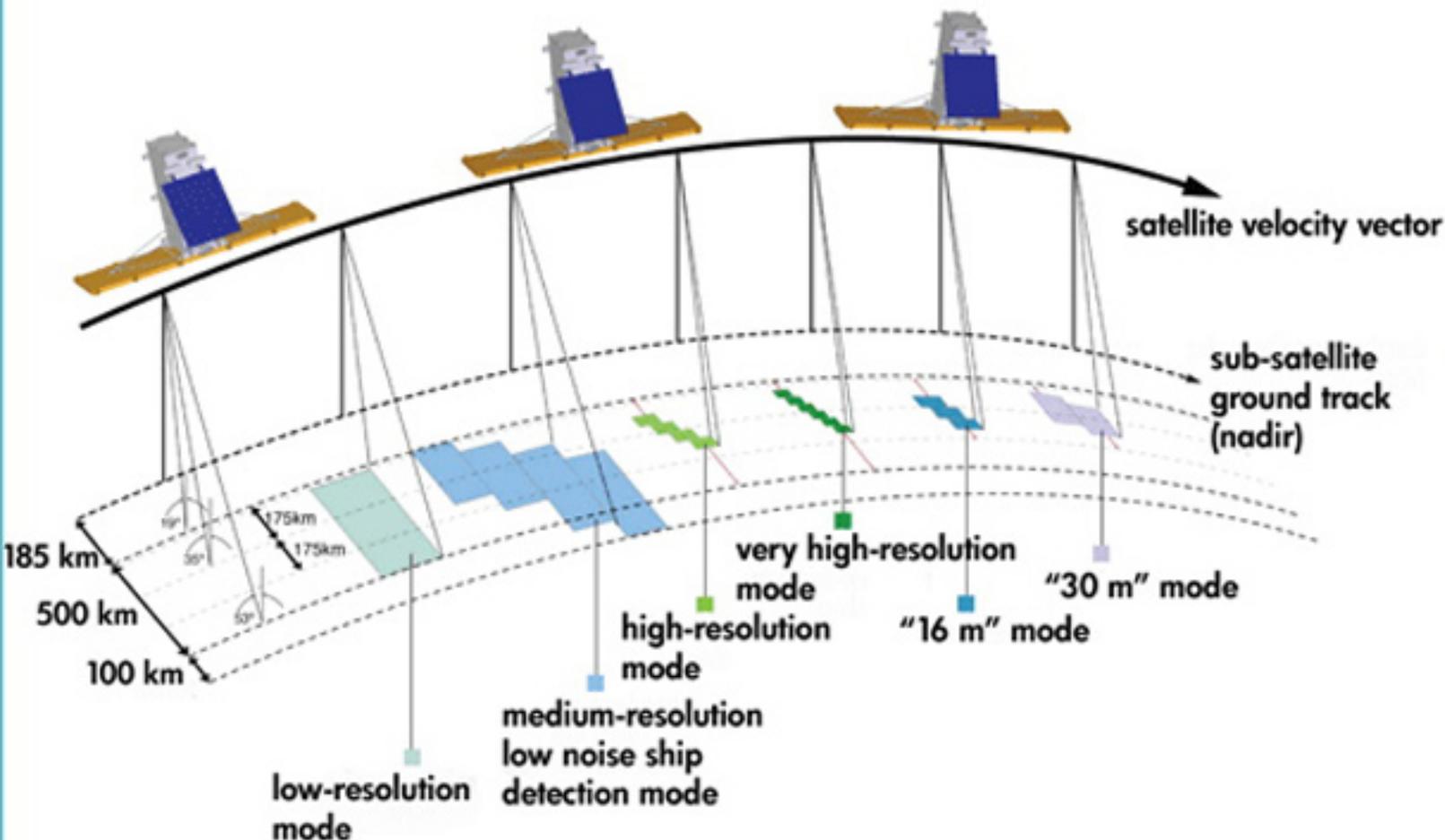
Figure 1 — Beam Modes

Imaging requirements are tailored to cover the areas identified by the government users, including both Canadian imaging and international imaging for Canadian users. Allocations are made for extra imaging capacity that may be used to fulfill international commitments.

Main Operational Modes

The system is designed as a medium resolution mission primarily dedicated to regular monitoring of broad geographic areas. This provides a 'big picture' overview of Canada's land mass and proximate water areas. Combined with higher resolution imagery from foreign missions going forward in the same time-frame, the data are expected to dramatically enhance Canada's ability

Figure 2 — Radarsat Constellation Imaging Modes



to manage resources and the environment and improve security by providing an operational surveillance system. The system also includes high resolution modes at 3m and 5m, primarily designed for disaster management. (See Figure 1 on the previous page.)

The RADARSAT Constellation payload is being designed to provide a beam mode similar to the RADARSAT-1 **ScanSAR** narrow, which is referred to in the following as the medium resolution mode. The medium resolution mode, which could be used for wide area coverage, was used to size the antenna dimension and power. Other beam modes (stripmap, high-resolution and low-resolution) are designed to be compatible with the system capabilities determined by the medium resolution mode. Starting from the medium resolution mode, the system can provide the following modes:

- » **High-Resolution Mode, which is simply the natural stripmap mode provided by the SAR. It has a single-look resolution approximately equal to half the antenna length**
- » **Very-High Resolution Mode, which can be either a stripmap mode or a spotlight mode**
- » **Low-Resolution Mode, which is simply a variant of the medium resolution mode where resolution is reduced in favour of a larger swath**

Beam Modes

The three-satellite configuration will provide complete coverage of Canada's land and waters offering an average daily revisit at 50m resolution, as well as a significant coverage of international areas for Canadian and international users. (See Figure 2 on the previous page.) It will also offer average daily access to 95 percent of the world. The satellites will be interoperable, enabling tasking from one satellite to the next and will be equally spaced in a 600 km low earth orbit. The constellation has a flexible design, allowing up to six satellites to fly in the same plane.

Data Availability

One of the most important project objectives is to increase data availability to the main operational users of SAR data in Canada. The system will be available when the first satellite will be on orbit then the availability of SAR data will increase as more satellites are launched. Requirements are set to ensure continuity

with RADARSAT-2. The project will provide continuity for RADARSAT-1 and RADARSAT-2 users, but the system is not designed to be identical. The mission focuses on core applications and products and the provision of best value for money for the government of Canada. Some advanced features like GMTI mode present on RADARSAT-2 are not included. The system performance requirements (NESZ essentially) and data quality (radiometric accuracy) specified for RADARSAT-1 and 2 are maintained. Some aspects of the data quality that were not originally specified for RADARSAT (like ScanSAR beam discontinuities) are now specified based on experience gained through the RADARSAT mission.

For the main system users, the operations should be simplified. Most of the acquisitions in Canada should be pre-planned and data made available to the users in near real-time. In some cases users will process the data; in other cases, specific products will be made available to user organizations. For non-operational users, the interaction with the system for data ordering and distribution should be similar to what is being implemented for RADARSAT-2. It will be possible to order data from an archive, but long-term archiving of the data will be dealt with separately by the CSA's Framework Data Policy and the practices of user organizations and CCRS.

Coverage, Access and Imaging Time

The design should be such that sufficient volume of data can be collected to enable both Canadian and international applications. Their core needs at the highest level can be summarised as:

- » **Daily coverage of Canada's inland, territorial and adjacent waters to support maritime surveillance, including ice monitoring, marine wind monitoring, oil pollution monitoring and ship detection**
- » **Ability to image any disaster location in the world within 24 hours to establish the state of critical infrastructure**
- » **Ability to monitor all of Canada for disaster mitigation on a regular basis (monthly to twice-weekly) to assess risks and identify damage prone areas**

Insight

Application	Geographic Coverage	Revisit	Resolution	CCD	Polarisation	Tasking	Latency	End Use
Ice and iceberg monitoring	Great Lakes Coastal zones (3 oceans) Shipping lanes	daily	medium	no	Dual co-cross	Pre-scheduled 1 day	1 hour	Ice charts
Marine winds	Great Lakes Coastal zones (2 oceans)	Twice daily	low	no	n/a	Pre-scheduled	1 hour	Wind forecasts
Oil pollution	Shipping lanes Coastal zones	daily	medium	no	Dual co-cross	Pre-scheduled Less than one day (major spill)	30 minutes	ISTOP Spill response
Ship detection	1200nm (above 42° N)	Daily or better	Medium to high	no	Dual co-cross	Pre-scheduled	15 minutes	Domain awareness product
Disaster mitigation	Canadian urban areas Transport and energy corridors	Daily to monthly	medium	yes	variable	Pre-scheduled	1 day	Risk map
Disaster warning	River basins Geohazard risk areas	Daily to monthly	variable	yes	variable	1 day or better	1 hour	Warning bulletin
Disaster response	Global	Daily access for period of crisis	High (except floods - low)	yes	variable	1 day or better	1 hour	Situational awareness; damage assessment
Disaster recovery	Global	Daily access for several weeks	high	yes	Dual co-cross or quad	1 day or better	6 hours	Maps
Forestry	Forest areas of Canada	Annual	medium	yes	Quad	Pre-scheduled	weeks	State of the forest report
Protected areas and wildlife habitat	Parks and sensitive areas	Annual	medium to high	yes	Quad	Pre-scheduled	weeks	Change map
Agriculture	Cultivated land in Canada	Weekly (seasonal)	medium (30m)	yes	Quad	Pre-scheduled	1 day to weeks	Crop classification, crop yield products, tillage practice product
Wetlands	Wetlands in Canada	Annual	medium to high	yes	Quad	Pre-scheduled	weeks	Change map
Coastal change	Coastlines 3% highly sensitive	Monthly	low to medium	yes	TBD	Pre-scheduled	weeks	Change map

Figure 3

» **Regular coverage of Canada’s land mass and inland waters, up to several times weekly in critical periods, for resource and ecosystem monitoring**

The RADARSAT Constellation shall provide 12 minutes imaging time on average per orbit per satellite, with peak imaging of 20 minutes per orbit per satellite. A significant increase in imaging time for the constellation is possible if more satellites are launched. Analysis is ongoing to determine international imaging requirements and their impact on overall imaging requirements.

