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Price: INR 150 / US$ 15 Subscriber's copy. Not for Sale

R.N.I No - UPENG/2010/34153; Registration no: UP/GBD-136/2017-19
Publication: 10th of every month I Posting: 15th / 20th of every month

JULY-AUGUST 2017 » VOLUME 08 » ISSUE 02 | ISSN 2277–3134

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THE NEW SPACE REVOLUTION

Space industry has ushered in an era of technological and entrepreneurial renaissance, changing the way we see the world

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CORNER OFFICE
HOWARD LANCE
CEO, MDA

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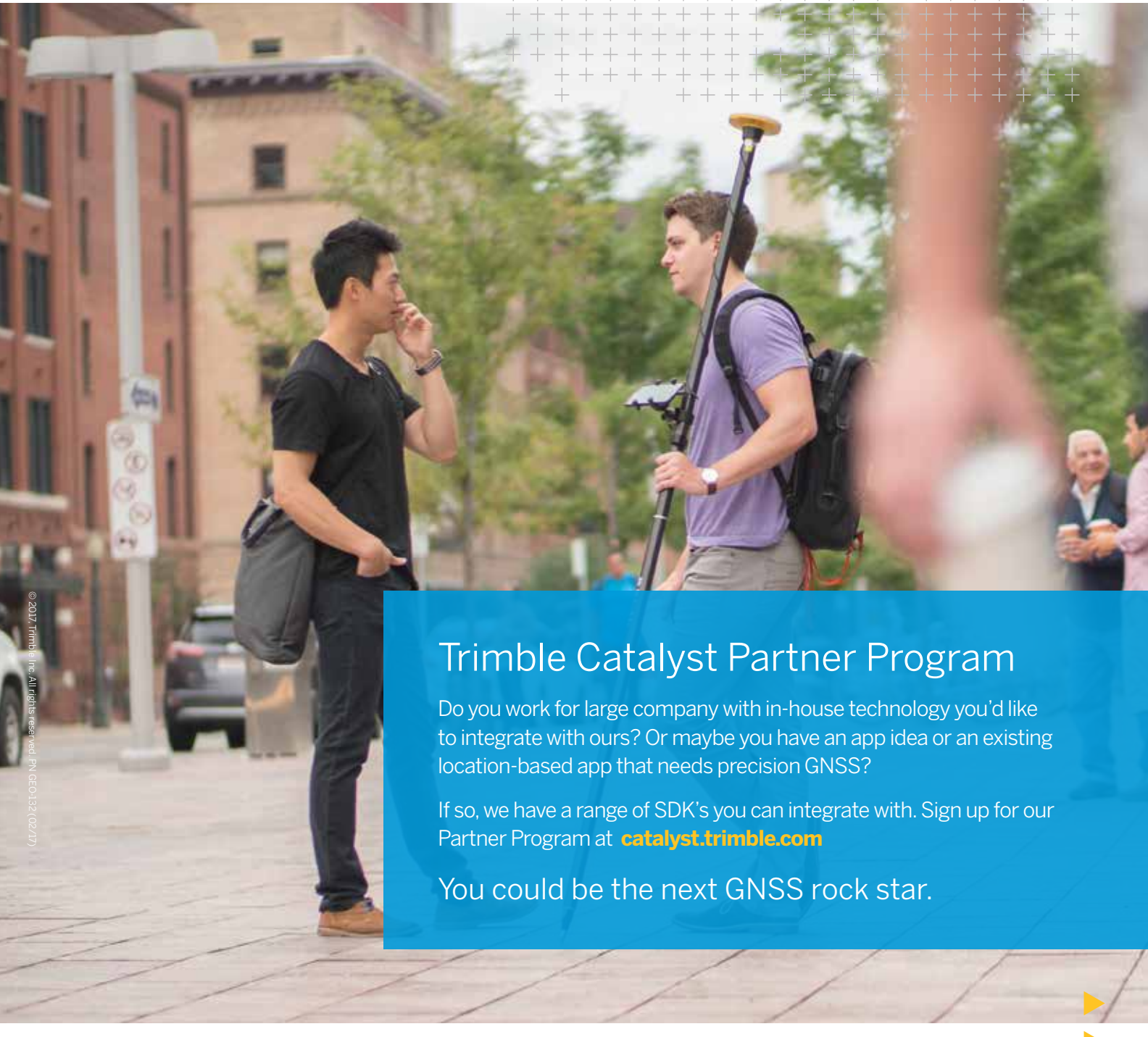
SPECIAL FEATURE
DR JOHANNES RIEGL
CEO, RIEGL GROUP



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VOLUME: 08 ISSUE: 02

Owner, Publisher & Printer: Sanjay Kumar
Printed at M. P. Printers
B - 220, Phase-II, Noida - 201 301
Gautam Budh Nagar (UP) India

Publication Address
A - 92, Sector - 52, Noida - 201 301 India.
The edition contains 68 pages including cover.
Geospatial World Geospatial Media and Communications Pvt. Ltd.
A - 145, Sector - 63, Noida, India
Tel + 91-120-4612500
Fax +91-120-4612555/666
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SUCCESS OF NEWSPACE

Prof. Arup Dasgupta
Managing Editor,
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Space, the separator, is disappearing from the novelty of Space as we hurtle into the era of NewSpace. Like most other 'newwords', it is a catchy way of describing yet another disruption that is happening in the arena of space technology and applications. This disruption is fed by the commercialization of space ventures from launching to applications. Dare we call it the democratization of Space? We could, if it meant the easy access of Space to the common person. So, before you start searching for the next shuttle to Mars for your vacation it might be a good idea to examine what is new in NewSpace.

For one thing it is all about commercial reusable launchers and small satellite using COTS hardware, which results in lowering of costs thus opening the field to many more players other than the government institutions and high net worth individuals. Looking at it from the geospatial viewpoint what will it mean? Will data become cheap? I think not. Private players have to first create value for their shareholders and that will come from data sales. Is data a commodity that can be grown, sold, purchased and consumed? Does it have a shelf life? If so, what is the opportunity cost of data lying in archives unused? As the US and other experiences show, a business model based on data sales is not viable unless there is a strong government backing in terms of assured purchases.

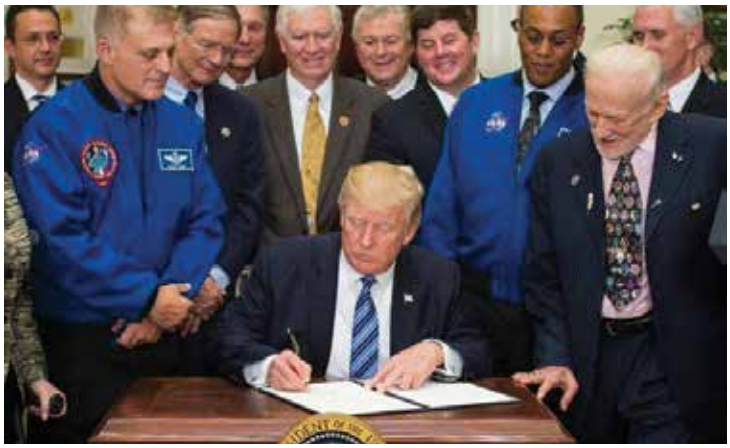
For Geospatial NewSpace not to come a cropper the key will be in value addition. Today, just imagery is not enough. Non-imaging data which may be structured or unstructured, which is collected purposefully or opportunistically, also presents a huge treasure trove to be mined. Technologies like the Cloud, Big Data analytics, deep learning and blockchain can be used on heterogeneous data ensembles to yield actionable information. This will be the model to rely on and this also constitutes a part of the NewSpace effort. How will imagery data producers enter this field? Will they grow these capabilities in-house or will they form consortiums? Will there be third party developers who will make profit on the value addition in the form of Apps (another interesting 'newword')? In the end, their business viability will depend on what they bring to the marketplace, at what cost and under what regulations.

The marketplace is not uniform. As Greg Scott and Abbas Rajabifard point out in their paper on "Sustainable development and geospatial information: A strategic framework for integrating a global policy agenda into national geospatial capabilities," while the developed countries have an embarrassment of riches in terms of data, the vulnerable communities suffer from the lack of it. In such an unequal scenario how do we see NewSpace developing? Many NewSpace entrepreneurs at this end of the market are working on solutions like crop insurance, disaster management, forestry, etc. which they hope to sell to government entities rather than individuals. These entrepreneurs are not bound by national boundaries. They are part of an international consortium which covers space technologies, financial services and brick-and-mortar industries.

Costs, accessibility and regulations governing these solutions will play an important role in such NewSpace solutions. Commercialization will also mean copyrights and patents which may limit the spread of such solutions. One needs to look at the pharmaceuticals market to get a picture of a possible future or one could be optimistic and hope for a 'NewCreativeCommons' in the future. In any case, most governments are not equipped to deal with the disruption likely to be caused by NewSpace. There are no policies which govern the entry of private industry as independent players in space technology and applications. In fact, many governments deny certain classes of spatial data to their citizens in the name of national security. Will they allow solutions based on such restricted data?

All said and done, NewSpace is exciting, just as Space was so exciting a few decades ago, when it was new.

TRUMP RESURRECTS NATIONAL SPACE COUNCIL AFTER 24 YEARS



The US President Donald Trump signs the order creating the National Space Council on June 30, 2017

The long-anticipated National Space Council that will bring both military and civilian government space programs closer, was signed by the US President Donald Trump on June 30. The council has been restored after 24 years. Vice President Mike Pence will chair the council and become the President's chief adviser on national space policy.

The council can either bring clarity and focus to the nation's space efforts, or can create more confusion in an environment where civilian and military programs have different goals and operating systems. US Representative Mo Brooks, who represents the district that is home of NASA's Marshall Space Flight Center, attended the signing ceremony and was optimistic.

"The National Space Council will realign our nation's space policy towards national goals and assess possible gaps in government systems," Brooks said. "With the reestablishment of the National Space Council today, President Trump and Vice President Pence have put America back on a path to global leadership in space."

Corroborating his thoughts, NASA Administrator, Robert Lightfoot said:
"I am pleased that President Trump has signed an executive order re-establishing the National Space Council. The council existed previously from 1989-1993, and a version of it also existed as the National Aeronautics and Space Council from 1958-1973. As such, the council has guided NASA from our earliest days and can help us achieve the many ambitious milestones we are striving for today.

"This high-level group advises the President and comprises the leaders of government agencies with a stake in space, including the NASA administrator, the Secretaries of State, Commerce, Defense, and others, and will be chaired by Vice President Mike Pence. It will help ensure that all aspects of the nation's space power—national security, commerce, international relations, exploration, and science, are coordinated and aligned to best serve the American people. A Users' Advisory Group also will be convened so that the interests of industries and other non-federal entities are represented.

"The establishment of the council is another demonstration of the Trump Administration's deep interest in our work, and a testament to the importance of space exploration to our economy, our nation, and the planet as a whole."

FARO ZONE 3D FOR PUBLIC SAFETY PROFESSIONALS

FARO has announced the availability of FARO Zone 3D software. This revolutionary platform, through its advanced smart tools, is the first of its kind to enable investigators to move fluidly between 2D and 3D environments and enhance the quality of incident reconstruction analysis or presentations for public safety professionals.

FARO Zone 3D drastically elevates the visual impact of presentations, including courtroom exhibits, by enabling accurate 2D and 3D scene diagrams, 3D scene walk-throughs, and full scene reconstruction animations.

FARO Zone 3D also enhances the ability of public safety professionals to plan for, and respond more effectively to emergencies by creating accurate representations of real-world locations within local communities.

KEY FEATURES

- FARO Zone 3D consists of precise diagramming and measurement tools.
- It has blood spatter analysis tools along with bullet trajectory analysis tools.
- Users can easily draw and edit in 3D or in 2D and see both views simultaneously.

PDF3D ANNOUNCES LATEST UPDATE ON V2.14, MEETS DEMANDS OF DRONES

PDF3D has announced the release of their latest major update to the entire suite of products including PDF3D SDK, XML Server, ReportGen and PV+. The new update brings features in line with users working with large and complex 3D data.

PDF3D, the long-established expert in 3D PDF conversion technology and 3D report enhancements, has continued to push up standards with their latest V2.14 release. The update, not only supports end-users and developers working with 3D data in the fields of manufacturing, geospatial and mining, but also those who work with scanned data, drone images and creative design applications. PDF3D tools enable users to convert and compress large and complex 3D data (typically generated in niche applications), into the universally-used PDF format, without losing any image quality, making it easier to share and archive for better collaboration and document management.