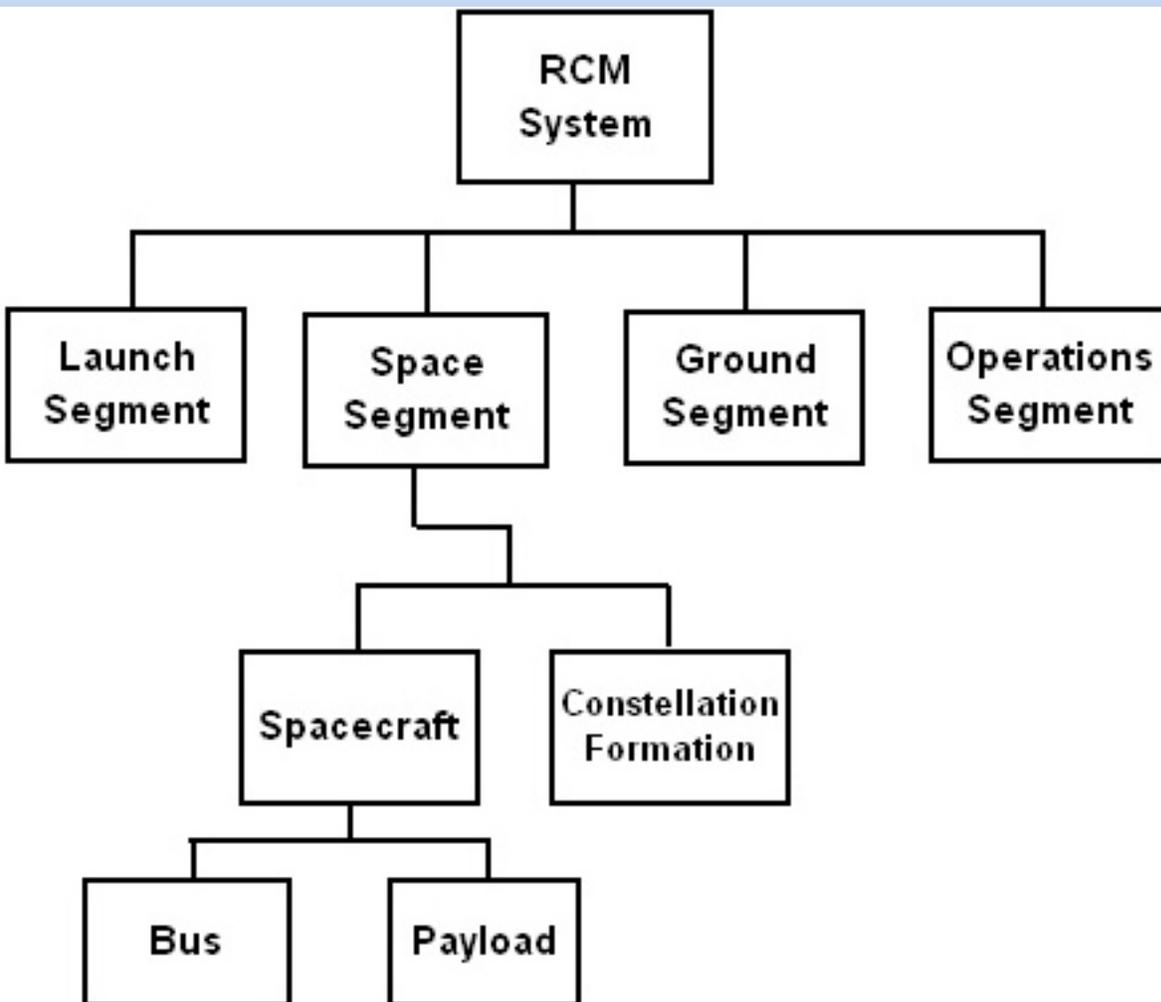
Revisit and Re-look

The RADARSAT Constellation shall provide a 4-day exact revisit, allowing coherent change detection using an INSAR mode. The RADARSAT Constellation shall provide an average daily global re-look capability in both medium and high resolution modes. Most of the applications considered required at least daily re-look and an exact revisit once to twice weekly (interferometric change detection applications). Very frequent re-look capability is critical to certain disaster management applications.

Timeliness and Data Latency

The timelines and data latency requirement is highly variable according to the application area. For many ecosystem monitoring applications, data delivered several days or in some cases several weeks later may be sufficient. However, maritime surveillance and disaster monitoring have much more demanding timeliness requirements. For maritime surveillance applications in Canadian and adjacent waters, RADARSAT Constellation shall provide 10 minute data latency from acquisition to delivery of data. For ice monitoring and global and Canadian disaster management applications, RADARSAT Constellation shall provide 2 hour data latency from acquisition to data delivery. For ecosystem monitoring applications, RADARSAT Constellation shall provide 24 hour data latency from acquisition to data delivery.

Figure 3 on the previous page summarizes geographic coverage, revisit, data latency and other system’s main technical characteristics for each application area. including ice monitoring, marine wind monitoring, oil pollution monitoring and ship detection. RADARSAT Constellation mission consists of the following segments:



Space Segment

The *Radarsat Constellation Mission Space Segment* will consist of a constellation of three satellites in a low-earth orbit. Each of the Spacecraft in the constellation will consist of a Bus and a SAR payload. There is also a secondary payload allocation for a potential *Automated Identification System (AIS)* for ships, which is not planned as part of the baseline mission and is being considered by DND. The radar payload will perform all imaging operations, store, encrypt and transmit the radar data. (See Figure 5.)

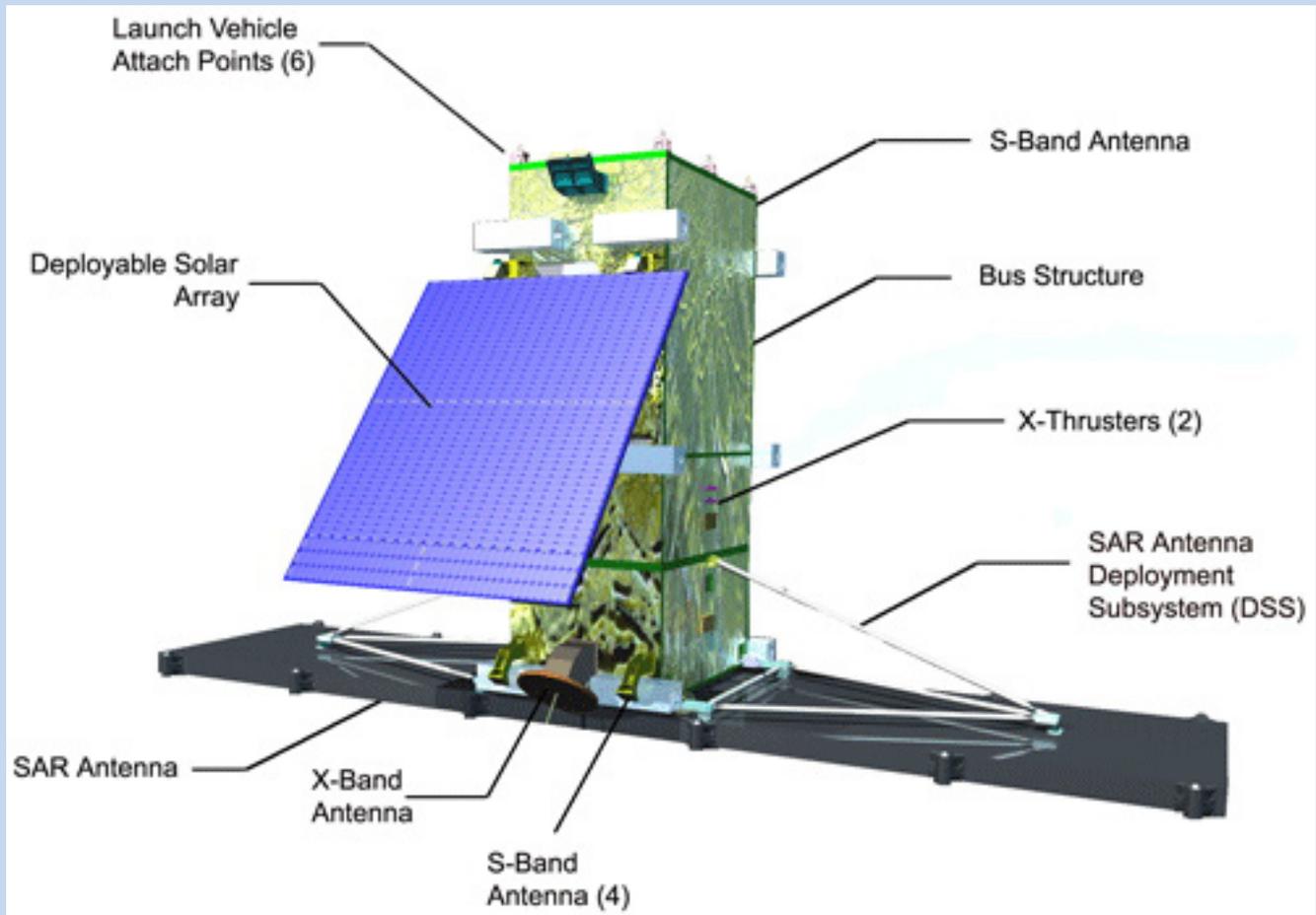


Figure 5 — spacecraft deployed configuration (AIS not shown)

The AIS payload could receive ship's messages in a wide swath larger than the accessible swath of the SAR. The Bus module will provide attitude and orbit control, power generation and storage, payload commands, telemetry, thermal control and the primary support structure.

Ground Segment + Operations Concept

The baseline ground segment is based on upgrades to the existing RADARSAT-2 ground segment, using the *Gatineau* and *Prince Albert* stations for data reception, the *St-Hubert* and *Saskatoon* stations for TT&C, and the *Svalbard* station as a backup for TT&C and data reception. It will be harmonized for data reception at the *Polar Epsilon* coastal stations in order to support near-real time maritime surveillance. It will also include a fast tasking capability allowing access to the satellites on every orbit, likely achieved through international partnerships.

Ground Segment

The RADARSAT Constellation will require ground stations with vast coverage over Canadian maritime

zones of interest in order to provide data within 10 minutes of acquisition. The ground segment will be based on upgrades to the existing **RADARSAT-1** and **2** ground segment, using the *Gatineau* and *Prince Albert* stations for reception and the *St-Hubert* and *Saskatoon* stations for TT&C. Upgrades will allow basic constellation operations. It will be extended to include upgrades to coastal stations and potential international partnerships in order to support near-real time maritime surveillance. It will also include a fast tasking capability allowing access to the satellites on every orbit, likely achieved through international partnership.

The maritime surveillance requirements are among the most demanding from a mission and system requirement point of view. (See *Figure 6 on the next page.*) DND has a requirement to cover three zones extending up to 1,000 nautical miles from the coast, which are shown below. **Transport Canada** has requirements to detect ships four days before they enter Canadian waters, which involves voluntary disclosure out to 2,000 nautical miles, and imaging out to 1,200 nautical miles.



Figure 6 — Maritime surveillance areas for ship detection

An important aspect of the system operation is the availability of an Automated Identification System (AIS) payload for ship identification. Using AIS, ships exchange information on their identity, position, course etc. The RADARSAT Constellation spacecraft will carry an AIS receiver to gather information on ships over the zone covered by the SAR payload. The AIS will report most of the ships over the zones of interest.

Launch Segment

Launch Segment will consist of the launcher and launch service provider. The mission will use a single spacecraft / single launcher configuration. The mission planning and spacecraft control functions will be located at St-Hubert.

System Characteristics

Please see Figure 7 on Page 68.

Phase A Accomplishments

The RADARSAT Constellation mission completed its Phase A in 2007. During this phase, the initial design concept was completed based on the User Requirements developed by the *Canadian User and Science Team* in collaboration with the *International User Team*. These requirements are meant as guidelines in the conduct of mission definition studies.