KEY FEATURES

- With updated 3D PDF surface visual effects there is improvement in texture handling and visual quality.
- Enhanced DWG coordinate system and more transparent conversion to match CAD views.
- PDF 3D tools enable conversion and compression of complex 3D data into PDF format without losing any image quality, making it easier to share.

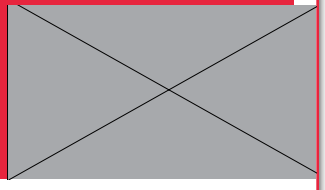


IMAGEM LAUNCHES SATELLITE-BASED EARTH MONITORING PLATFORM

IMAGEM has launched Cloud-based platform Rheticus in partnership with Planetek Italia, for Belgium, The Netherlands and Luxembourg. Based on Hexagon Geospatial's M.App Enterprise technology, Rheticus delivers fresh and accurate data and information for monitoring of the Earth's surface transformation phenomena.

Rheticus geo-information service uses a series of industry-focused dashboards to deliver timely and accurate information to policy and decision makers, managers and users for operations and data-driven decision making. The Rheticus platform has been developed by Planetek Italia, a Hexagon Geospatial premium partner from Italy.

IMAGEM aims to deploy Rheticus with the local governments, environmental and forestry agencies, road and rail, networks (NUTS), construction, mining, heavy industry and more. The platform can be used directly by these organizations or by solution providers and system integrators.

KEY FEATURES

- Rheticus geo-information service uses a series of industry-focused dashboards to deliver accurate information.
- It allows users to have an early warning system, avoiding unnecessary risk and cost.
- Integration of Rheticus in Hexagon Geospatial Smart M.Apps can offer analytics and dynamic maps to users worldwide.

ADVANCED IMAGE AND SIGNAL PROCESSING TO AFFORDABLE LAUNCH SYSTEMS: THE EXCITEMENT

In recent years we have heard much from the US national security community about the growing threat to space assets and the need for transformation of space systems. What is driving the concern and what do you think needs to be done?

Over time, the decision makers and military forces of the US and allied nations have come to rely heavily on space-based intelligence gathering and communications. Highly advanced satellite systems provide the information needed for leaders to prevent conflicts, or if military action is needed, to act swiftly and decisively. But in recent years certain adversaries have demonstrated their intent and ability to "level the playing field" by denying the US and its allies space-borne advantage using kinetic or cyberattacks. This threat has led to an emerging strategy for "mission assurance" and "resilience". Facets of such a strategy include use of larger numbers of smaller satellites, disaggregating missions across multiple platforms, rapid reconstitution of satellites including on-demand launch, and providing persistent situational awareness of activities in both space and on the Earth. Enabling this strategy will require the industry to build and deliver systems faster at lower costs with performance sufficient to meet mission needs. It also requires a system-of-systems approach, recognizing that multi-intelligence tipping and cueing, advanced image and signal processing, change detection and Big Data analytics are all part of the end-to-end solution. Our customers are looking for innovative approaches to address their tough challenges and I believe SSL MDA is well positioned to meet their needs.

How is the challenge faced by the government customers impacting MDA's US Access Plan? How is the Plan shaping up?

Our US Access Plan is designed to address the critical needs of the US government customers. I am pleased with the progress we have made thusfar. We formed a Government Systems Business Team with deep domain expertise in defense and intelligence missions. We also increased our ranks of cleared intelligence professionals. We are focusing on serving the US Government's evolving strategy, and as I mentioned earlier, they desire a highly automated, multi-intelligence architecture designed to tip and cue across platforms, with far greater sensor diversity. The customers know they must rely more on advanced image and signal processing, cloud computing and data analytics to identify the key "insights" they seek.

Government customers need to have the space segment and the ground segment operate seamlessly together, including in a contested operational environment. This is a very challenging and critical issue, but I am confident we can help solve. For instance, we are already a significant player in both government and commercial geospatial systems, thanks to our RADARSAT 1 and 2 commercial missions. We are the intelligence community leader in advanced image processing and change detection, and we provide cutting edge geospatial information production and analytical tools. We are also building innovative smallsats with production in our specialized manufacturing facility. And then of course, pending regulatory approval, we will acquire DigitalGlobe, making us the preeminent provider of commercial geospatial imagery collection and data analysis. We have focused our plan on delivering solutions for government's most pressing needs.

You mentioned the acquisition of DigitalGlobe. How is that progressing? What synergies and growth opportunities will emerge with the merger?

The regulatory approval process is proceeding as expected. We anticipate closing in the second half of 2017. We are excited to get

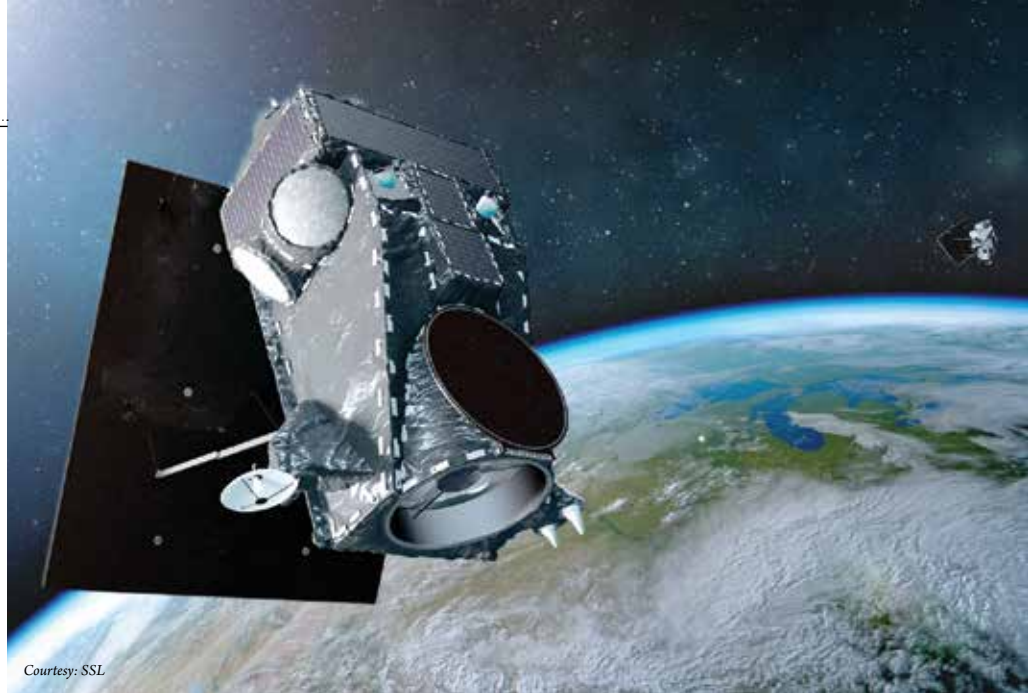
Space has once again become the "new frontier" with capabilities such as in-orbit satellite servicing and in-orbit assembly incessantly challenging the human mind. Intriguing geospatial innovations have blurred the difference between reality and science-fiction. Such developments are exciting and encouraging, **MDA CEO Howard Lance** tells in an exclusive interview

CONTINUES

> Our US Access Plan is designed to address the critical needs of the US government customers. I am pleased with the progress we have made thus far

started because we know the complementary nature of the two firms will deliver more value to our customers, expand opportunities and maximize value for our shareholders.

We are getting very positive feedback from our customers about the pending merger. Customers see the benefits that can come from combining world class RADARSAT collection and data processing with the DigitalGlobe Electro-Optical commercial imaging and big data exploitation. In addition, both firms understand the need to expand satellite constellations to combine large, "exquisite" payloads with smaller payloads and spacecraft and together will certainly drive more value which will benefit our customers.



Courtesy: SSL

SSL builds earth observation and communications satellites at its manufacturing facility in Palo Alto, California

You brought up smaller satellites. There seems to be a debate about whether smaller satellites can meet mission needs. What are your views?

One size does not fit all in my view. Depending on mission needs, we will see space architectures that include both high-resolution, high-accuracy class payloads that need very large optics, antennas and power capacity, working together with larger numbers of smaller satellites that provide near continuous coverage from both GEO and LEO orbits.

Advances in electronics, processing and manufacturing have led to very capable smaller satellites, and a resilient architecture that answers mission needs will incorporate a variety of systems. SSL MDA has a proud legacy of building and delivering both large and small satellites known for high reliability and mission performance and will continue to excel in the domain.

You were the Chairman and CEO of Harris Corporation earlier in your career. How did that experience help you in leading MDA?

There is no substitute for experience gained from prior decision-making. I tend to learn both from my previous successes, but also from those decisions that were off the mark given the benefit of hindsight. That is particularly true when looking at mergers and acquisitions. Today, I have a much keener focus on identifying realizable deal synergies and also thinking about "dis-synergies". I also very carefully evaluate the compatibility of the cultures within both companies. In the end people, not technologies make all the difference with regard to making a merger a success.

What is your leadership style?

I believe in balancing my personal time between management tasks, strategic thinking, and organization and talent development. Unless a company can excel in all three of these areas, they are going to fall behind competition. My leadership style can best be described as hire the best talent, set clear goals and direction, empower with accountability, and enable the organization to do its best work. I am always reminding my team to stay focused on the top 3-5 priorities that will have the greatest impact on future outcomes. Time is our rarest commodity, so we try to use it on the most important tasks. I also believe in driving active collaboration across the company. The days of organizations being able to be effective in silos are long past.

Where do you see the geospatial satellite industry heading? How do you see the future in, say, five years down the line?

It's going to be an interesting time as today's technology is enabling greater capabilities and insights. The ability to scale and invest will be critical. I think we will see more diverse architectures, for example building both highly capable "exquisite" systems that can run periodic revisits, tipped and cued by larger numbers of small satellites that can provide nearly persistent surveillance. We will also see near real-time integration of different sensors, including signals and images. We expect to see a very sizable investment in automation, including change detection, in order to "buy back" time for intelligence analysts and military operators. Finally, I think we can also expect to see a move to multi-level-security architectures that permit both classified and unclassified data to move seamlessly in real-time.

With so many developments happening around the technology vertical, what is it that excites you the most?

Space is once again the "new frontier" with capabilities such as in-orbit satellite servicing and in-orbit assembly once thought of as science fiction. They will be a reality in just a few years. Smaller satellites and payloads will make access to space less expensive, so the customer base will broaden and customers wanting affordable persistent coverage will finally achieve it. Smaller satellites will mean more frequent launches from smaller, more affordable launch systems. Some of the really incredible changes are not in space at all – cloud computing and Big Data exploitation will continue to advance, including far more sophisticated uses of change detection to support analysts.

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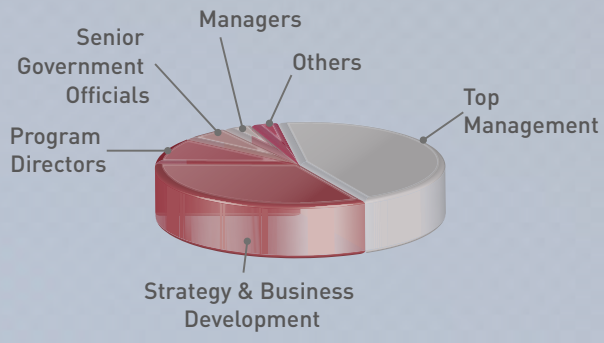

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It takes persistence to be a scientist with stellar academic records. It takes divergent thinking to be a disruptive innovator. It takes confidence to be a business tycoon. It takes the highest degree of proficiency to be a skilled pilot. And it takes a formidable combination of all these virtues to be Dr Johannes Riegl.

"My goal was to have the freedom to realize my vision and ideas in the field of laser ranging technology, unhindered by constraints as given when working within an organization other than my own," reels off free-spirited visionary Dr Riegl.

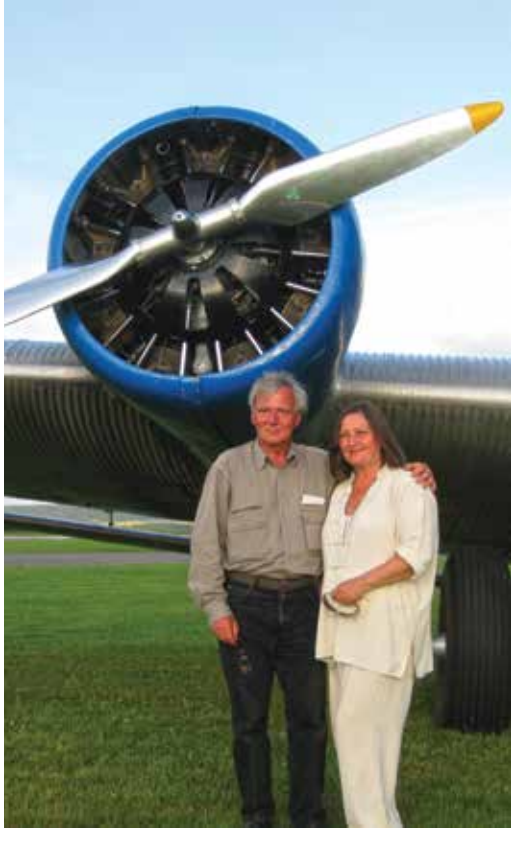
Studying radar and communications engineering in the year 1964-69 from the prestigious Vienna University of Technology provided him the means to quench his thirst for innovation. Here, he pioneered development of the essential circuitry — in principle, unchanged to this day — for driving a semiconductor laser transmitter. Young Dr Riegl also began gathering the first of many national and international patents based on his research. From 1970 to 1972 he developed the first miniaturized laser distance meters, and in 1975 when GPS was not yet available, he developed and designed a rangefinder for use in hydrographic surveying.

However, 1978 was the turning point year, after being encouraged by university colleagues to start his own company; with a handful of students he left to start Riegl Laser Measurement Systems (LMS). Based on his R&D work at Vienna University of Technology they began developing industrial and the first surveying applications.

Dr Riegl and a very early Laser Distance Meter, the RF90 with trigger handgrip, 1984

Dr Riegl and his son Johannes Riegl Jr. who is the Chief Marketing Officer are leading the company into a new era of advancements

Dr Riegl presenting latest innovations at a RIEGL LiDAR user conference in Hong Kong



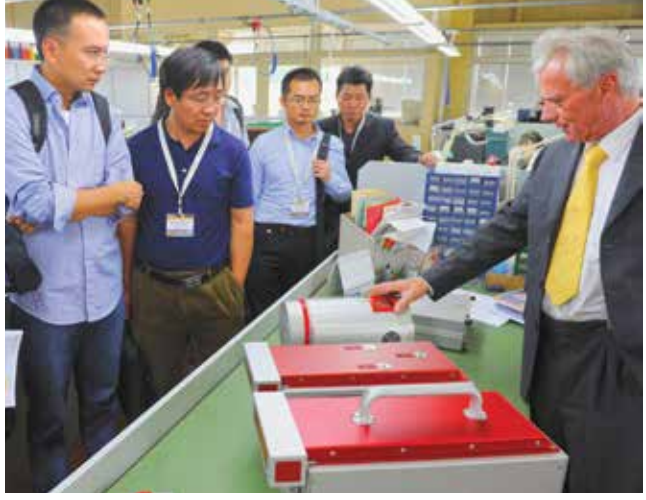
Dr Riegl's better half Eva Riegl has always been a source of unflinching support

> My goal was to have the freedom to realize my vision and ideas in the field of laser ranging technology, unhindered by constraints as given when working within an organization other than my own

The difference between something good and something great is attention to detail. Dr Riegl knows this all too well. It is still the guiding principle on which he established the now internationally-renowned RIEGL Group. "I was rather young. I managed the finances with much audacity. You could even say some amount of hubris. I had achieved every academic degree to be expected reasonably for that age. And I was convinced of my visions and, if I may say so in all modesty, my talents," Dr Riegl smiles.

The transition from the well-sheltered status of an academician to a start-up entrepreneur wasn't easy, but it was most certainly worth it.

At a point, while making a sales presentation, a manager of one of Riegl's main competitors today asked,



Top: Dr Riegl showing a delegation of visitors from China sensors at Riegl facilities in Austria

Left: Dr Riegl and Dr Ullrich (CTO) in front of the VMX turnkey mobile mapping system

"Why do we need to know Dr Riegl?" This simple question became a driving force in Dr Riegl 's life.

In 1979, Dr Riegl began experimenting with digital signal processing. In time, RIEGL technology was broadly adopted for such uses as tunnel profiling, rifle scopes, cargo cranes and cargo ship docking, and an application for determining the distance to the ground for a commercial airliner on a landing approach. Handheld 'binoculars' came in 1982. Applications capable of withstanding high heat, such as needed in the steel industry, were also developed.

"The big breakthrough came around 20 years ago. Our focus from so-called 'single point' measurements like range finding and distance or speed measurement shifted into the field of 2D and 3D laser scanning. And in 2004, we had the successful commercial launch of the LMS-Q 560, having been the first really compact airborne laser scanner engine with an up-to-date pulse repetition rate and providing full echo signal digitization and

Dr Riegl and Dr Ullrich, Chief Technology Officer and Senior Vice President (then Technical Director) with RIEGL's first commercially available 3D scanner LMS-Z210 for surveying and for industrial applications, 1998

> The biggest achievement of RIEGL is the fact that we have been able, again and again, to prove ourselves to be a leading innovator in the field of LiDAR technology for nearly four decades now

subsequent waveform processing," Dr Riegl remembers.

Soon after, Dr Riegl trained to be a pilot.

"There was a need and the opportunity for RIEGL to acquire and to operate our own plane for testing airborne LiDAR systems — a very nice, modern twin-engine plane. I, of course, also wanted to fly myself — in principle the same motivation like dozens of years ago when starting the firm!," he recalls.

Along the years, Dr Riegl has received several offers of a buyout. He still does! But, the answer is always a stern 'No'. He is of the opinion that, RIEGL is best-suited to fulfil the requirements of the customers and of the market as a standalone firm and an acquisition would have hampered innovation. Which is why, going public is also out of question.

"I was told that going public means to be damned to rapid success. And that is exactly what I did not want —

Dr Riegl receives Lifetime Achievement Award at 2017 Geospatial World Forum for his significant contributions towards the geospatial industry globally

As an accomplished academician, Dr Riegl has always rooted for innovation in RIEGL products

One of the many awards for RIEGL over the years, in this case an award for the first fully integrated Airplane/ LiDAR combinated system with Diamond Aircraft

to restrict so much my personal and my firm's freedom." This freedom is what has been fuelling innovation at RIEGL for decades now.

An intensely private man, whose hobbies include flying and water skiing may reveal an intrepid streak, is circumspect when it comes to giving advice. His success speaks quietly for itself. The $50 million RIEGL Group has more than succeeded in what Dr Riegl set out to do in 1978. Integrating technologies and data that has been gathered, processed and presented in a cost-efficient and timely manner is an equation that works.

"The biggest achievement of RIEGL is the fact that we have been able, again and again, to prove ourselves to be a leading innovator in the field of LiDAR technology for nearly four decades now."

And in the able hand of Dr Riegl and his dynamic management team, the trend of innovation with RIEGL LiDAR is set to continue for the future.

Navigating NAVIC

NAVIC is very useful for positioning in urban canyons where other systems fail. Also, its immediate users will be the armed forces who will have access to the very accurate restricted service signals. **By Prof. Arup Dasgupta**

On April 28, 2016, Indian Regional Navigation Satellite, IRNSS-1G went into geosynchronous transfer orbit and by May 3 it had taken up its position in the geostationary orbit at 129.5 degree East. With this, the IRNSS constellations of seven satellites are in position. Since then, there has been an intriguing silence on the availability of the system. The initial euphoria about an Indian GPS has subsided. This may be a good time to take stock.

IRNSS constellation consists of three Geostationary Earth Orbit (GEO) spacecraft and four spacecraft in Geosynchronous orbit (GSO) inclined at 29 degree to the equator. IRNSS will provide two types of services, namely, Standard Positioning Services (SPS) — provided to all users — and Restricted Services (RS), provided to authorize users.

Three satellites IRNSS-1C, 1F and 1G at 5-degree inclination are called GEO satellites. IRNSS-1F is placed at 32 degree East, 1C at 83 degree East and 1G at 129.5 degree East. The four GSO satellites, IRNSS-1A, B, D and E are placed in inclined orbit with longitude crossover of an equatorial plane at 55 degree East and 111.75 degree East. GSO satellites are placed in two planes with the planes being 180 degree apart. These seven satellites will cover a service area of 1,500 Km around India with an SPS accuracy of 20 m or better.

The IRNSS satellites carry two types of payloads — navigation payload and CDMA payload. The navigation payload operating in L5-band and S-band will transmit navigation service signals to the users. It also has a highly accurate Rubidium atomic clock. The ranging (CDMA) payload consists of a C-band transponder which facilitates accurate determination of the range of the satellite. It also carries Corner Cube Retro Reflectors (CCRR) for laser ranging.

Navigation satellites work on the principle of Trilateration. The position of an object is determined by its latitude, longitude, and height above Mean Sea Level. If at the time of measurement, the instantaneous position of three satellites are known and the distance of the point of measurement from each of these three satellites is known then the latitude, longitude, and height of the point can be determined using the simple distance formula.

Working of GPS receiver

A GPS receiver determines its distance from each satellite by comparing a code generated by a satellite with the same code generated internally in the receiver. The time difference between the two codes multiplied by the speed of light gives the distance. That requires a very stable signal source on the satellites which is provided by the Rubidium clock that is used to generate the code and the carrier signal for the code. Each satellite has a unique code hence the receiver can identify each satellite in its view. The carrier also contains the precise orbital parameters of the satellite which is updated regularly. The Rubidium clocks on the satellites are also synchronized regularly. The IRNSS satellite downlink signals are in L and S band. The L-band signal cannot be received by standard GPS

ISRO launched the seventh and final satellite of IRNSS on board the PSLV-C33 on 28 April, 2016

IRNSS-1 G during initial phase of integration

Courtesy: ISRO

receivers as the L-band frequency of IRNSS is different from the standard GPS satellites. Therefore, both the L and S bands will require new receivers.

The different frequencies could work as a boon. Systems like GPS, GLONASS, Beidou, and Galileo working in the L-band are subject to atmospheric distortions. Therefore they bank on the atmospheric model to assess frequency error and they have to update this model from time to time to assess the exact error. This effect is more in the L bands than in the S-band. In NAVIC, the actual delay is assessed by measuring the difference in delay of the S and L bands. Therefore NavIC is not dependent on any model to find the frequency error and is more accurate than GPS and other systems.

In January 2017 the news emerged that all three Rubidium clocks, one main and two standby, had stopped working on IRNSS-1A. In fact, the failures were as early as June 2016. However, ISRO Chairman maintained that the service was still available with the remaining satellites. Signals from IRNSS-1A would be received but not used for position location. A degradation of the positioning accuracy is expected if data from IRNSS-1A is used. The clocks, made by a Swiss company, Spectracom, have also failed on Galileo satellites of the European GNSS system and on the Chinese Beidou system. It looks like a problem with the clocks rather than the satellite. ISRO is trying to restart the clocks on IRNSS-1A, but it is not an easy task. Meanwhile, ISRO is getting ready to build and launch IRNSS-1H later this year as a replacement for IRNSS-1A.

It is interesting to note that IRNSS-1H will be assembled by a private consortium of MSMEs, Alpha Design Systems who beat biggies like L&T and BEL. ISAC facilities will be used by 70 engineers from Alpha Systems under the supervision of ISRO engineers for IRNSS-1H. Other IRNSS-1 series of backup satellites could be assembled by Alpha independently.

The precise position of each satellite is determined through CDMA Ranging using the C-band ranging transponder and the Corner Cube Reflectors which reflect laser ranging signal transmitted from the Laser Ranging ground stations. There are 14 IRNSS Range and Integrity Monitoring Station, IRIMS, located in different parts of India and more are planned in countries outside India. The IRIMS are very precisely located. They receive signals from the IRNSS satellites and establish the integrity of the constellation. Data from the IRIMS, CDMA, and Laser ranging stations are fed to the IRNSS Navigation Centre at Bylalu where the entire system is controlled and all orbital and timing updates are generated and fed back to the satellites.

NAVIC: The chosen one

Why are IRNSS satellites not in perfect geostationary orbits? Since IRNSS is a national system it makes sense to have them in geostationary orbits so that they are always visible. However, this would limit the service area to only a part of India. By adopting GEO and GSO orbits the service area is extended from 40 degree East to 140 degree East and from 40 degree North to 40 degree South. More specifically, this arrangement can give about 20 m accuracy for about 1,500 km around India and better on the Indian mainland. The choice of seven satellites ensures that any receiver in the service area will always see at least four satellites at any time. Even though 3 satellites are ideally enough to determine a 3-dimensional position, a fourth satellite is required to determine the bias between the satellite clocks and the receiver clock.