In addition, the **CSA** has drafted a *Mission Requirements Document (MRD)*, which translates user requirements into mission requirements that the industry

System Characteristics

Radar	
C-band	5.405 GHz
Imaging Time/satellite	12 min average/orbit
Orbit	
Altitude (Nominal)	592.7 km
Inclination	97.74 degrees
Period	96.4 minutes
Ascending mode	18 hours (+ -15 min)
Sun-Synchronous	14 11/12 orbits per day
Repeat cycle	12 days

Figure 7

team must address in designing the mission concept. At the system level, the industry team has drafted a *System Requirements Specification (SRS)*, which translates the higher level mission requirements into detailed system requirements.

Phase B

During Phase B, the design concept was refined and the preliminary design of the satellites completed. CSA continued consultations with other Canadian Government Departments that have a vested interest in this space mission, to ensure that the design effectively responds to their requirements. A *Data Utilization and Plan* was drafted early in Phase B to identify required developments for project success. The document covered all aspects of the data utilization, including the new applications enabled by the constellation. A plan for science activities was included in the Data Utilization Plan, which will seek to maintain a balance between the operational applications development and the science applications developments.

Internationally, CSA continued discussions with a number of potential partners to identify collaborations in the following main areas:

- » **Missions' interoperability**
- » **Data exchange**
- » **Use of International ground stations for data reception**

CSA is also closely following the evolving developments in the international remote sensing community to identify potential synergies, recognizing how the mission could

serve global initiatives that rely on data from advanced Earth observation satellites. See *Figure 9* on the next page for the constellation project schedule. The final design will be approved in Phase C and the satellites will be manufactured in Phase D. As of this writing, the satellites are planned for launch in 2014 and 2015.

About the Canadian Space Agency

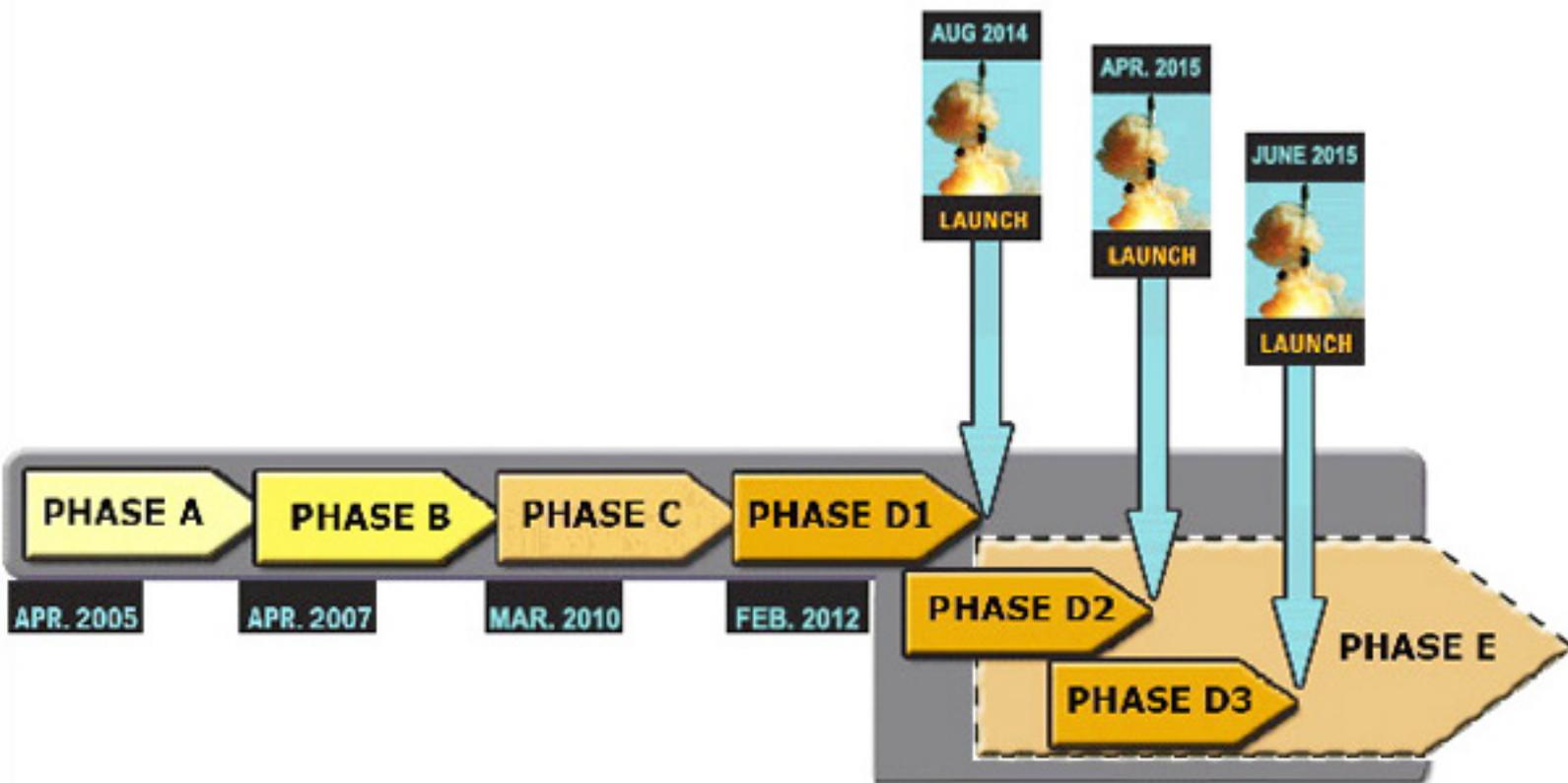
The Canadian Space Agency is committed to leading the development and application of space knowledge for the benefit of Canadians and humanity.

To achieve this, the Agency promotes an environment where all levels of the organization:

- » *pursue excellence collectively*
- » *advocate a client-oriented attitude*
- » *support employee-oriented practices and open communications*
- » *commit itself to both empowerment and accountability and*
- » *pledge to cooperate and work with partners to our mutual benefit*

Mandate

The mandate of the Canadian Space Agency is to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians.



Phase	Description	Milestones
A	Concept Development	Mission and System Requirements
B	Initial Design	Preliminary Design
C	Critical Design	Critical Design
D1	Manufacturing Satellite 1	Launch Satellite 1
D2	Manufacturing Satellite 2	Launch Satellite 2
D3	Manufacturing Satellite 3	Launch Satellite 3
E	Commissioning & Operations	

Figure 8 — RADARSAT Constellation Project Schedule

The Canadian Space Agency (CSA) has set out to ensure that all Canadians learn and benefit from the innovations of space science and technology to the greatest extent possible. Its objectives are to support and promote a highly competitive space industry and address the needs of Canadian

society. With almost half of Canada's GDP growth in the knowledge-intensive sectors of the economy, the Canadian Space Program is a key driver behind continued leadership on the world stage, new opportunities for industry and scientists, and long-term social and economic benefits for all Canadians.

Network Management — The Next Step

author: Wally Martland, President, Newpoint Technologies

Most of the Network Management Systems (NMS) solutions on the market today evolved out of Monitor and Control (M&C) solutions. Operators at an Earth station relied on the M&C system to monitor and control one or more antennas' RF equipment without having to walk amongst the racks in order to determine if there was a failure on any piece of equipment. As network operators acquired or built out more infrastructure to meet the ever growing demand for bandwidth from their customers, M&C systems were forced to evolve into the NMS solutions on the market today.



Network management WITHOUT confusion!

The goal of the network management system was to provide operational efficiencies by allowing the operator at a *Network Operations Center (NOC)* to monitor and control all the equipment that comprised their transmission network, regardless of geographical location, from a single location or in some cases, a primary and a back up location.

Today, this goal has largely been realized as many network operators have the ability to manage all the equipment that comprises their network from a single Operations Center. This is accomplished from a **NMS** graphical user interface which typically consists of a map-based overview with graphical icons depicting each of the sites that make up the operators' network. These icons are colored coded to represent the status or "health" of the equipment at the site. By drilling down into a site, the operator is presented with a block and level display for each of the antennas located at the site (see *Figure 1*).

Operators are able to identify when any of the equipment fails through the use of pop-ups and changing icon colors that are displayed based upon equipment or site status. More importantly, they are able to recover from equipment failures via the NMS without having to dispatch a technician to site. In the event they cannot resolve the issue via the NMS, they can determine the most likely cause of the problem and dispatch a technician to the remote site equipped with the appropriate tools and parts to repair the issue. Not only does this make them more efficient in the operation and maintenance of the network, but it also saves significant costs in doing so.

However, network operators today are faced with new challenges. Customers are demanding more capacity as well as higher reliability from their network providers through complex *Service Level Agreements (SLAs)*. Today, it is not uncommon to see reliability requirements of 99.995 percent or greater on the network. This is coupled with increased competition as more network operators enter the market.

Although the NMS does allow operators to recognize and recover services by alerting them to equipment failures and allowing them to correct them from the console, the NMS does very little to communicate to the operator