The advantage of NAVIC is that all seven satellites are always in view and at very high elevation angles. This makes it very useful for positioning in urban canyons where other systems fail because of signal shadows and multipath problems. As **Dr Tapan Misra, Director, Space Applications Centre (SAC)** says, "Chips in today's mobile phones are GPS-enabled. Since our signals are coming vertically from stationary reference, so in crowded place and narrow lanes, our NAVIC is going to work better than GPS".

Why did India opt for such a system when other systems are already available like GPS, GLONASS and Galileo? In fact, a GLONASS base station is planned for India to serve both military and civilian needs as GLONASS is compatible with NAVIC according to Group Captain Ajey Lele, Senior Research Fellow at the Institute for Defense Studies

and Analyses, New Delhi. However, all these systems are controlled by other nations and their continuity of service for global users is not guaranteed. A location is not just for finding a pizza parlor nearest to you when you are hungry! It is of utmost importance for locating and tracking mobile assets like trucks, earth moving machinery, containers to name a few. Other mission critical areas are disaster management and most importantly C4ISR program of the armed forces.

The biggest immediate users for NAVIC will be the Armed Forces who will also have access to the very accurate Restricted Service signals on the L5 and S bands. As Dr Misra puts it, "There are two uses of navigation systems. NAVIC receivers are there for security, air navigation and important installations, which are not price conscious. Good NAVIC receivers for such applications, working in both L and S bands, costing around INR 50,000 (US $775.62) are already available. These NAVIC receivers are going to be installed in aircraft soon. Progress is slow, but things are moving." For commercial users, there are several other products which can be used for both navigation and asset tracking. Hardware and software for using IRNSS for other technical applications like precise timing and mapping and geodetic data capture are also available.

The big question

NAVIC is not yet available for the use to the Indian consumers. According to Accord Software and Systems, a private company which is working with ISRO and AAI on the GAGAN project and now on the IRNSS user hardware, the easiest and fastest way is to use an add-on IRNSS dongle to any smartphone having USB On-The-Go port and a software on the phone to view the dongle output. Dr Misra adds, "If you use both L and S bands, our accuracy is more than 5 meters. This has a better potential than a 20-meter accuracy GPS which is actually supplemented by GPRS information. But NAVIC can give you the accuracy of GPRS and GPS combined, and that accuracy is not only for cities but every rural part of the country".

Dr Tapan Misra
Director, SAC,
and Accord Software Systems

> "In the absence of a chip development company, we thought we will develop our own chip and I am glad to share with you that we have already built a chip with 32 channel IRNSS receiver"

Smartphones with NAVIC support inbuilt is some way off and will depend on how fast the system picks up in the commercial market. This is because an additional receiver and antenna are needed in the smartphone to pick up IRNSS signals which are in the L5 and S bands. Smartphones in India use receiver chips that mainly support GPS. Some also support GLONASS and Beidou. All these work around the L1 band which has resulted in a quicker development of multi-constellation receivers for GPS, GLONASS and Beidou.

However, things are likely to change. Dr Misra says, "Market will look for a chip but the market is so price sensitive that investment in chip development is beyond market's capability as the chip is different from mobile phone assembly. In the absence of a chip development company, we thought we will develop our own chip and I am glad to share with you that we have already built a chip with 32 channel IRNSS receiver. This chip is now being tested and by the end of this year, we will be able to provide a blueprint of that chip. Market penetration will start slowly and once people will see the benefits, it will explode."

The future of GAGAN

Interestingly, GAGAN will not be using NAVIC. This is because AAI has to cater to international users whose aircraft are already equipped for using WAAS, EGNOS and MSAS. GAGAN has to maintain compatibility with these systems. However according to Dr Misra, "GAGAN usage is valid only up to 250 m height after which visual navigation has to take over for landing and take-off. A new type of a technology that is called Inverse NAVIC will be positioned around airports and aircraft equipped with NAVIC receivers will locate their position with respect to the ground transmitters and auto landing below 250 meters will be possible. SAC has built the technology and are on the verge of field testing it. It's very compact and we want to make it very cost effective. This new system will enable UAV operations very precisely. When you need an accuracy of one meter to operate UAVs then this system needs to be spread all across the city".

Will NAVIC displace GAGAN? Dr Misra thinks that at present they will work in co-operation, but if one technology progresses, another technology has to die over a time. Once the product becomes cheaper and receivers become small that can be even put in a drone then it can change a lot of things. Will NAVIC be shared like the recent South Asia satellite? Technically, it is possible but there has to be a demand from the neighboring countries that fall within the coverage area.

IRNSS, now NAVIC is a bold venture which is the hallmark of Made in India. The scientists and technologists have done their bit. It is for the industry to take off from here and make NAVIC a commercial success not only in India but in neighboring countries as well.

Parts of this article appeared on Governance Now in June 2016. The author would like to acknowledge with thanks the help received from Dr Tapan Misra, Director, SAC, and Accord Software Systems in the preparation of this article.

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INSPIRE Conference 2017

INSPIRE a digital Europe: Thinking out of the box
September 4-8, 2017, in Kehl ans Strasbourg

The 10th European INSPIRE Conference will be held in Strasbourg, France. Organized by Germany, France and European Commission, the conference will contribute to the implementation of the INSPIRE Directive by 2020 and serves to demonstrate the potential of the European Spatial Data Infrastructure resulting from INSPIRE for the environment and the EU Digital society. At the conference public and private sector stakeholders will meet and discuss the progress reached so far, discover new opportunities, and further examine possibilities for accelerating the implementation of the INSPIRE Directive.

The conference will focus in particular on providing incentives for strengthened cross-border and cross-sector cooperation among all those stakeholders active at national, regional and local levels.

Specific goals pursued:

- Using INSPIRE for environment and the digital society;
- Capacity building - Technologies and Training;
- The INSPIRE Maintenance and Implementation Work Programme 2017-2020;
- INSPIRE Thinking out of the box – INSPIRE innovation.

Two days of workshops will be organized in Khel, Germany, just in front of Strasbourg, **September 4-5**.

They will offer the opportunity to exchange with experts from all Europe, to learn and to propose new ideas.

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DEMOCRATIZATION OF SPACE

Decreased costs, increased capabilities and pathbreaking innovations are making earth observation satellites more relevant to businesses and public good. **By Anusuya Datta**

There is a silent revolution happening with space technology. The ability of satellites to transform businesses and quality of life today is more relevant than ever, and associated technologies have expanded at an exponential space in the recent times.

This phenomenon, which is coming to be known as 'democratization of space', essentially implies that more people and/or organizations are participating in the industry. This is to say we are on the verge of a new space race where the players, technology, and services are as diverse as it is innovative.

As **Anne Hale Miglarese, CEO, Radiant.Earth**, puts it: "The transformation of the space industry is largely driven by innovations in launch and satellite manufacturing technology." For instance, we have moved from a satellite launch mass of 20,000 kg to less than 4 kg in the span of 60 years. This "NewSpace" industry is not only defined by rapid inventions, lower costs, and rideshare opportunities, but also commercially available parts and incremental development.

Time-elapsed photo shows the successful December 21 launch and return of SpaceX's Falcon 9

Courtesy: SpaceX

The sharing economy in space, already a double-digit billion-dollar industry, is one of the fundamental societal transformations that we are experiencing collectively. It relates to the shift from just large players — specifically, governments and big corporations — who operate satellites, distribute data and supply services, towards opening of the market participant aperture to include many dozens of startups that not only deploy new technologies to support traditional applications, but also develop new applications, she adds.

"We are witnessing a convergence of technologies that will revolutionize remote sensing, generating more diverse data than ever before," points out **Fritz Schlereth, Head of Product, Descartes Labs.**

What are the drivers

The state of technology within the satellite industry is evolving rapidly. On one hand, improvements in launch systems, sensors and other input technologies, and innovations such as the smallsat architecture are driving down costs. On the other hand, more sensors and a greater diversity of sensor types mean greater spatial resolution, higher temporal cadence, and richer spectral coverage. This combination of decreased cost and increased capabilities opens up new use cases, industries, and applications for businesses, stresses Schlereth.

These innovations, along with advancements in sensor integration, machine learning, predictive algorithms, and natural language processing techniques, contribute to providing relevant and timely insights that help organizations understand their world, as events unfold, says **Jason Andrews, CEO, Spaceflight Industries.**

"A recurrent theme is that the barriers to access are being reduced and that this is at the core of this revolution," feels **M. François Lombard, Head of the Intelligence Business Cluster, Airbus Defence and Space.** There is significant ongoing investment in telecommunications, navigation and earth observation applications — it isn't just the global superpowers and multinationals that have access to space and related services, but also emerging countries, startups and even individual users with smartphones that are able to reap the rewards from this investment.

Agrees Miglarese: "The first change is associated with lower costs to access earth imagery, as well as an explosion in the availability of high-quality spatial, spectral and temporal imagery. The second is linked to the innovations in computer science, such as Cloud computing and machine learning that allows us to analyze imagery faster, and at scale." Other changes are related to the removal of technical and financial barriers to entry, and creating global standards.

Why smallsats are a big deal

Traditional large satellites, as big as school buses and weighing tens of thousands of kilograms, typically cost hundreds of millions of dollars per piece and often take years to build and launch. Because of the massive investment required to build, launch and operate them, all these years, only governments and large corporations had the necessary deep pockets.

But all that is changing. "The recent advent of smallsats, spacecraft that weigh anywhere from an ounce to as much as a few hundred pounds, has upended that status quo," a White House document *Harnessing the Small Satellite Revolution to Promote Innovation and Entrepreneurship in Space* said in October 2016. The same advances in electronics and communications technologies that enabled smartphones and put significant computing power in the palm of everyone's hand are allowing scientists and engineers to design smallsats and coordinated networks of multiple smallsats (known as smallsat constellations) that deliver novel and diverse capabilities from orbit.

These satellites — typically weighing anything between 1 to 10 kg — are made of off-the-shelf parts, and manufactured in just a matter of days, thus lowering the barrier to entry for commercial entities — from complexity, timing and cost perspective.

"Because smallsats are developed with commercial technology, we are able to build less expensive, larger satellite constellations that allow for more opportunities," reiterates Andrews. Naturally, this is encouraging a new model driven by commercial companies that are committed to making space more accessible and affordable for organizations outside of government and defense.

For instance, in February this year, the Indian Space Research Organisation (ISRO), put a record 104 satellites into orbit from a single rocket, 88 of which were from Planet, each weighing just 5 kg.

It packed in 48 doves on a Soyuz trip on July 14, making it the owner and operator of the largest

KEY DRIVERS

- NEWSPACE COMPANIES
- EVOLUTION OF SMALL SATELLITES
- CHEAPER LAUNCHES AND RIDE-SHARE OPPORTUNITIES
- INNOVATION IN COMMUNICATION TECHNOLOGIES

> The transformation of the space industry is largely driven by innovations in launch and satellite manufacturing technology

ANNE HALE MIGLARESE
CEO
Radiant.Earth

KEY BENEFITS

- DATA AT LOWER COST
- GREATER ACCESS TO DATA
- OPPORTUNITIES FOR EMERGING COUNTRIES
- BOOST FOR START-UPS
- GREATER TRANSPARENCY AND COMPETITION

fleet ever put in orbit — 197 in total, enabling it to photograph every inch of Earth's surface every day. Something even the US government can't do! No wonder the National Geospatial-Intelligence Agency (NGA) has awarded a $20-million contract to Planet, to obtain imagery of at least 85%of the Earth's landmass every 15 days.

No other company has perhaps been as significant as Planet in this nanosat revolution. As **Robbie Schingler, Co-Founder, Planet** wrote following the historic ISRO launch: "This is not just a launch (or a world record, for that matter!); for our team this is a major milestone. With these satellites in orbit, Planet will reach its Mission 1: the ability to image all of Earth's landmass every day."

"The shrinking size of the satellite has helped us (and will help others) launch more satellites. The small, standardized size of the cubesat allows us to build a larger, risk tolerant disaggregated sensor network to collect imagery of the entire Earth every day," says a Planet representative.

As the White House document noted: These capabilities can sometimes be delivered at a fraction of the cost and time of legacy satellite systems. Scientists and engineers can more quickly test their systems on orbit, allowing them to devise new, better systems more quickly, shortening the cycle of innovation and finally bringing 'Moore's Law' to space.

A growing trend that **Matteo Genna, Chief Technology Officer, SSL** (an MDA subsidiary), points to: "The popularization of smallsats and nanosats is not only making space more accessible to the masses; but since they are smaller, lighter, and less expensive to build and launch, it is within the realm of possibility for pioneering university students and individuals to build their own satellites and have them actually reach space."