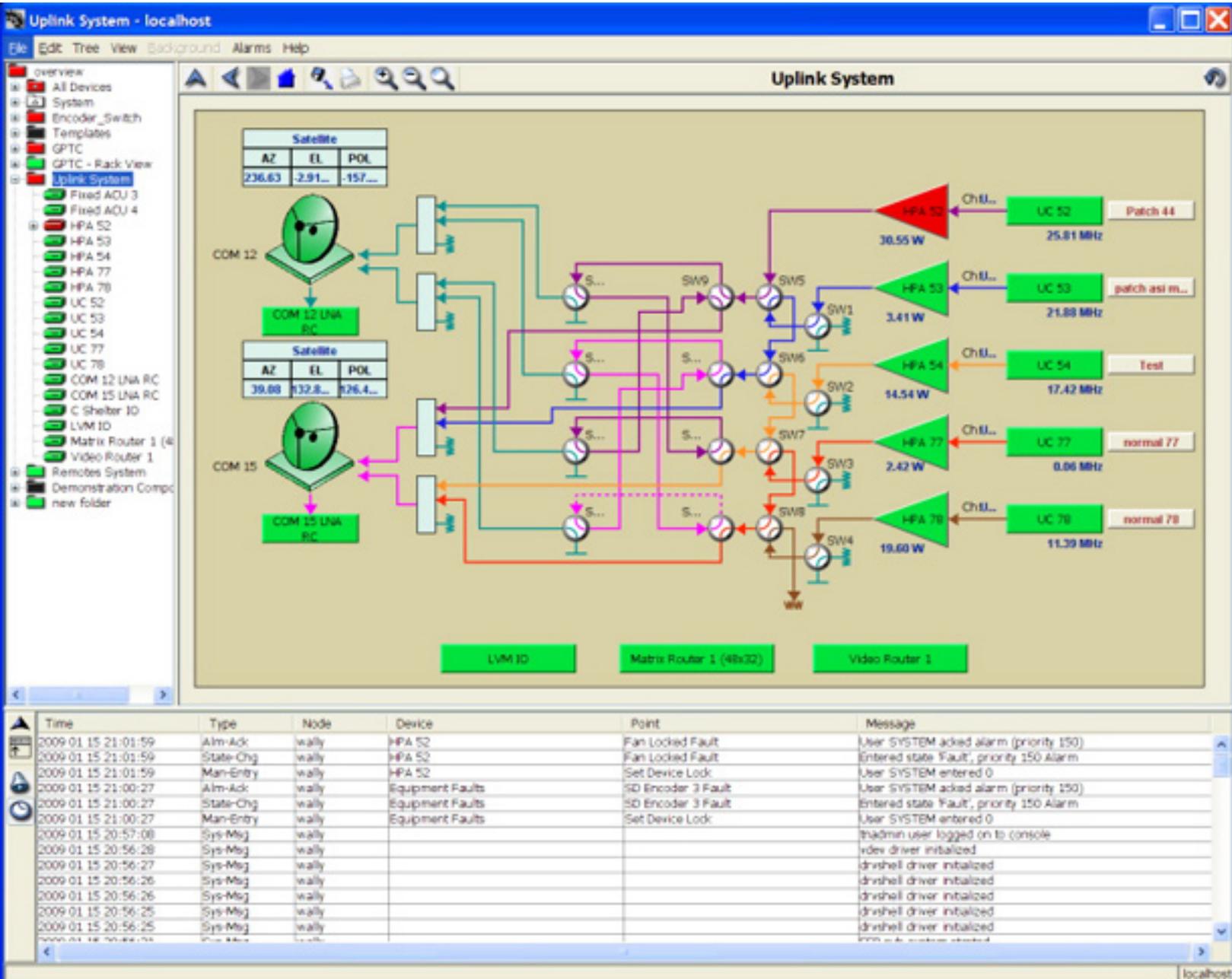


Figure 1 – Traditional NMS Block and Level Display

what the REAL impact is of these equipment failures. The basic problem is this — the NMS is still simply managing the *equipment*, while the network operators are trying to manage their *services* in an effort to maximize the network revenue based upon the SLAs they have established with their customers.

At **Newpoint Technologies Inc.**, a wholly owned subsidiary of **Integral Systems Inc.**, we are working hard to close the gap between what the network operators require and what the current NMS solutions offer.

Newpoint is introducing a new **Service Management Module** to our industry leading **Compass/TrueNorth Network Management Solution**. The **TrueNorth Service Manager** takes the NMS solution to the next level by allowing operators to not only continue to view the network as they do today using the traditional block and level displays (*Figure 1*) but also provides them views for each of the services that are running on the network.

These service views provide an origination to destination view of only the specific equipment associated with the transmission of the service (*Figure 2*). As online units fail, and standby units are activated, the service displays are automatically updated to reflect the new transmission path for the service. When there is an alarm in the

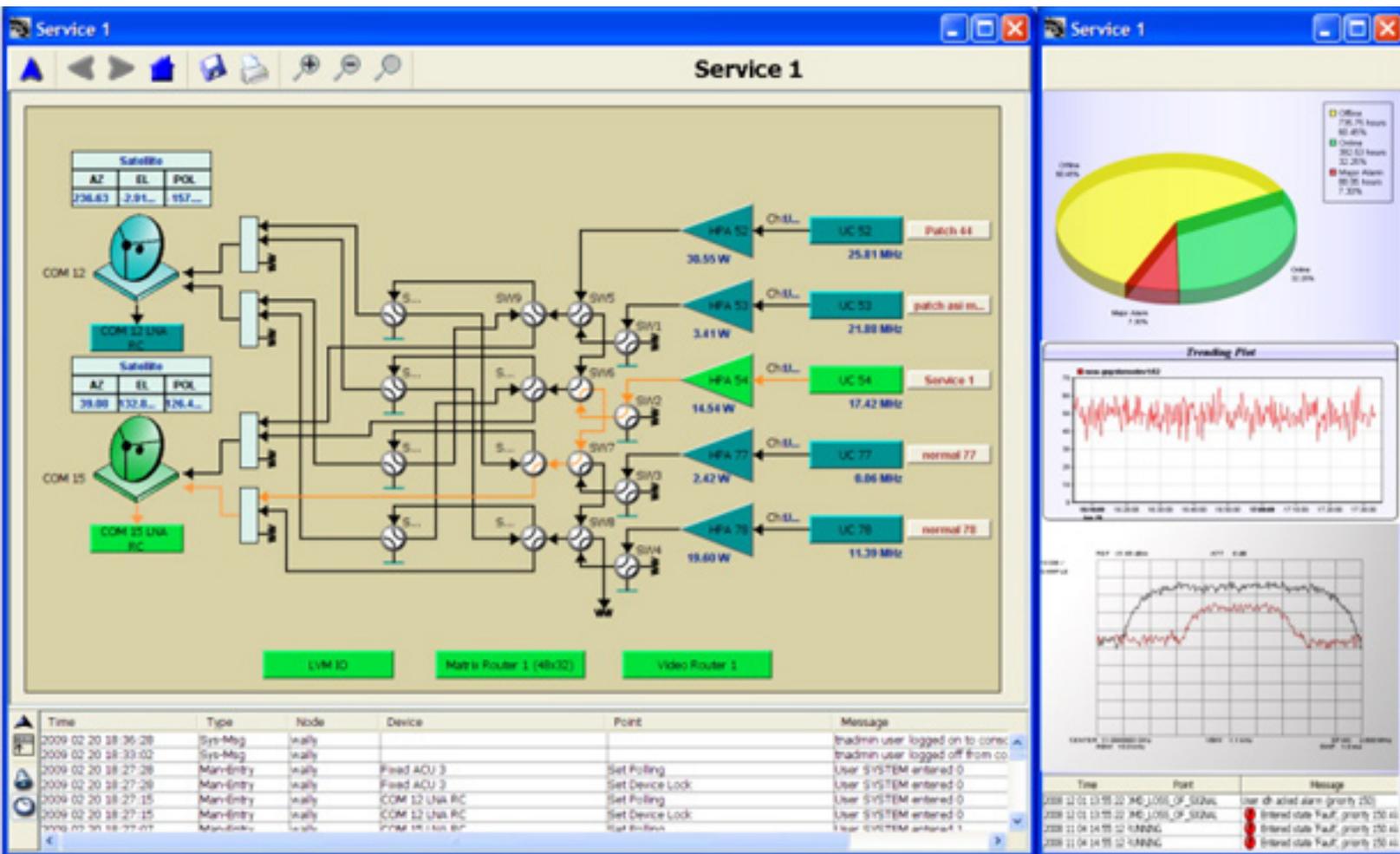


Figure 2 – Service Management Display

system because of an equipment failure, operators are alerted to not only the fact that a piece of equipment has failed, but also to what “downstream” services are affected by the equipment failure.

By allowing operators to assign priorities to the individual services based upon the established SLAs that they have setup with their customers, operators can quickly distinguish the high revenue generating services from the low revenue generating services and elect to recover the higher priority services first, and then work on the lower priority services. In the event that the equipment failure has left the network short on capacity to carry all the services, lower priority services can be replaced with the higher priority services until spare equipment can be put in place.

To assist operators in the activation and deactivation of services, or in moving services from one transmission chain to another, profiles can be stored for each of the services which contain the parameters needed to be set in the equipment to bring the service online. To bring a service up using profiles, the operator only has to select the equipment to be used for the service transmission, and the profile to be applied (a service could have more

than one profile), and the software will execute the set up of the service by downloading the profile to the equipment and verifying the profile has taken. If an error occurs along the way, the operator is prompted and required to take action to resolve any issues.

Once the concept of services have been introduced into the NMS, the operators are provided with powerful reporting tools which can be used to provided feedback into the SLA Management or Billing Systems. This includes detailed information on when the service was activated and deactivated over any given time frame, what alarms occurred while the service was running, and how long the service was down or degraded while it was active, etc.

Managers can have this information rolled up to a system view and see network usage statistics. For example, on average how many services were running on the network at any given time, how many services were offline because of equipment problems when they should have been active, how much spare capacity is on the network at any given time, etc. These can help them make powerful, educated decisions on when and if the network should be expanded, where

Focus

system bottlenecks are that need to be resolved, or which components are causing a high rate of service interruption because of failure.

Network Management Systems can no longer afford to be focused on only equipment failures, but must provide more information and tools to allow them to do their job even more efficiently and effectively. Operators are required to manage the services on their networks and their NMS should assist them to do just that. By introducing service management concepts into the equipment focused NMS, operators can make important decisions which minimize the revenue impact of equipment failures. Furthermore, the NMS can provide key indicators on the performance of the network and identify short comings on the network which should be addressed. The service based NMS is an essential part of managing any network.



About the author

Wally Martland is the President of Newpoint Technologies, Inc., a wholly owned subsidiary of Integral Systems, which provides Satellite Command and Control, Network Management, and Carrier Management software solutions to the satellite communications and broadcast marketplaces. Wally has more than 19 years experience in providing Network Management and Remote Site Monitoring Solutions to the Satellite, Microwave, Transmitter, & SCADA marketplaces.

COMPASS



Newpoint Compass was created from the ground up to protect the vital traffic handled by communications networks easily and with outstanding reliability — all while minimizing integration costs to save money. Users benefit from Compass with reduced workload, while owners benefit from reduced operation costs and higher levels of customer satisfaction.

Compass is a complete software package for managing all types of networks. It is built with the flexibility that allows for support of as many as 100,000 devices and designed to meet the requirements of diverse applications, from satellite to VDSL, to the Internet. Ready to interface to devices that are SNMP-based, as well as with devices that require serial or contact closure interfaces, Newpoint Compass does it all.

New in version 6.0 is a familiar, Windows Explorer-like administrator. The new Administrator enhances the users experience and capability to administrate a real-time network management system.

Also new for version 6.0 is Compass Creator, a unique application that automatically configures your M&C interface at the touch of a button. Once equipment is added to the system, the Creator builds device detail pages, overview pages and configures the database for you. This tool significantly reduces the time associated with creating an M&C system. Compass comes packaged with a built-in library of device drivers, and also supplied with a Visual Driver Studio that allows users to write their own drivers.

The alarm log displays all open and unacknowledged alarms, and includes the ability to filter alarms by type and priority, simplifying system management. Detailed records of all system activity are stored for system analysis.

Compass can be configured to interact with external data that is part of a corporate database, such as Oracle. A large variety of options are available that make Newpoint Compass a flexible package that can handle all converging network management requirements.



Executive Spotlight

Richard Hadsall

Founder, CTO, MTN Satellite Communications

CEO + CTO, MTN Government Services

Richard Hadsall is the founder and CTO of MTN Satellite Communications (MTN) in Miramar, Florida, and is also the CEO and CTO of the MTN Government Services (MTNGS) subsidiary in Leesburg, Virginia. From 1969 to 1972, Richard worked at Eclipse Systems, Fairfield N.J., specializing in fluidic computer and control systems. From 1972 to 1974, he was a sales engineer for Wilshire Electronics, in Passaic, New Jersey, specializing in electronic components for the military and aerospace industry. He became the vice president and general manager of Wire Concepts in Fairfield, New Jersey, from 1974 to 1976, and he then founded Crescomm Inc., which was sold to Pirelli in June of 1987, and went on to found RJ Earth Satellite Communications, providing communications equipment and services to local and regional governments. In 1981, Richard founded MTN Satellite Communications, and operated as the senior vice president and CTO and became the company's CEO and CTO in 2009.





SatMagazine (SM)

Richard, please tell us about how you came to found MTN in 1986.

Richard Hadsall

Prior to April 1986, I had founded Crescomm Transmission Services, a Federal Communications Commission (FCC) satellite common carrier providing transportable satellite communications to the TV broadcast industry on a global basis using the Intelsat satellites to deliver breaking news events from around the world.

In April of 1986, at the request of then Secretary of Defense Casper Weinberger, I received a call from his military attaché, Cmdr. Mel Sundin, at the Pentagon asking me if I could provide a satellite antenna that would allow a broadband uplink from a moving vessel at sea.

At the time, it seemed like a logical question, and something I thought shouldn't be too much of an issue, so I said no problem. After I hung up the phone, I had

no idea how to accomplish the requested task, although I knew there had to be an easy or economical way to provide the same satellite services that we had been providing to the Reagan administration from the ground transportable antennas at various summits held around the world.

My first task was to find some type of stabilization, so I contacted my associates at Comsat Labs in Maryland, who customized antenna fixtures for me. They referred me to R.J. Matthews, a former Comsat employee, who had retired and was building TVRO antenna systems for private boats and some cruise ships. He was the founder and president of Sea Tel, Inc., then located in Martinez, California.

When I contacted R.J. and explained what I wanted to do and asked if he was interested in my quest, surprisingly R.J. said he was, and he didn't think I was crazy for asking. With my FCC licenses for the antenna and transmitters, and R.J.'s TVRO pedestals as stabilizers, we presented our solution at the Pentagon.



Executive Spotlight

In the third quarter of 1986, we agreed to deliver a Beta system. As partners for this joint venture, R.J. and I agreed to name the company Maritime Telecommunications Network, Inc.

We worked on the project for four months and, in September 1986, delivered the first stabilized Ku-band satellite antenna to the U.S. Navy. The antenna was installed on the USS Iwo Jima (LPH-2) when it deployed to the Middle East during the first Persian Gulf crisis. The antenna system was classified under the U.S. Navy for two years and was released to me for commercial endeavors in May of 1988. At that time, I started to take the antenna out on many commercial vessels, research ships, and cruise ships to provide live video uplinking back to the United States, for various national and international broadcasters.



USS IWO Jima class amphibious assault ship (LPH-2)

SM

What was the state-of-the-art technology then regarding how companies were communicating?

Richard Hadsall

Most companies and organizations back in the 1980s were using large-scale, transportable, satellite antennas (five meters or larger mounted on trailers) from remote

locations around the world. The maritime applications were accomplished by using Inmarsat standard A terminals, where they have one or two telephone lines on a 56 Kb satellite channel, at a user cost of \$15.50 per minute. There were no stabilized VSAT antennas available at the time. The military had some converted gun mounts on vessels which held large-scale satellite antennas for X-band but these were very expensive (over \$3 million each at the time).

SM

What have been the major technology advances in the industry since then and how have they affected the industry?

Richard Hadsall

The technology has advanced quite a bit, much of the advancement was developed and paid for by MTN's sole source contracts with the U.S. Navy, that constantly asked for better mobility, more power, more bandwidth, and more applications to support not only the tactical requirements but also the morale and welfare needs of the crew. Our advanced technology allowed for higher quality, more efficient antennas with better stabilization, and cost-effective prices for the integrated services.

SM

Could you give us a brief description of your current C- and Ku-band networks? How is your technology different?

Richard Hadsall

The MTN network consists of both C- and Ku-band coverage. The C-band coverage provides a seamless service utilizing overlapping global beams; we augment these with various regional beams that cover specific areas of interest of our sailing clients. Our Ku-band beams are all wide area regional beams set up in overlapping configurations allowing for seamless sailing through the most popular areas of interest for the cruising and commercial industries. We provide automatic beam switching service within our network that takes the pointing operation away from the shipboard operator. We also provide a complete managed service network allowing our clients to contract guaranteed committed information rates (CIR's), but allow them to burst above their contracted rates as bandwidth becomes idle.

Executive Spotlight

SM

We understand you are making an important investment in upgrading your European teleport. Can you give us details?

Richard Hadsall

The MTN/Erzia teleport is a strategic fit for our day-to-day business. It allows MTN to collocate all of our business units' requirements into one location saving the need for additional hub equipment, and terrestrial connectivity to multiple locations. It also allows for the collocation of government business needs for onsite X-band support. Having all of our services available in one location (like our Holmdel site) allows MTN to be a one-stop shop for all of our clients' satellite teleport needs.

SM

What do you see as the big technology breakthroughs in the next 5-10 years?

Richard Hadsall

Over the next 5-10 years, I expect to see more development of new satellite frequencies, which will allow users to communicate with higher bandwidths and smaller antennas. This could come out as wide area Ka-band or higher power Ku-band satellites covering larger footprint areas. With the current development of spread spectrum and CDMA, it will allow users "to continue to push the envelope" when bandwidth requirements exceed today's capabilities. The higher frequencies will allow for smaller and lighter terminals used in the field for military and government operations. We can expect to see many

new antenna designs being delivered using flat-array technology instead of the more commonly used parabolic or dish antenna.

SM

What is the most exciting client MTN has taken on and tell us how the solution and applications worked?

Executive Spotlight

Richard Hadsall

Our two most exciting clients have always been NBC and ABC. NBC, for example, has asked us many times to provide elaborate satellite setups for delivering special events and unique applications. These range from “The Raising of the Titanic” for the Today Show on NBC and for the Discovery Channel to coverage of the launching and maiden voyages of mega cruise ships.

Additional applications and a one-of-a-kind project included the unique design and construction of the now infamous NBC Bloom Mobile, named for the late NBC Today Show anchor David Bloom. The Bloom Mobile consisted of a 200-watt stabilized 1.5-meter Ku-band antenna mounted on the back of a custom-built Ford F450 4WD diesel truck, which allowed full motion broadcasts while the vehicle traveled at speeds of up to 70 mph across the desert.

ABC has given MTN exciting challenges as well. They called and requested that MTN provide a live uplink from a nuclear submarine somewhere out in the Atlantic Ocean and 50 feet below the surface. Not only did we broadcast the live video from inside the submarine for ABC’s anchor Robin Roberts of Good Morning America, we also delivered back to the submarine live Verizon cellular telephone connections, which ABC used for their IFB connections and producer coordination lines from under the ocean.

Another fun challenge from the Good Morning America team was building a redundant (two unilateral antenna systems) 100-watt, 1.2-meter, Ku-band uplink from a moving Amtrak train traveling from Massachusetts, west to Ohio and south through West Virginia, Maryland, and on to Washington D.C. for the week-long Good Morning America’s “Whistle Stop” tour during the presidential election in September 2008.

As most people in the industry know, I started in the satellite business in 1979 based upon challenges. I live for new technology challenges every day; it’s what keeps me active and still enjoying my job. It gives me a

reason to look forward to come to work. My motto that I transferred into the company over the years has always been “No problem and never say ‘No’.”

I want the challenge — there is always a way to make something work. The fun part is just getting there. Once you arrive, there is so much satisfaction just being able to say, “I did it” or that I found a way to get it done.

Guys, now, wasn’t that easy?

About MTN Satellite Communications

MTN Satellite Communications (MTN) is the global service provider of communications, connectivity and content services to remote locations around the world. MTN’s maritime VSAT solutions and global satellite communications network offer the reliability that only “Always On — Always Available” systems can provide. More than 600 vessels and land-based terminals worldwide, including commercial ships, offshore drilling and production sites, cruise ships, government and military vessels, private yachts, and ferries depend on MTN’s voice and data networks to allow them to “be in the middle of nowhere and at the center of everything.” Premium services include remote access for Internet, fixed and mobile phones, fax, television, onboard newspapers, banking services, direct payroll deposit for crew, and other enterprise solutions. MTN is based in Miramar, Florida, and has offices worldwide. For more information, visit www.mtnsat.com.

Editor’s Note

This is the first in a two-part Executive Spotlight series from MTN Satellite Communications. Next time, we will feature CEO *Jonathan Weintraub*.



Focus

Transitions—Satellite Fleet Migration

author: Gonzalo Garcia, VP of Operations (USA), GMV

To remain innovative, efficient and cost-effective, more satellite operators are investing in the migration of their fleet operations from a legacy ground system to a state-of-the-art commercial off-the-shelf or COTS-based system. A challenging but worthwhile process, the transition must be carried out with minimal risk and without any impact on the satellites' operations. However, a successful migration enables the new ground system to have a better performance with expanded capabilities, such as automation and lower costs, over the fleet's lifetime, which is often at, or above, 15 years.

Migration — en route toward something better



Why Migrate?

There are several compelling reasons for satellite operators to migrate ground systems for geostationary Earth orbit (GEO) missions. One common issue involves obsolescence of the hardware or software, or serious issues related to the servers or base band units.

Operators also encounter challenges with hardware and software availability and maintenance, as the systems were usually selected for the very first satellite of the fleet. Often there is a need or desire to consolidate operations into a seamless multi-mission system, or to reduce the total lifetime operations costs of a satellite fleet. Improving the fleet's efficiency and reliability; taking advantage of modern technology, such as open architectures, automation, advanced telemetry archiving and broadcasting; and safe and efficient collocation station keeping are also reasons satellite operators opt for a ground systems migration.

Overcoming Challenges

In GMV's experience of managing the migration process, there are challenges in each of the seven phases, which include specification and analysis; development and system configuration; data and operations migration; factory acceptance; on-site installation and acceptance; shadow operations; and operational support. One challenge relates to specification and documentation as the existing system's documentation is often not updated. There are often numerous non-documented

features and adaptations such as derived telemetry parameters and flight dynamics system algorithms that may become a critical issue during validation if they are not properly managed.

Another concern involves exposing the operations team to the new system through demonstrations or prototyping since they are used to the old process and may be resistant to change. Detailed planning and anticipating of realistic space needs and transfer rates are required

for historical telemetry migration because data completeness and compatibility may be a challenge. The best strategy for telemetry migration depends on many factors.

Data can be migrated in the form of raw or processed telemetry. Validation at this point is a critical task, which usually requires the development of ad-hoc tools for massive automatic comparisons between legacy data and data from the migrated ground system. Migration of derived or synthetic telemetry parameters deserves a detailed analysis from the start, including different aspects such as migration of algorithms for the real-time generation, migration of historical data, and validation. A dynamic satellite simulator may even be needed to simulate special situations impacting the telemetry.