Advancements in launch technology

Along with the nanosat revolution, the other obvious driver is the dramatic and ongoing reductions in the cost to launch satellites into orbit by private start-ups. The most prominent example is SpaceX, which has made a habit of successfully landing boosters back on Earth and has even launched re-used boosters twice this year. While Elon Musk's miracle company remains the first and only one to do so thus far, Jeff Bezos' space venture

> We are seeing some creative and exciting ideas come from new entrants to the industry. Unfortunately, space is hard, and the barrier to entry is often significant

MATTEO GENNA
Chief Technology Officer
SSL

Courtesy: SSL

On-orbit satellite servicing will provide operators with the ability to enhance the existing use of space assets through life extension, inspection, and repair

There has been a tremendous progress in the use of software-defined components and new sensors, further bringing down the cost and time required to provide new space-based services

Blue Origin is close on the heels, and Richard Branson's Virgin Galactic is working on the world's first commercial spaceplane.

SpaceX already boasts of lower launch costs than its traditional competitors. The starting price to launch the company's Falcon 9 rocket is $62 million, half the price of its traditional competitors like United Launch Alliance. If Musk succeeds in making his rockets routinely reusable, SpaceX costs could drop as much as 30%. Add to it the innovations in launch being done by the likes of Blue Origin or Virgin Galactic or even traditional giants like Boeing, the great advances happening at some of the Silicon Valley startups, and the already high bar in terms of low costs set by the Indian space agency ISRO, we are looking at a completely new ball game in launch space.

Then there are things beyond technology innovations. For instance, as Andrews points out, the concept of a sharing economy in space is essentially what Spaceflight's launch business is built upon, and is similar to other industry disruptors such as Airbnb and Lyft. As a launch services company, Spaceflight offers the most access to global launch opportunities by working with nearly every launch vehicle provider on the planet. "Customers can hitch a ride to popular destination or secure a launch on one of our dedicated rideshare missions. As the secondary payload, we are able to secure an extremely cost-effective option for our customers."

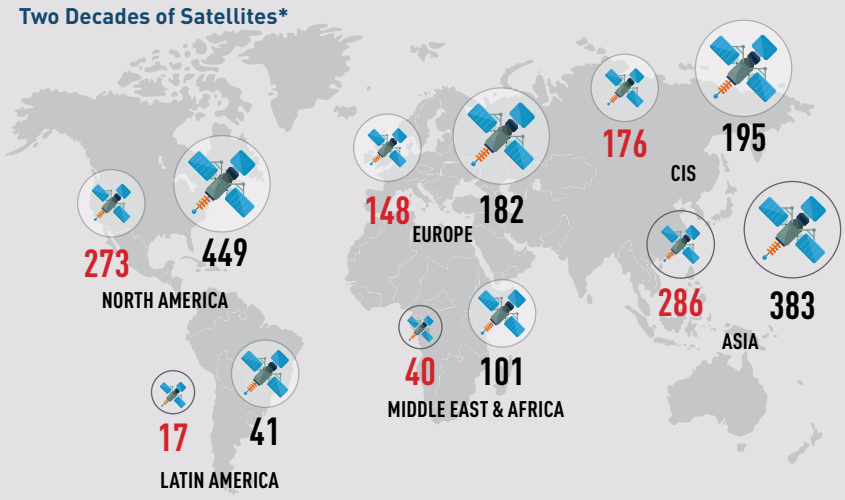
As the cost barriers come down, and the market opens up further, new business models like these will become the norm.

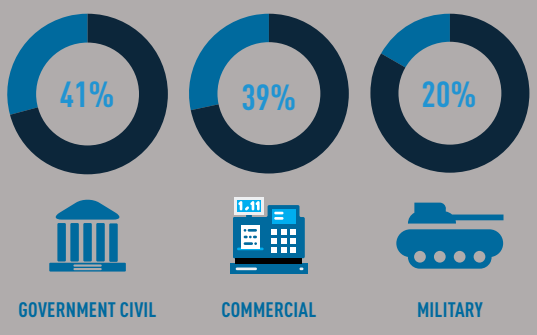
Other technological advancements

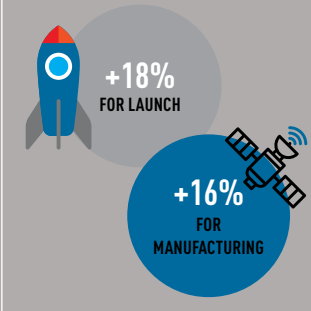
The satellite industry is constantly evolving and manufacturers are paving the way with flexible

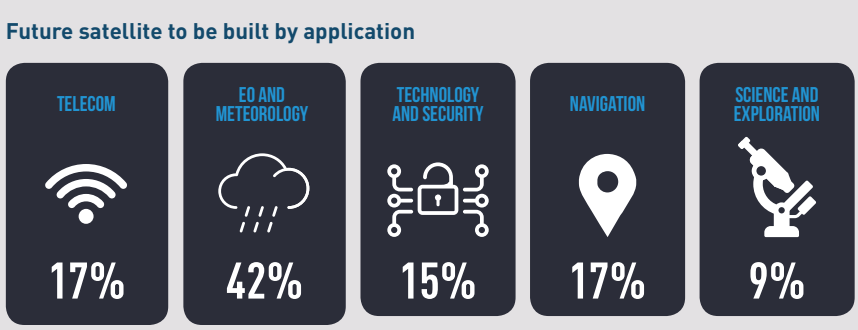
SATELLITES TO BE BUILT AND LAUNCHED BY 2025

Euroconsult anticipates that 145 satellites with launch mass over 50 kg will be launched on average each year by 2025 for government agencies and commercial organizations worldwide. In the commercial space sector, a total of 560 satellites are expected to be launched over the decade by 40 companies.

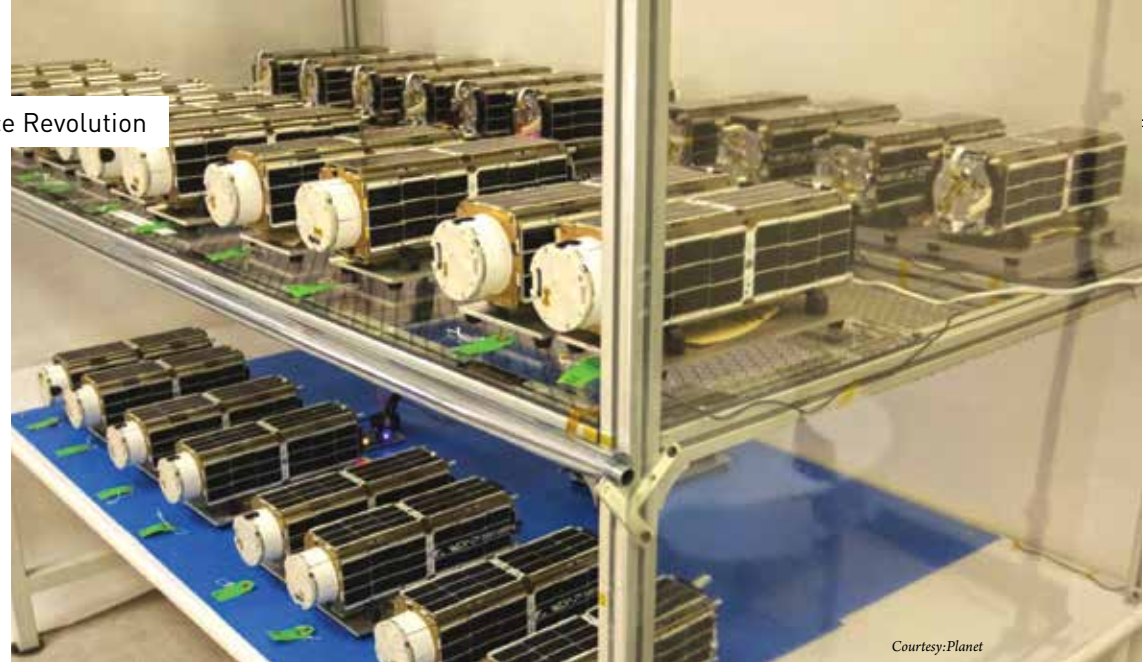








Courtesy: Euroconsult's report Satellites to be Built & Launched by 2025



Planet's Doves weigh about 5 kg each, and are designed and built in-house

TECH LEAP

- SENSOR INTEGRATION
- MACHINE LEARNING AND PREDICTIVE ALGORITHMS
- INNOVATIVE TECHNOLOGIES LIKE BLOCKCHAIN, QKD, QED
- SPACE ROBOTICS

> These innovations, along with advancements in sensor integration, machine learning, predictive algorithms, and natural language processing techniques, contribute to providing relevant and timely insights that help organizations understand their world, as events unfold

JASON ANDREWS
CEO
Spaceflight Industries

solutions that are ready to meet next generation demand and are helping to democratize access to space-based resources, emphasizes Genna.

There has been a tremendous progress in the use of software-defined components and new sensors, further bringing down the cost and time required to provide new space-based services. Increasing intelligence of satellites and concepts like SpaceDataHighway, machine learning and blockchain are revolutionizing the industry like never before.

As **Carsten Stöcker, Senior Manager, innogy SE**, who is also a member of the Blockchain Global Future Council at World Economic Forum, writes: Blockchain-enabled "smart contracts" can also allow satellites and systems that need their services to autonomously negotiate and complete transactions based on predetermined criteria such as the price a customer is willing to pay for a certain image and how quickly they need it. Users, satellite owners and even the satellites themselves could dynamically create new services to pay for their launching, insurance and other costs.

Then there are unprecedented advancements in areas like satellite servicing. As Genna reveals, SSL is working with NASA and DARPA to lead the development of satellite servicing technologies that will provide operators with unprecedented flexibility to inspect, augment, refuel, and repair satellites in GEO and LEO orbits, even for satellites that were never designed to be serviced.

The evolution in space robotics is another interesting area — remote controlled or self-supervised space robots are making space cheaper and much more accessible.

Add to it the continuously evolving cutting-edge technologies like Quantum Key Distribution (QKD) — an application built upon Heisenberg's, Planck's and Feynman's principles of quantum physics for secure distribution of very long encryption keys — quantum electrodynamics (QED), and how the technologies of light waves — whether visible or not to humans — are propelling a new global enlightenment age — including a future- habitats design movement that could be named astrospatial architecture… The future is uncharted but exciting. ***(Read: How Satellites are Rebooting Building Design, Page 40)***

Schlereth believes machine intelligence and data fusion are the keys to maximizing the value of earth observation data. This conflux of technologies is unlocking more opportunities to understand the planet and transform the way businesses use earth observation data.

Access to data

Not only is space becoming more accessible through new launch technology and spacecraft form factors, but the data that is beamed down from satellites is now made available same-day online via GUI and API. Making the data more accessible enables governments, researchers, NGOs and even students to run analysis and make new discoveries, says the Planet representative.

Democratization is also translated into how we allow partners and third parties to plug analytics over our own datasets. Plug-and-play APIs are a powerful yet easy way to develop meaningful applications and a good example would be Airbus's recent contracts announced with Space Know or Bird I. "Our objective is to simplify earth observation, to the point that seeing the world from above can be as easy as taking a selfie. With OneAtlas, a

Startups and the commercial space industry will drive improvements and transform all steps of the satellite data value chain

yearly updated basemap of the entire world at high resolution, we even take the picture before you need it," Lombard adds.

However, he also points out that space-based resources were already available to a significant extent for some time now. For instance, programs such as the US Landsat and Europe's Sentinel program have been furnishing high-quality globally orientated datasets free at the point of use for many years. GPS data, deployed by the US military, is open to all. What is changing now is the seamless way of merging datasets supported by different funding models to derive new services.

Shared satellite platform arrangements like CondoSats, PODS (Payload Orbital Delivery System), and hosted payloads are providing more frequent and cost-effective access to space, and companies like OneWeb plan to utilize smallsat technology to make satellite internet available on a global scale, believes Genna.

Similarly, with BlackSky, Andrews was among the first ones to attempt to build and scale an entire system — from developing the user interface people use to search and buy imagery, to combining the images, ground sensors, social media, news and other data feeds, building and operating the satellites, and bringing the images back to Earth.

The commercialization and heightened access to Big Data globally has made satellite imaging, data and communication less expensive and more prevalent. In the near future, almost anyone with the desire will be able to explore Earth in ways we never dreamed about some 20 years ago.