One of the most critical elements of implementing a new ground system is the flight operations procedures migration. There may be a need for several types of procedures, including paper, semi-automated, and electronic with multiple versions, which requires working with the operations team to agree on a specific strategy. While validation can be costly in this case, using an advanced, open, high-level language in the new system helps to streamline the process of the flight operations procedures migration.

To be successful, all satellite engineers and satellite controllers should participate actively in very thorough training sessions that include a differential analysis with the legacy system, so that the support team fully understands the new system.

Another challenging phase is shadow operations, which also requires adequate planning. **GMV** has achieved success in this part of the migration by making sure all the necessary facilities are in place to support both systems running in parallel until the transition is complete and functional. Other keys to shadow operations include ensuring that the operations team is adequately manned, anticipating tools to perform data alignment, and making sure that all external interfaces support shadow operations through dual compatibility and concurrent operations.

“close collaboration between the operator and the industrial team is essential”



Lessons Learned

Over the course of several successful ground systems fleet migrations, GMV has learned some valuable lessons to ensure smooth and cost-effective transitions for the world's largest satellite operators.

First, close collaboration between the operator and the industrial team is essential, starting with a complete understanding of the legacy system. It's easy to underestimate the number of people that should be devoted to the transition, so adequately staffing the migration on the part of the operator is integral to success.

Once an appropriately-sized team is in place, it is important to involve the fleet's entire operations team and stakeholders — not only people involved in software support — deeply into the process. However, establishing a balance is crucial and GMV is careful not to ruin their involvement with excessive testing or regressions.

It is highly beneficial to schedule early demonstrations and prototyping for some elements of the transition, and especially important for the migration of flight operations procedures phase. From the start, GMV takes into consideration customer-specific operational concepts so that the process is best suited for the satellite fleet at hand.

Validation, another essential part of the process, requires early access to key elements in the end-to-end tests, such as the dynamics satellite simulator, base band units and encryptors. GMV ensures that the validation phase procedures are as close as possible to the operational usage of the system to avoid problems when the system is operationally deployed. Performing exhaustive factory and regression testing before submitting the system to the operations team helps to streamline the process.

GMV has found that it is extremely important to have one baseband unit early on-site for testing because it allows many issues to be resolved early on in the transition. Making the unit fully compatible with the satellite before final integration is also helpful. The presence of a baseband unit early also allows anticipated end-to-end tests with telemetry processing, synchronous and asynchronous telecommands, and ranging.

GMV also stresses the importance of custom, high-fidelity algorithms for the flight dynamics system to guarantee the compatibility with the legacy system. Also valuable are open, dynamic languages for procedures automation and continuous, remote availability of the dynamics satellite simulator. This allowed for the development team to engage in multiple remote validation activities and made it possible to simulate the end-to-end tests of the new system before on-site installation.

Throughout the lengthy and complex process, GMV works closely with the satellite operator to ensure the transition is progressing smoothly. One notable transition was the successful migration of a 24-satellite fleet with eight different satellite platforms from six manufacturers that included adding many new satellites during the process. As it becomes necessary for satellite fleets to evolve prior to the end of their lifespan, migrating the ground system is key for operators to remain on the cusp of technology and cost effectiveness.

About the author

Gonzalo Garcia is Vice President of Operations (USA) for GMV, one of the leading suppliers of satellite ground systems in the world, and the global leader in satellite flight dynamics for all types of satellite missions.



The logic of validation allows us to move between the two limits of dogmatism and skepticism – Paul Ricoeur



Imagery Impetus

Astrium

The **TanDEM-X** radar satellite, designed and built by **Astrium** (Friedrichshafen), was successfully launched on Monday, June 21st). A Russian **Dnepr** launch vehicle carrying the huge satellite, which has a launch mass of more than 1.3 metric tons and measures five meters in length, lifted off from the **Baikonur Cosmodrome** in Kazakhstan. Approximately 10 minutes later, the satellite separated from the launch vehicle's upper stage. The first signals from the satellite were received



TanDEM-X radar satellite

by the Norwegian "Troll" ground station in Antarctica at 04:45 hours. TanDEM-X will operate in tandem with its almost identical twin, the **TerraSAR-X** satellite that became operational in 2007. Together, the pair of satellites will survey the entire surface of the Earth from an altitude of 514 kilometers. They will pass over each region many times, gathering data with which to construct an elevation model of the globe — covering no less than 150 million square kilometers.

DigitalGlobe

DigitalGlobe (NYSE: DGI) has an agreement under which the company provides high-resolution imagery for **DeLorme's** Earthmate series, including the **PN-30**, **PN-40** and **PN-60** models. Through this agreement, hikers, climbers, and other outdoor enthusiasts, will be able to update their DeLorme Earthmate GPS device with highly

accurate imagery for real-world perspective that exists between the lines of a traditional map. DigitalGlobe's imagery is available in tandem with the release of DeLorme's latest handheld GPS device, the Earthmate PN-60w with **SPOT Satellite Communicator**. In addition to offering premium imagery content, this GPS and satellite communication product will be the first handheld GPS navigation device capable of sending customized text messages even when the user is operating far beyond the range of cellular communications. Imagery will be available for the DeLorme devices on a subscription basis.

EUMETSAT

EUMETSAT, the **European Organisation for the Exploitation of Meteorological Satellites**, held its 70th Council meeting in Rome, Italy, where the Second Generation **EUMETSAT Polar System** took further shape. The Council agreed that a two satellite configuration be studied in Phase A, with distributed payloads for the two satellites. In regard to **Jason-3**, the Council approved the Memorandum of Understanding (MoU) with the **US National Oceanic and Atmospheric Administration** (NOAA) and **National Aeronautics and Space Administration** (NASA). The Council also approved the Cooperation Agreement between EUMETSAT and the **Italian National Meteorological Service** (NMS) on the Continuous



Jason-3



Sentinel-1

Development and Operations Phase (CDOP) of the *Satellite Application Facility on Support to Hydrology and Operational Water Management*, led by the Italian NMS. The CDOP

will cover the period between September 2010 and February 2012. Also discussed

was **Sentinel-1**, which will be the first Earth observation satellite to be built for Europe's **Global Monitoring for Environment and Security (GMES)**

program. The EUMETSAT Council also reaffirmed the role of EUMETSAT in the European Space Policy and in GMES through the adoption of a dedicated resolution. In the GMES context, the European Commission is responsible for the interaction with user communities to specify European space systems in support of European policies. EUMETSAT could be the European entity supporting the EU for the GMES activities related to operational oceanography, atmospheric composition monitoring and climate monitoring.

Geoimage

Geoimage Pty Ltd. has unveiled their new and improved website, which provides extensive information on Geoimage's imagery products and services as well as information on the current commercial optical and radar satellites. Also, information as to how GIS and remote sensing assists industries such as mining and exploration, agriculture, environmental

management and engineering, will be found at the new site.

The image galleries show the sample imagery at various resolutions, and the list of the most Frequently Asked Questions is designed to assist viewers gather the information they require quickly and easily. As satellite imagery is used by a range of industries in Australia and overseas, there is also a large amount of information explaining how spatial imagery and analysis can assist clients make their projects more cost-effective and efficient.

Here's Looking @ Earth... JAXA

The **Japan Aerospace Exploration Agency's Hayabusa** spacecraft streaked across the sky like a saber of light through the clouds as it re-entered Earth's atmosphere over the **Woomera Test Range** in Australia. In Kingoonya, the spacecraft's re-entry was visible to the human eye for only 15 seconds.

Orbital Sciences

Orbital Sciences Corporation is celebrating the second anniversary of the launch of the **Fermi Gamma-ray Space Telescope** spacecraft, which has performed flawlessly over the initial two years of its mission to supply scientists with important new data about the nature of the universe. In the second year of operation the spacecraft, which



is based on the mid-class low-Earth orbit platform that Orbital recently acquired, established an overall system availability of 100 percent, providing continuous scientific data and enabling the mission team to lower costs by reducing staff needed for routine spacecraft operations. The spacecraft began its mission known as **GLAST**



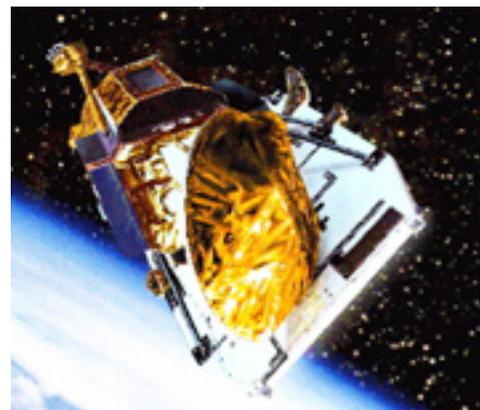
(*Gamma-ray Large Area Space Telescope*) when it was launched in June 2008 and was later renamed in honor of famed physicist *Enrico Fermi*. Its two payloads, the *Large Area Telescope (LAT)* and the *Gamma-ray Burst Monitor (GBM)*, have been continuously mapping and providing data on the sources of gamma rays, the most energetic form of radiation in the universe. The LAT maps the cosmos for gamma rays using a “Sky-Survey” mode of operation, in which it maps the entire gamma-ray sky every two orbits, or just over a three-hour period, providing scientists with a continual picture of the dynamic gamma-ray universe. For the past two years, the Fermi space-based observatory has been generating a rich stream of data for the scientific community, providing the basis for numerous publications and symposia. The Project Scientist for the Fermi mission, *Julie McEnery*, notes that each month scientists are publishing an average of almost 30 new papers based on data from the Fermi spacecraft.

The Fermi spacecraft is built on a platform engineered and constructed by the **General Dynamics** satellite unit that Orbital acquired in April 2010. The acquisition brought 325 new employees and a state-of-the-art 135,000 square foot space systems manufacturing, integration and test facility under Orbital, which now offers a comprehensive range of small- and mid-size space systems to meet the needs of the scientific, defense and intelligence, and commercial space communities for low-Earth orbit and geosynchronous orbit missions.

Thales Alenia Space

Thales Alenia Space has signed a contract with **Ball Aerospace** covering the preliminary phase for the **GFO-2** RA altimeter, which will equip the new-generation **Geosat Follow-On 2 (GFO-2)** satellite. This phase covers the

definition, design and system compatibility aspects; the final contract for the production of the altimeter is expected by the end of 2010. Ball Aerospace is the program’s



prime contractor on behalf of the U.S. Navy. The measurements provided by this new-generation GFO-2 will cover all of the planet’s oceans, delivering vital data for military strategy. As a partner in this program, Thales Alenia Space will develop the bi-frequency altimeter, using a technology derived from the Poseidon family of altimeters, already in operation on the Jason series of oceanography satellites. Thales Alenia Space and Ball Aerospace have already teamed up on climatology, since the **Caliop** instrument built by Ball Aerospace was integrated in the **Calipso** satellite in Thales Alenia Space’s clean rooms, within the scope of the partnership between **NASA** and French space agency **CNES**.



Connecting The Other 3 Billion...

author: Steve Blumenthal, Chief Network Architect, O3b Networks

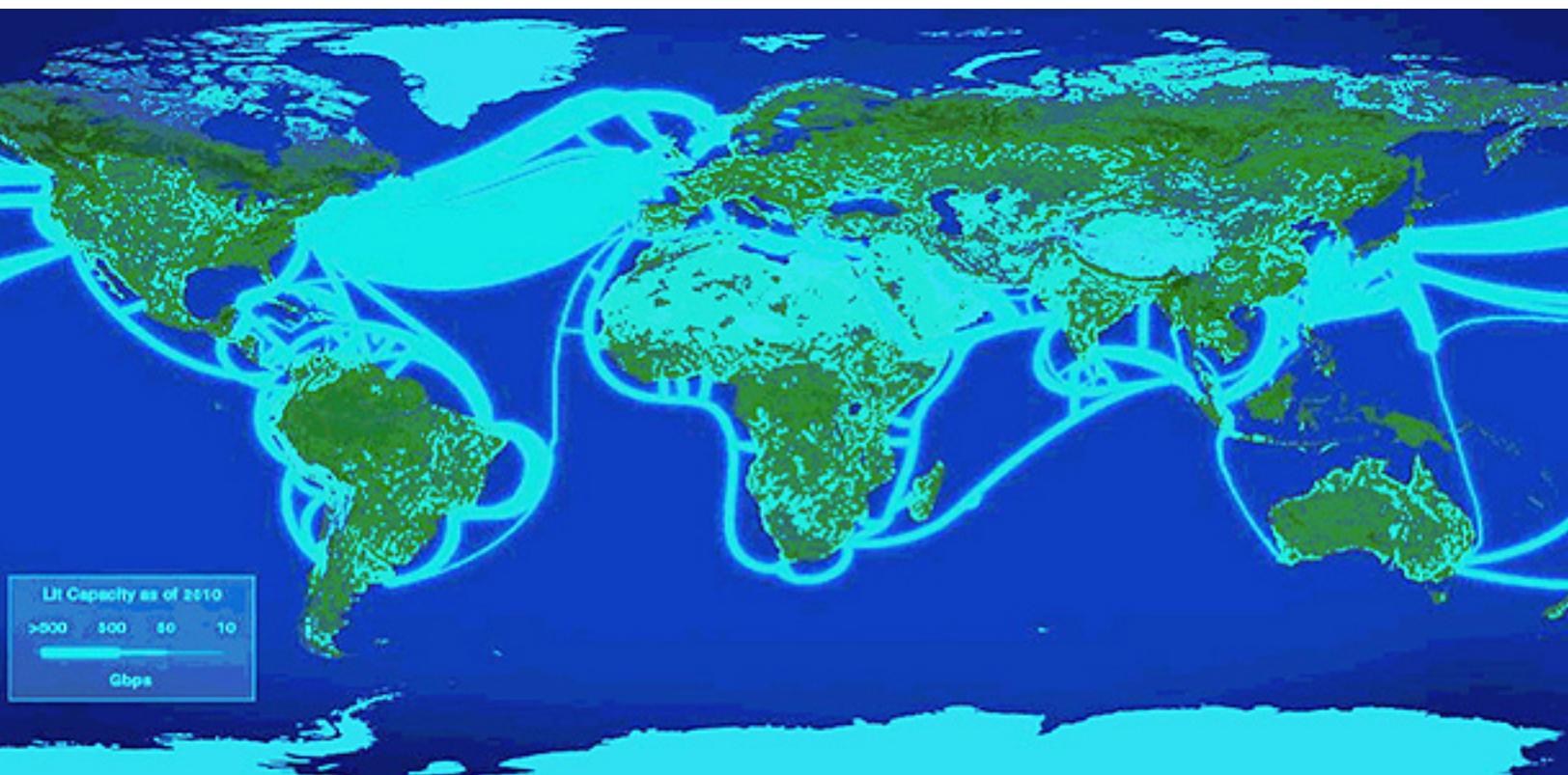
Suppose you want to start a business to provide online access for offshore oil rig platforms off the coast of Nigeria. Initially you want to provide interactive tutorials on how to safely extract the most oil and gas from the undersea well without endangering the environment along with training on worker safety.

You would also like to provide video monitoring of the offshore assets to protect them against pirate attacks. Eventually you want to provide email, voice calls and video chats for the workers to talk to their families back home, as well as Internet access and video on-demand movies for worker education and entertainment. It is very difficult and expensive to provide all of these services today in that region of the world.

Much of the developed world is linked by high capacity fiber optic cables providing voice, video and high speed Internet services. The developing world (Latin America, Africa, Middle East, South Asia, and Southeast Asia)

has limited fiber connectivity around the periphery of its continents. There is also very limited fiber connectivity to a few of the Pacific Island countries. The interior regions of these continents are dependent on very expensive, limited capacity from geosynchronous orbit satellites.

In addition to the high costs (due to limited available capacity on the satellites that are over these regions), the services offered by these satellites have very high round trip latencies (> .5 sec.) due to the distance to the satellites of 35,786 kilometers. The limited available bandwidth, high costs, and long latencies combine to deliver a poor experience especially for interactive



services, such as voice calls, video conferencing, or web site downloads. The map on the previous page reveals the current global fiber connectivity and the underserved populations in all key markets addressed and covered by the company. The nexgen satellite network will reach more than three billion consumers, businesses, and organizations in more than 150 countries across Asia, Latin America, and the Middle East.

The organization will launch and operate a new constellation of communication satellites operating in a *medium earth orbit (MEO)* in the equatorial plane at an altitude of 8062 kilometers. By bringing the satellites closer to Earth, the latency aspects are lowered by a factor of 4.4. The amount of signal power required is also reduced by 13 dB (a factor of 1/20th), which reduces the satellite's size and weight, multiple satellites can be launched into orbit with a single launch vehicle, dramatically lowering the capital required to build and launch the constellation. Lower capital expenditure means the service pricing can also be significantly lower.

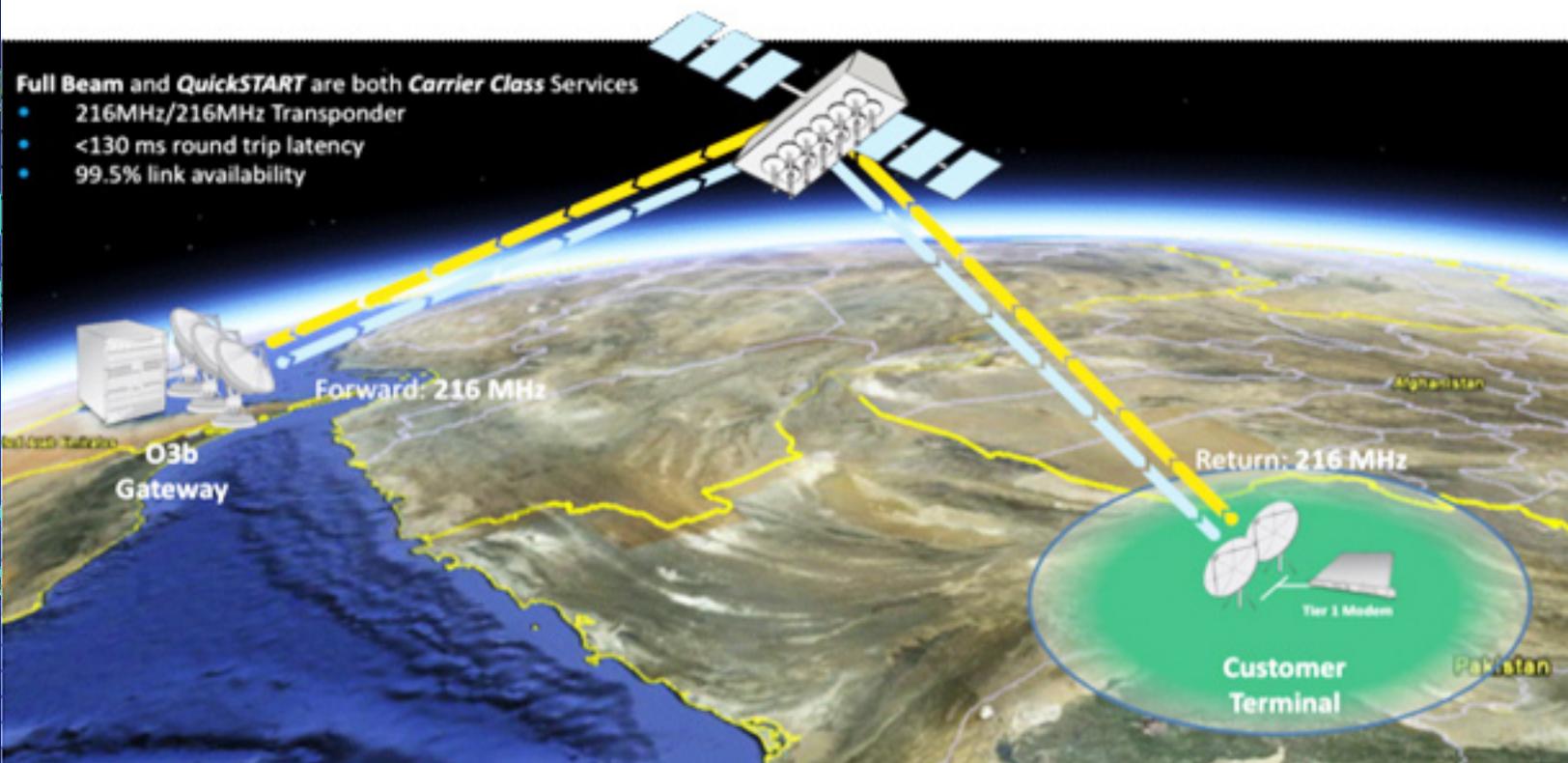
The first set of eight satellites are being built by **Thales Alenia Space** in Cannes and will be launched by **Arianespace** using a **Soyuz 2** rocket from French Guiana. As each satellite will weigh on the order of 600-700 kg, four satellites can be launched simultaneously using a single Soyuz 2 launch vehicle.

The O3b constellation is highly scalable. With successive launches, new satellites can be added to the orbit, which brings additional capacity as well as in-orbit satellite redundancy. Plans are to operate a constellation of 20 satellites by 2015. O3b's groundbreaking concept is endorsed by investments from **SES, Google, Liberty Global, HSBC Bank, Allen and Company** and **North Bridge Venture Partners**.

Satellite Capabilities

Each satellite will have 12 steerable antennas that can focus a 600 km diameter spot beam on any point of the Earth between +/- 45 degrees N/S latitude. In one configuration, two of these steerable beams will be dedicated to a Gateway site and the other 10 beams used for customer locations in each region. RF circuitry in the satellite communications payload multiplexes these 10 customer beams into the two Gateway beams. Each customer beam operates in the Ka-band and has an available bandwidth of 216 MHz.