New business models

Smaller, lower-cost satellites that are able to effectively operate as autonomous swarms allow us to increase the amount of relevant data we can gather and analyze in a shorter period of time (for a lower cost). Andrews thinks this is a real game changer for commercial entities when it comes to making well-informed business decisions about global assets. As the recent trends have shown, these advances, along with the advances in the economic models of commercial space launches, will continue to make geospatial intelligence more affordable and accessible for everyone.

However, as Miglarese points out, the disruption in the market extends past the space segment hardware. In terms of the remotely sensed imagery itself, a dramatic increase in the supply of earth observations has implications for new business models, lower costs and more flexible licensing terms for commercial imagery. There is also an expansion in the utility of satellite data for a broad range of new applications. At the same time, lower technology barriers and costs are encouraging new participants, from high-tech professionals to non-experts, thereby further broadening the market.

Startups and the commercial space industry will drive improvements and transform all steps of the satellite data value chain, feels Schlereth. This extends from the origination of the data (i.e., the satellites themselves) to the processing and refinement of the data, and finally to the insights and analysis that represent value to businesses and public organizations.

One outcome of this new business environment for space-based remote sensing industry is that it will drive greater transparency and competition in the market. It will also inspire more people to participate, thinks Miglarese. Indeed, the idea of space is becoming so approachable that we now see high school students designing, building and launching cubesats. This can only lead to positive results for the industry and humanity.

"We are seeing some creative and exciting ideas come from new entrants to the industry. Unfortunately, space is hard, and the barrier to entry is often significant," feels Genna, whose company SSL partners with startups to help them across the board with new business challenges by providing a holistic support environment including testing and engineering facilities, technical support, supply chain assistance, sales channels, and financing.

It is by leveraging the startup model, which is geared for rapid iteration, that the commercial space industry will push for scale and efficiency, emphasizes Schlereth.

There is a feeling that this innovation is accelerating and is increasingly being commercially led

> The idea of a 'sharing economy' implies a revolution in the ownership of space assets. Here all users have access to increasingly relevant data free at the point of use under a distributed ownership scheme

M. FRANÇOIS LOMBARD
Head, Intelligence Business Cluster, Airbus Defence & Space

The International Space Station's Canadarm2 robotic arm captures Orbital ATK's Cygnus cargo spacecraft

Courtesy: NASA

with the government fostering the environment and acting as a catalyst, thinks Lombard. And there is no doubt that this is a positive trend for the future. "However, I would like to make one point — innovation shouldn't be concentrated on hardware and software. Of equal importance, though often over-looked, is commercial innovation. We need appropriate business models, routes to market and derived service offerings that close the business model for rolling out the infrastructure," he reflects.

> We are witnessing a convergence of technologies that will revolutionize remote sensing, generating more diverse data than ever before

FRITZ SCHLERETH
Head of Product
Descartes Labs

Not all smooth sailing

Of course, it's not all smooth-sailing, and there are obstacles along the way that need to be successfully navigated in order to reach space. Genna is spot on when he says while there has never been a more exciting time to be involved in the industry, the legal framework for non-traditional commercial space operations has yet to be established. In order to develop rules that maintain a safe and predictable space environment while at the same time encouraging commercial innovation and growth, countries need to develop innovative new national space laws to support activities ranging from satellite servicing to asteroid mining.

Miglarese also thinks political and policy frameworks struggle to keep pace with the fast changes in technology; and, many legal frameworks are inappropriate and outdated in today's world. And although these issues are being raised and addressed, it does take time.

"That said, I believe the most important challenge we face is to discover, expose and scale impactful commercial and humanitarian applications that can help our planet, and everyone who inhabits it. If we can make this happen, we will see the growth of a healthy commercial and public earth observation market place for the benefit of society and the industry at large," she adds.

Schlereth points to two major stumbling blocks today to unlocking the true value of data. The first is technological — from both the generation of the data and the compute resources to turn the raw data into actionable insights. The second is the distribution model itself — the ability to rapidly test the data for a given application and transact will accelerate the iterative loop.

In order to develop rules that maintain a safe and predictable space environment, while at the same time encouraging commercial innovation and growth, countries need to develop innovative new national space laws to support activities ranging from satellite servicing to asteroid mining

The transactional model for satellite imagery is largely optimized for just sale and purchase of imagery, and to accelerate the progress, we must shift to a model that is better suited to data, which entails an ensemble of fundamental changes. First, transactions need to be instantaneous and programmatic. Second, transactions need to reflect the value that the purchaser obtains from the imagery. For example, the purchaser should be able to easily evaluate the value of the data for his/her application and purchase scenes (or even pixels) in a piecemeal fashion. Third, the transactional space needs to be accompanied by a compute environment that allows the buyer to work with the imagery immediately and efficiently. One of the major barriers to rapid development is simply the fact that datasets aren't co-located in a high-performance computing environment. Fourth, the transactional space needs to house multiple datasets in the same compute environment. Ultimately, the most interesting and valuable applications leverage multiple data sets to create a richer awareness (and greater predictive accuracy) of the observed phenomena.

"The idea of a 'sharing economy' implies a revolution in the ownership of space-assets. Here all users have access to increasingly relevant data free at the point of use under a distributed ownership scheme where, for example, NGOs could play a part. This trend is being driven by multiple technical innovations, for example reusable launchers and nanosatellites," says Lombard. There are questions over the sustainability of this model, especially for for-profit organizations that need to make a return on their investment and have gone to significant lengths to support, for example, the operations of NGOs and the UN International Charter on Space and Major Disasters. Additionally, there are certain applications such as the ones that are security or defense-related where such a shared-ownership model may not be appropriate.

Miglarese's Radiant.Earth is trying to address some of the challenges — the need to build a vibrant community of GDC users of space-based resources; a place

'Govts shouldn't use public funds to go into commercial competition with private industry'

Dr Scott Pace
Director of the Space Policy Institute, Elliott School of International Affairs, George Washington University

How to eliminate barriers to nanosats such as high licence fees and other capital requirement?

Nanosats need not be exempt from regulations applying to larger satellites, but those regulations may need to be tailored to the particular characteristic of nanosats. For example, the small size of nanosats means they can be difficult to track and assess whether they are a collision hazard. Thus it may be necessary to require such satellites to have active or passive means of making them more easily observation. States are liable for damages causes by private actors under their jurisdiction or control, thus they have an incentive to ensure appropriate regulation and oversight.

How to regulate the space infrastructure to prevent its misuse without stifling innovation?

Licensing and regulation should be introduced carefully, in close consultation with industry, and on-best practices to ensure the long-term sustainability of space activities. Such practices should include those necessary to minimize orbital debris, comply with international spectrum regulations, and ensure that states are able to provide authorization and continuing supervision of private sector activities under their jurisdiction or control.

Should there be government support and subsidy to this idea of sharing economy in space?

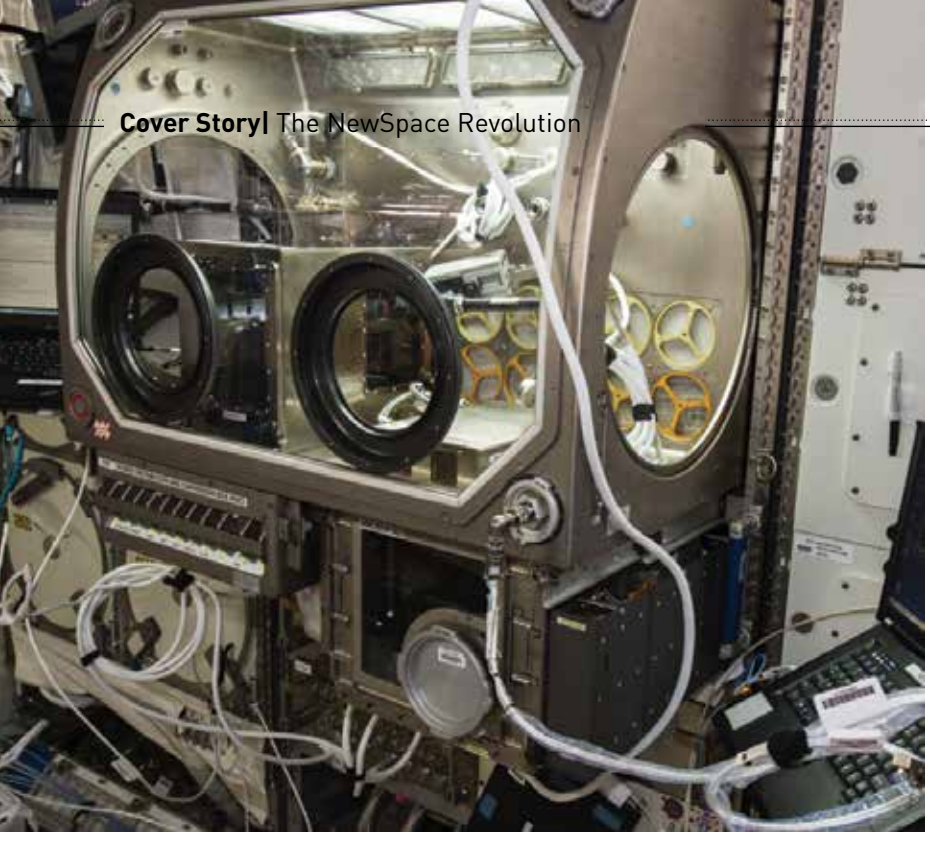
All types of funding should be encouraged. But government funding brings with it the responsibility to provide public goods as well as private gain. Direct subsides should be avoided if possible as they distort markets and create unfair competition. Indirect supports such as funding for research and using the government as an anchor customer create fewer market distortions.

Who should own the data, and the resulting analysis?

If civil remote sensing data is acquired using public funds, the data should be made available to the public. If private funds are used, then private companies can have full control of the data. If governments buy data from private firms, they should only buy the data rights needed to serve public needs. Governments should not have the right to demand private data and distribute it without fair compensation. Government-funded satellite data providers should not compete with the private sector except for compelling reasons of national security or public safety. In general, governments should not use tax money to go into commercial competition with private industry.

How should this data, services and transactions should be taxed?

They should be taxed on the same basis as any other information service or software. There should not be special treatment just because data comes from space. Revenues should go to a general treasury to serve the nation as a whole, not a particular agency or authority.



Courtesy: NASA

3D printer in Microgravity Science Glovebox on ISS. The first ever 3D printer in space was developed by California startup Made in Space Inc.

where the global development community can go, not just for earth imagery and geospatial data, but also for focused thought leadership, remote sensing market analytics, best practices guides, return of investment methodologies and discussion of the important policy issues of the day. Supporting the growth of informed, skilled and motivated geospatial practitioners working on global development can also help accelerate democratization of space.

> With these satellites in orbit, Planet will reach its Mission 1: the ability to image all of Earth's landmass every day

ROBBIE SCHINGLER
Co-Founder
Planet

The road ahead

From the iconic Blue Marble photograph to our first experience zooming into our hometown with Google Earth, satellite imagery has always produced a startling effect in people. In part, this is because satellite imagery extends our perceptions in space and time. In contrast to our unaided senses, satellites allow us to see entire regions, or the entire planet, in a single image or to witness changes that unfold over years, or even decades. Of course, as Schlereth says, this expansive observational power extends beyond the visual — it enables scientific predictions and analytics that can be fed into decision-making for public policy and commercial interests.

"It is fair to say that this ground-breaking creativity and modernization of business models could not have happened in-part without open data and satellite systems, which have ushered in new ways of consuming and attending to customers," says Miglarese. As is happening in the satellite industry, the disruptions in the earth observation data market are allowing for more people to participate in the economy.

Amazon, Airbnb, Uber, among many other ingenious businesses, are testament to this new age of individual and social transformation

In his new book, *The Fourth Industrial Revolution*, Professor Klaus Schwab, the Founder and Executive Chairman of the World Economic Forum, argues that humanity is being changed on a level never experienced before. This individual and societal change is typified by new technologies that blend the "physical, digital, and biological worlds."

"For our trade, it translates to the amalgamation of the satellite industry, new computer technology, creative applications, and the influx of venture capital that have ushered in new business models, which are transforming the very foundation of the industry," Miglarese adds.

Amazon, Airbnb, Uber, among many other ingenious businesses, are testament to this new age of individual and social transformation. These companies have completely disrupted traditional markets, based on the idea of the sharing economy. Perhaps more telling however is that these new businesses are changing the way people shop, communicate and think. In fact, studies are suggesting that this new global economy is changing us biologically, that is, being connected online is essentially rewiring our brains.

We have come a long way since the world's first successful satellite launch in 1957. Yet, as Miglarese puts it, this new space race is just the tip of the iceberg!