Once launched, the satellites will be equally spaced around the equator. Earth has been divided up into seven regions for the initial eight satellites. Within each region, there will be one satellite passing overhead. Each region will be anchored by a Gateway site (a point of interconnection to the fiber Internet) and a simple handover method has been designed to allow each



Focus

satellite to transition from one region to the next at the end of its pass. Onboard computers and navigation systems keep each steerable tracking antenna locked on a specific location on the Earth (either a Gateway or a customer site) as the satellite moves through a pass over each region.

Network Services

The firm makes its services available to customers via wholesale beam purchases, in which the customer has access to the full beam's 216 MHz of bandwidth in each direction and can choose to purchase any O3b compatible ground equipment from the suppliers. Alternatively, customers can purchase a fully managed service that includes a portion of the beam's bandwidth, the customer terminal equipment, and delivers 155 Mb/s in each direction with an availability guarantee of 99.5 percent.

Initially, the plans are to offer ground equipment to support two types of services: **high speed IP trunking (Tier 1)** and **lower speed remote site access (Tier 2)**. Tier 1 service will use a new high speed modem being developed by **ViaSat** to provide dedicated point-to-point links at data rates starting at 155 Mb/s (STM-1 or OC-3 data rates) up a top data rate of between 600 and 800 Mb/s, depending on local conditions. Tier 1 services will be used primarily by carriers for high speed access to core Internet exchange points. They can also be used to bring back aggregated voice and data traffic from remote regions to a central network hub facility.

The plans are to have equipment available to provide lower speed Tier 2 services. Tier 2 services will be used for remote backhaul for 2G/3G/4G mobile or WiMAX wireless towers, business Internet or VPN services, along with access for government facilities, schools, libraries, and health centers. Tier 2 services will be configured as point-to-multipoint networks and operate at data rates

between 1 to 50 Mb/s.

These services will be similar to traditional enterprise-class VSAT services using a hub system that is located at an O3b Gateway or a customer owned central gateway site with the remote terminals spread out within a single customer beam or across several O3b beams.

Ground Network Components

The Earth has been divided into seven regions based on longitude — each region is anchored at a Gateway that provides interconnection to the fiber Internet and access to the major Internet exchange points in that region of the world. Additional Gateways can be added over time.



Focus

O3b recently announced a contract with ViaSat to provide the initial suite of ground equipment for the Gateway terminals and the Tier 1 customer terminals. In addition, as indicated earlier, ViaSat will develop a new high speed modem based on the **DVB-S2** standard to provide data rates up to 800 Mb/s. O3b compatible Tier 2 hub and remote VSAT terminals will be produced by a number of VSAT vendors.

Gateways

Initially O3b will build seven gateways to provide connectivity to the Internet in each of the seven Earth regions. The figure below shows these regions and Gateway sites.

Gateways will be located at sites that have high speed Internet connectivity and are also in locations with very low average and peak rainfall to minimize any Ka-band interference. Each site will have three 7.3m tracking antennas and associated modems and RF electronics.

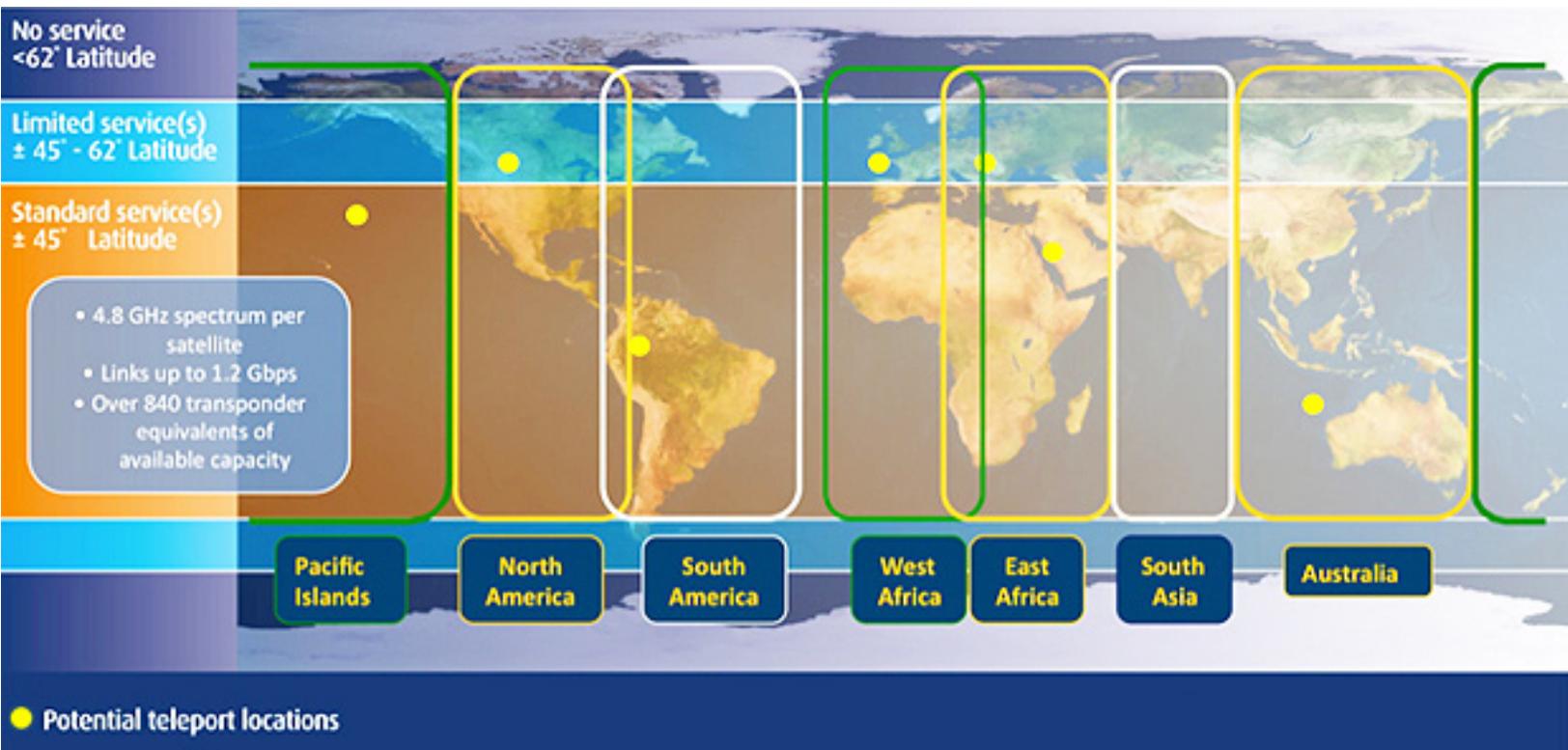
Two antennas are required to track the satellite overhead and to be available for handover to the next rising satellite. The third antenna will serve as a hot standby spare to provide high site availability. An IF-band non-blocking switch matrix under control of the network management system is at the core of the Gateway. It assists with handover and will permit any modem to be

connected to any antenna in the event of a hardware failure. Each of these Gateway sites will have redundant fiber paths to the core regional Internet exchange points. In addition to caching servers, high speed routers and LAN infrastructure, the Gateway sites will provide collocation space for customer owned equipment, such as other servers, routers, or VSAT hubs.

Tier 1 Customer Terminals

The Tier 1 terminals are designed for high speed point-to-point IP trunking. The basic configuration consists of two 4.5m Ka-band tracking antennas, associated RF electronics including a 500W high power amplifier (HPA) and a very high speed modem. A third hot standby antenna can be added for a fault tolerant configuration.

The high speed modems can handle data rates from 155 Mb/s up to over 800 Mb/s using standard DVB-S2 modulation and coding rates. The Tier 1 modems support real-time *Adaptive Coding and Modulation (ACM)* which allows them to cope with any channel interference that may arise, and to operate at the optimal data rates that are supported by the link conditions. The Tier 1 terminals work in conjunction with the Gateways to implement handover from one satellite to the next at the end of each pass. Initially the Tier 1 terminals will be supplied by ViaSat, though over time there will be other suppliers.



Tier 2 Customer Terminals

A wide range of services can be offered with the Tier 2 terminal equipment, such as access to the Internet for a business, school, government office, hospital or library, a multi-site private network for an enterprise or another institution, or remote cell tower to base station controller (BSC) or WiMAX tower backhaul. Tier 2 terminals will operate over medium data rates at speeds between 1 Mb/s up to 50 Mb/s. These services will be implemented using a VSAT point-to-multipoint hub and spoke network. The VSAT hub equipment can be located at an O3b Gateway or at a customer owned Gateway.

The remote terminals can all be located within a single customer beam or spread across several beams that all go back to the same Gateway. A set of requirements for the Tier 2 terminals has been published and supplied to the VSAT vendors to allow them to create an O3b compatible version of their current products. O3b is planning to qualify a number of VSAT systems to work with the constellation. The main requirements are to have the remote terminals track the satellites across the sky, to handle the small amount of Doppler shift in the signals from the satellites, and to implement handover from one satellite to the next.

For efficiency within each beam, most of the configurations access the remote terminals via a flexible time division multiplexed forward link (outbound from the hub to the remote terminals). Depending on the nature of the application, the required data rates, and the number of remote terminals, different schemes such as *single channel per carrier (SCPC)*, *time division multiple access (TDMA)*, *frequency division multiple access (FDMA)* or *code division multiple access (CDMA)* can be used for the return path from the remote terminals back to the hub system. O3b expects to have Tier 2 terminals from several vendors available to customers prior to the launch of the satellites.

Bandwidth Bonanza

The company is poised to be a disruptive influence in the satellite industry by making a copious amount of new bandwidth available to the developing world at a moderate cost. The wideband beams will significantly increase the data rates delivered to end users in the regions that are served. In addition, the significantly lower latency will enable new more natural real-time applications and provide access the developing with

access to the latest Web 2.0 applications such as cloud computing, software as a service, social networks, financial market tools, and emerging **Ushahidi** collaborative event reporting wikis (that have been used to track the violence following the recent elections in Kenya and to assist in finding survivors of the Haitian earthquake by allowing individuals to update online databases from their mobile phones).

About the author

Steve Blumenthal leads the design of the end-to-end system architecture for the O3b network. Prior to joining O3b, Steve worked as the CTO and head of engineering at BridgePort Networks, Genuity, GTE Internetworking, and BBN. At BBN, Steve worked on the commercialization of the Internet and early R&D related to packet satellite networks. Following the terrorist attacks of September 11, 2001, Steve served as an advisor on Internet Security to the US Congress and the President's Special Advisor on Cyberspace Security. Steve holds BS and MS degrees in electrical engineering and computer science from MIT.





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Authors

Steve Blumenthal
Gonzalo Garcia
Carol Hively
Dr. Christoer Ralph Lavers
Hartley Lesser
Scott Smith
Wally Martland
P.J. Waldt

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Satnews Publishers
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Sonoma, CA 95476 USA
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