Anusuya Datta
Executive Editor
anusuya@geospatialmedia.net

TRIUMPH-LS and J-Field

Hands free operation

RAMS

Remote Assistance & Monitoring Services (RAMS) allows you to connect to your TRIUMPH-LS from anywhere in the world when both your computer and TRIUMPH-LS have access to the Internet. Every function of J-Field that is available to the operator of the TRIUMPH-LS that's in the field, is available to the remote viewer!

There's nothing else on the surveying market like RAMS, that I'm aware of. What an extremely handy tool that works really well and is perfectly integrated into the field software!

Over the past year I've kept the LS system mostly to myself, learning as much as I could about it and getting comfortable with it before I started training any of my crew leaders to use it. Recently I've started training one of my guys to use it, the most experienced of my field team and an extremely bright guy.

This morning, while on a project 40 miles away, I was re-walking him through setup/ground projections and I was logged on to RAMS watching/helping his setup process. ***It's an amazing thing to be able to step in and help out a crew from the office!*** *It's been incredibly helpful the countless times I've called @Adam for help.*

I have to say, this is excellent work by the Javad team!!

Here's a cool screen grab of him staking to his base point to make sure everything was jiving.

Wes Cole
Asheville, NC

TRIUMPH-LS in use • J-Field features

What a beautiful picture!

Make lots of money
Twice as much!

And how ugly competition can get!

A competitor's dealer at a state show takes one of our happy TRIUMPH-LS customers to his booth and tells him when Javad dies we will buy his company and close it.

How ugly a person can get! Instead of promoting innovation, he wants to kill it for his personal stupid benefits.

Also the idiot does not know of two things:

1. That I am healthy like a horse and have no intention to die anytime soon.

2. That JAVAD GNSS is not a start up company. Over 130 people working on the TRIUMPH-LS alone. It is a solid deep rooted institution which does not depend on any one person, including myself.

The TRIUMPH-LS and its field software, J-Field,

have many revolutionary and innovative features as compared to current GNSS systems:

- The TRIUMPH-LS contains everything needed to function as a **complete RTK rover** in one small, compact, ergonomic and very portable unit: an 864 **channel GNSS receiver, a UHF or spread spectrum radio, a GSM modem, a Wi-Fi adapter, two internal cameras, a flashlight, and a bright 800x480 pixel display.** Included with the system is a collapsible monopod rover pole which allows the unit to be quickly folded up to fit in a very small space, **perfect for carrying the system through the woods** or quickly stowing inside a vehicle. The lack of a data collected bracketed to the rover pole increases further increases its portability and the user can **carry the system through the woods** without having to worry about a data collector bracketed to the rover pole getting caught in brush.

- This system was ergonomically engineered; the head height vertical display allows the user to operate the TRIUMPH-LS while standing in an upright position and looking forward. The user does not need to bend their neck to look down to view the display as is traditionally done with a system having a data collector attached to a rover pole. This feature allows the system to be used **without the neck soreness** that can plague a user bending their head downward to view a data collector for extended periods of time.

• The field software, J-Field, is included **at no extra charge** with the system. There is no need for an external data collector or software. J-Field is constantly being improved and updates will always be available free of charge with the system. The updates can be **downloaded through Wi-Fi** and are very simple to install, requiring only a couple button presses to update the system.

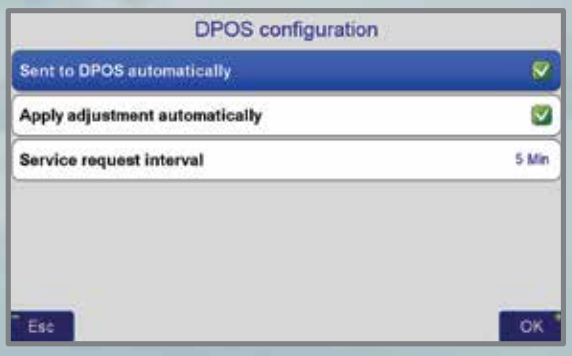
• J-Field, features **6 separate parallel RTK engines** that all run simultaneously with separate assumptions. This allows for fixes to be obtained quicker than if only a single RTK engine was used.

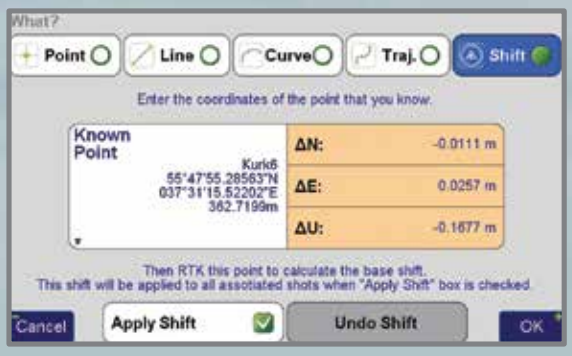
• It has an advanced **RTK verification system** that can be used in difficult RTK environments where there is high multipath and/or tree canopy cover. This process will automatically reset the RTK engines and eliminate points from being collected with bad RTK fixes that often plague other systems in difficult locations.

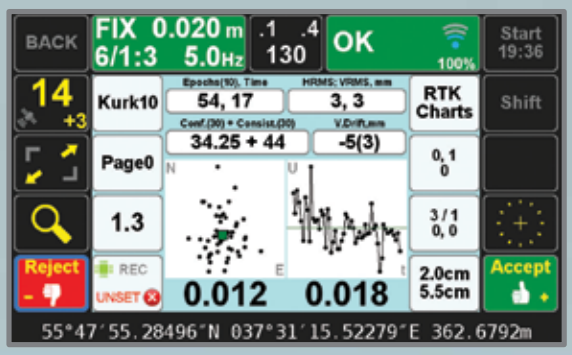
• J-Field has many **customization** features that can be used to increase productivity as your knowledge of the system grows. The stake and collect screens have **10 white boxes** that are easily customized to display a number of fields which the user may desire.

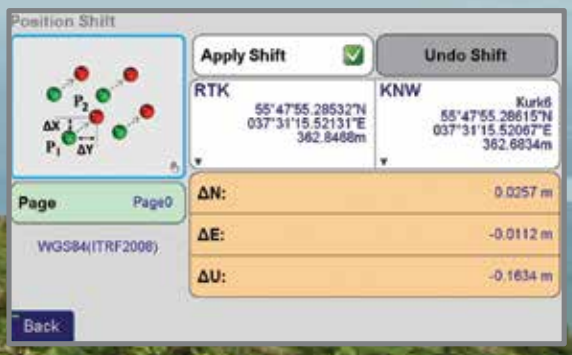
• Post processing raw data is very simple in J-Field. GNSS raw data files can be configured to be stored **for each RTK point automatically**. After stopping your local JAVAD base station, the raw base station data is downloaded into J-Field where it can then easily be uploaded to JAVAD's post-processing server, **DPOS (Data Processing Online Service)**. Autonomous base station coordinates and all the RTK points collected from the base station session can then be adjusted to a solution obtained from processing the base station data with **NGS CORS data**.

Base to rover vectors can also be processed with DPOS. This allows the user to compare the RTK coordinates with the post-processed coordinates and then choose the desired coordinate for that point. This feature is very useful when surveying in areas outside of the base station's radio range as points can still be collected and post-processed in these areas.

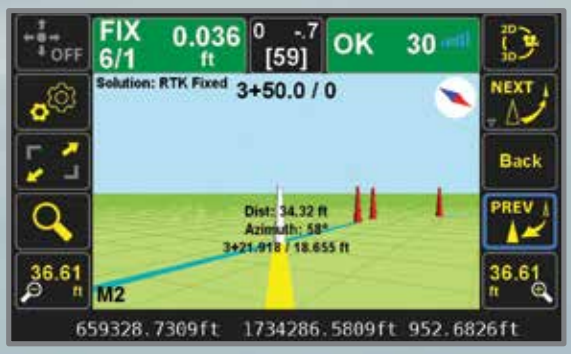




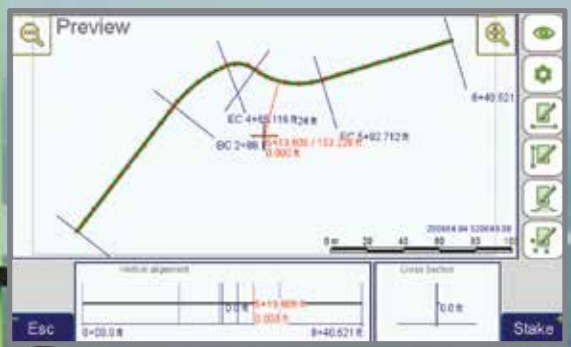




• It contains a **built-in compass and tilt sensors**. The built in compass allows for the quick and efficient stake out of points. Forward/back and left/right offset readings relative to the face of the display show precisely where the stake out point is located. This stakeout method allows **reduces the time** required to stake out a point as compared to using traditional north/south and east/west offsets. The built-in tilt sensors can be used in lieu of having to plumb the rover pole. Taking advantage of the tilt sensors is also a **"Lift & Tilt"** mode that allows for collection of topo points without having to press any buttons. In this mode, when the TRIUMPH-LS is plumbed a point will automatically start collecting and can be programmed to collect a set number of epochs or to stop collection when the unit is tilted. After the point is collected the user tilts the TRIUMPH-LS and walks to the next point which will be collected when the unit is plumbed again.



• With the built in GSM modem, it is very easy to connect to **RTN networks**. Alternatively, it can also be connected through Wi-Fi using a mobile hotspot.



What Do You Use the TRIUMPH-LS For?

In some ways, I would use the LS for any of the items you list, but my specific work is boundary and topographic. About the only thing I won't use the LS for is precise vertical (hard surface topo for example) that requires better than a centimeter, particularly if I have to collect a lot of points with that accuracy requirement. This is pretty uncommon for my needs though.

I would use it for many types of construction layout. I don't do a lot of construction layout work though. It's the way to layout utility corridors.

Shawn Billings, PLS
Kilgore

The more fitting question for me would be what don't you use the LS for.

I even used it to set the locations for the post holes on my construction project and then drilled them. I did not have to shave out any of the holes. The posts went in perfectly.

The LS is a workhorse when it comes to open sky topo. I finished the field in just a few hours and never cut anything. I was able to crawl around and get to where I needed then let the LS work.

Adam Plumley, PLS

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HOW SATELLITES ARE REBOOTING BUILDING DESIGN

Today's electromagnetic and earth observation systems are propelling a future-habitats' design movement that could be named Astrospatial Architecture.

By Davina Jackson

Spaceship Earth is back on the agenda with futuristic architects and environmental planners. Popularized by Richard Buckminster Fuller and other modern science pundits during America's 1960s space race against Russia, this term remains the most evocative of several concepts which promote the accelerating ambition to manage holistically our planet's environmental systems.

Courstey:OXO Architectes

Manal Rachdi's proposed "City Sand Tower" to sustain a new population in the Moroccan desert

In this century, the Spaceship Earth dream is being facilitated by tele computation tools originally devised to fly airplanes, rockets and satellites. Pulsing the scenes flickering across our myriad screens are the semiconductor and sensor-enabled infrastructures of massive parallelism; connecting non-visual data across globally distributed grids of processors, portals and storage banks. As predicted by Al Gore in his 1992 proposal for a "Digital Earth" global climate model, parallelism seems to be the only systems architecture, and conceptual metaphor, that could "cope with the enormous volume of data that will be routinely beamed down from orbit".

How will all these bits of information help architects to envisage structures made of atoms? This question, published in 1995 by William J. Mitchell to extrapolate the urban development implications of common access to the Internet, still highlights the crucial paradox and paradigm for professionals dealing with virtual architecture. He wrote: "The network is the urban site before us, an invitation to design and construct the City of Bits (capital of the twenty-first century). ... But this new settlement will turn classical categories inside out and will reconstruct the discourse in which architects have engaged from classical times until now. ... How shall we shape it?"

Today, astrospatial (developed for space exploration) and geomatics technologies are propelling the hybrid domain of earth observations, which underpins fundamental reforms of geography, surveying and environmental planning. Emerging systems of visualizing today's torrents of location-specified data also require major innovations to help merge different ways of modeling natural and constructed environments. Third millennium simulations, comprehensively explained by Stephen Wolfram in A New Kind of Science (2002), are being underpinned increasingly by his "Principle of Computational Equivalency" between complex natural processes and their correct mathematical models (which may be generated by surprisingly simple cellular automata codes). Wolfram's concepts are accelerating various compatible practices across many long-estranged science

disciplines and are unlocking (for advanced architects and other building professionals) digital simulation scenarios that go far beyond the current capacities of CAD-CAM, BIM, GNSS (GPS) and GIS.

Textbooks explaining behavioral modeling for a "new science of cities" were published by Michael Batty (2005, 2013)after his University College London colleague, Andrew Hudson-Smith, wrote a comprehensive thesis (2003) on virtual visualization technologies relevant to online urban planning. Spatial techniques to represent urban flows are exemplified by mobile phone data videos of pedestrians and buses (MIT SENSEable City Lab, 2006, and many later examples) and are expanding architecture's core premise to envisage (static) building stocks.

Modeling global earth systems

More than any physical structure, Google Earth was the artifice which explicitly highlighted massive urban implications from our escalating "space economy"; a phenomenon surveyed by the Organisation for Economic Co-operation and Development (OECD) since 2007. Google Earth and other early virtual globes suddenly showed why it has been intelligent for earthlings to explore outer space. It demonstrated that we must rely on ubiquitous surveillance from orbiting vehicles to realistically comprehend our planet's conditions: visible and invisible, spatially from core to stratosphere and horologically from genesis to oblivion. The better we are at flying in outer space, the better equipped we can be to sustain life on Earth.

Today, international scientists and technically literate policy strategists are updating the Spaceship Earth and Digital Earth visions via an epic scientific movement called the Global Earth Observation System of Systems (GEOSS). Proposed at the World Summit on Sustainable Development in Johannesburg in 2002, progressed at two following Earth Observation Summits in Washington DC (2003) and Tokyo (2004), and launched in Brussels (2005, the same year as Google Earth), this intergovernmental program is refunded to continue to 2025.

GEOSS is co-ordinated by the Group on Earth Observations (GEO) in Geneva, an intergovernmental secretariat representing more than 200 member nations, global science bodies, UN agencies, conventions and foundations. It supports key environmental declarations including the UN's Sustainable Development Goals (SDGs), the Paris Agreement, the Convention on Biodiversity and Agenda 2030. Its groups of specialists are working with the UN Statistics Division to exploit satellite and remote sensing data to measure and monitor advances towards the UN goals. More than 150 major government agencies now provide datasets for public access through the GEOSS portal: the raw information often must be visualized (frequently with dynamic map platforms) to be comprehensible to audiences lacking statistical analysis skills.

Online environmental planning

What does global monitoring from space vehicles have to do with architects of terrestrial buildings? It seems logical that government planners in future will require property developments to be designed and cross-checked against locally relevant environmental datasets and that ECV data and other natural systems information will need to be integrated (more visually) with design modeling of major building projects. EO surveillance, using equipment to measure invisible electromagnetic waves reflected from land, sea and air surfaces, seems especially valuable to help clarify whether sites are suitable, or not, for future human living.

The world's first earth observation photograph from space: captured by a 35mm camera aboard the US Army's V-2 #13 missile, launched from the White Sands Missile Base, New Mexico, United States, October 24, 1946

Courtesy: White Sands Missile Range/Applied Physics Laboratory

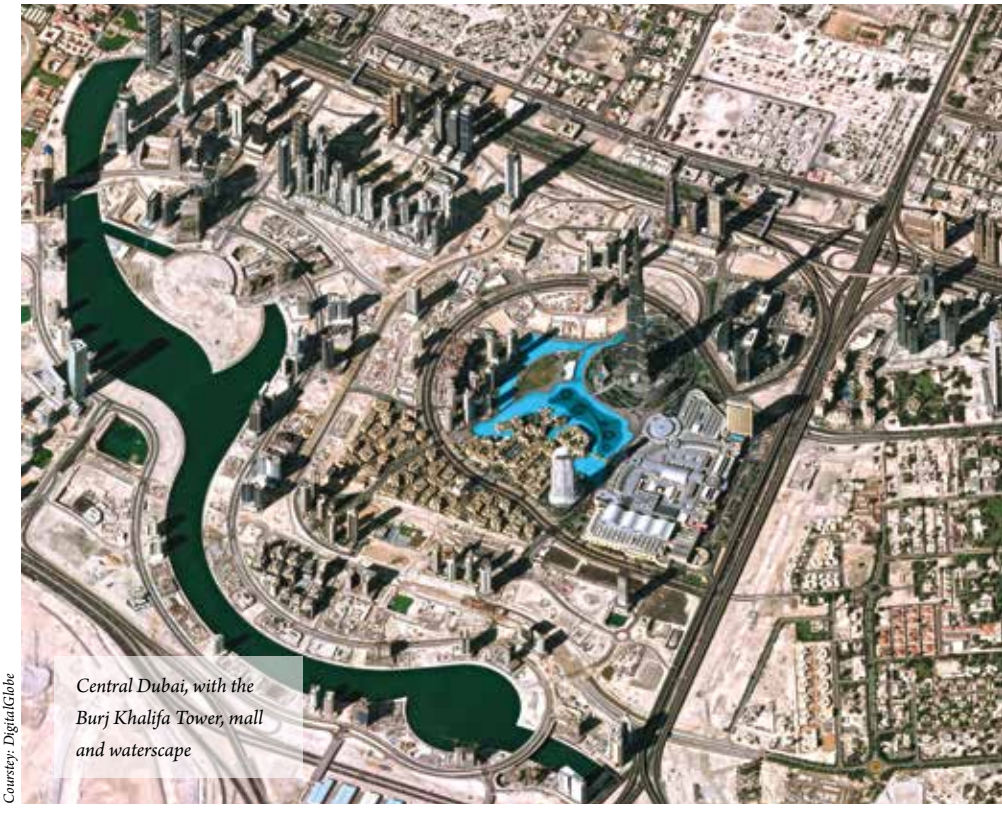
One example was the 2004 Arup-planned proposal to build China's first eco-city, named Dongtan, on a swampy island off Shanghai. After substantial international publicity that was later described as "greenwash", viability for this project evaporated after scientists revealed not only that construction would slaughter local wildlife but that Dongtan is among many coastal and island locations that will be submerged by progressively higher tides.

Previously, sea-surface heights were not considered often in architectural design, but today's satellite-informed forecasts are becoming more pertinent: not only for planning seaside cities but also in designing and insuring houses for oceanfront, clifftop and flood-prone sites.

Conversely, Earth monitoring may have potentials to highlight large land areas, for example the deserts of North Africa and Australia, that may become suitable habitats for humans (via global warming or other climate changes, or with substantial engineering). Architects already are imagining fantastic scenarios, which via photorealistic CGI, may convince (unfamiliar) viewers that they have been built. For example, Manal Rachdi (OXO, Paris) has

published a 450 m-tall vertical city concept, proposing solar and geothermal power and rainwater collection to sustain a tower of offices, a hotel, community facilities and six hundred housing units, suggesting this be sited in Morocco. Swedish architect Magnus Larsson visualized a new Sahara "dunescape", incorporating a 6,000 km-long "shelterbelt" of trees and a sand-sculpted desert camp comprising caves for several thousand refugees. He suggested sowing Bacillus pasteurii, a wetlands bacteria, to transform the sand particles into a structurally cohesive, fibrous stone structure with cavities that could be occupied by otherwise homeless humans. Rachdi, Larsson and other speculative architects seem inspired to draw solutions for the current international governance challenge of creating new cities for large groups of refugees from wars or natural catastrophes.

Like the ancient disciplines of cartography and surveying, cadasters today are evolving from 2D static maps on paper to nD (theoretically infinite dimensions and domains) of information, most of which



Courtesy: DigitalGlobe

Central Dubai, with the Burj Khalifa Tower, mall and waterscape

Today's massive mutations of cadaster administration systems are driving latest global debates about smart cities and data cities where governments decide how to handle public information

must be communicated between semiconductor-enabled devices, often without being visualized for the eyes of humans. Today's massive mutations of cadaster (and census) administration systems are driving latest global debates about smart cities (mainly enabled by commercial systems) and data cities (where governments decide how to handle public information).

Currently, there is a vacuum of coherent recognition about how public open online access to extensive repositories of environmental data might help local planning and development professionals to more effectively serve their constituencies, and contribute responsibly to global climate management strategies. Minimizing corruption of data — during gathering, storing, analyzing, exchanging and disseminating — looms as a colossal challenge.

Conceptually at least, national and local spatial data infrastructure systems seem essential to seriously consolidate today's rhetoric about "evidence-based planning". Three international data-agglomeration movements are evolving — and all depend on both automated computation and visual representations to make sense of the raw content. First, many advanced governments now have programs to location-tag as much public information as possible, especially Census statistics: this thrust may help transform representations of cities from 2D and static mapping to 3D (and conceptually nD) dynamic models. Another new scheme is ISO 37120:2014, the world's first standards code to support comparisons of municipality performance indicators, prepared by the Global City Indicators Facility at the University of Toronto and adopted by the International Standards Organization in 2014.

An earlier concept, launched by UN-Habitat at its Habitat II conference in Istanbul in 1996 and prototyped by some Middle East and North African cities, since, is the GUONet global network of "urban observatories": centers for collating, analyzing and publishing (mostly graphically, using 2D maps) statistics recording location-relevant social and environmental conditions.

The urban observatories idea was conceived by American information architect/author Richard Saul Wurman, beginning with his same-scale plasticine models comparing the land contours of fifty different cities (1963).In Design Quarterly 80: Making the City Observable (1971), he reviewed the potentials for visual evidence (of urban stocks such as buildings and flows of traffic or natural forces such as wind and water) to inform more accurate development decisions. He proposed two types of clearing houses: "urban observatories" (for monitoring and analysis) and "urban data centers" (for storage and access). These distinct, yet interlinked, operations still seem vital to underpin a globally congruent system for planning and managing future urban developments, and would need science-astute professionals, remotely supported by supercomputers, to facilitate valuable uses of the data.

Earth observation outcomes: Data city systems and geodesign

How will the GEOSS affect architectural practice? And (how) will architecture practitioners contribute to this scientific vision?

If implemented successfully over the next decade, the GEOSS would provide access to many globally distributed banks of the geo-tagged and climate-related information that seems necessary to underpin evidence-informed designs for future places to live. The point of all this data, for built environment professionals, is that architects will be expected to exploit it not only for specific projects, but to continue to reform the profession's methods of design and representation. Today's vital innovations are coming not just from visualization software suppliers (Autodesk, Esri, Trimble, Hexagon, Bentley and others — noting Google-Alphabet's Sidewalk Labs spinoff), but also from the research departments of major inter-disciplinary professional consultancies (for example, AECOM, Aedas, Fosters, MVRDV, Frank Gehry, Zaha Hadid, Greg LynnFORM, Heatherwick Studio, Arup, Buro Happold and many engineering firms).

Academia's contributions include progressive international research-conference networks (such as Smartgeometry and various computer-aided architectural design groups) and agenda-setting

Paris artist Yann Kersalé's Sea Mirror heliostat of color-changing LEDs and mirrors, cantilevered from an upper floor of Sydney's Central Park One apartment tower, designed by Jean Nouvel with Peddle Thorp

Courtesy: Fraser Properties-Sekisui House

postgraduate centers at various universities (notably the CASA, Space Syntax and architecture units at UCL's Bartlett faculty, the MIT Media and SENSEable Cities Labs, the ETH-Z Future Cities Labs, the Dutch, German and Austrian TU systems and independent schools like the AA in London and IAAC in Barcelona).

Underlying recent debates about the latest long wave of Climate Change is a shared concern about how (or whether) humanity can avoid massive losses of life (or even eventual extinction as a species, as predicted by Elon Musk and other space travel entrepreneurs). Scientists promoting integrated earth systems simulations suggest that "visual computing" of multiple dimensions of information is essential to clarify patterns of activity and insights towards effective solutions.

Bob Bishop, chairing a campaign to build an International Centre for Earth Simulations (ICES) in Geneva (comparable in his proposed scale to the CERN particle physics facility), suggested that "one important advantage for visualization-based analysis is that computer simulation output can be presented as multiple layers of data for every time-step in a process".

One example is the Australian Geoscience Data Cube, launched in 2013 by Geoscience Australia's National Earth Observation Group to save substantial time in analyzing time-sequences of NASA/USGS Landsat imagery over Australia's vast land mass (which spans forty zones of longitude and latitude). The Data Cube process is to slice the Landsat imagery into tiles covering precisely the same land co-ordinates, then to stack the tiles as a time-series, then to identify, extract and analyze only the differences of data for each specific zone.

While the idea of layering datasets was dramatically demonstrated with Apple's Time Machine method of storing and visualizing

An emerging technique for urban simulations is procedural modeling, which saves considerable time in modeling and changing volume outlines for urban areas comprising many buildings; so is useful for planners concerned with stakeholder consultations

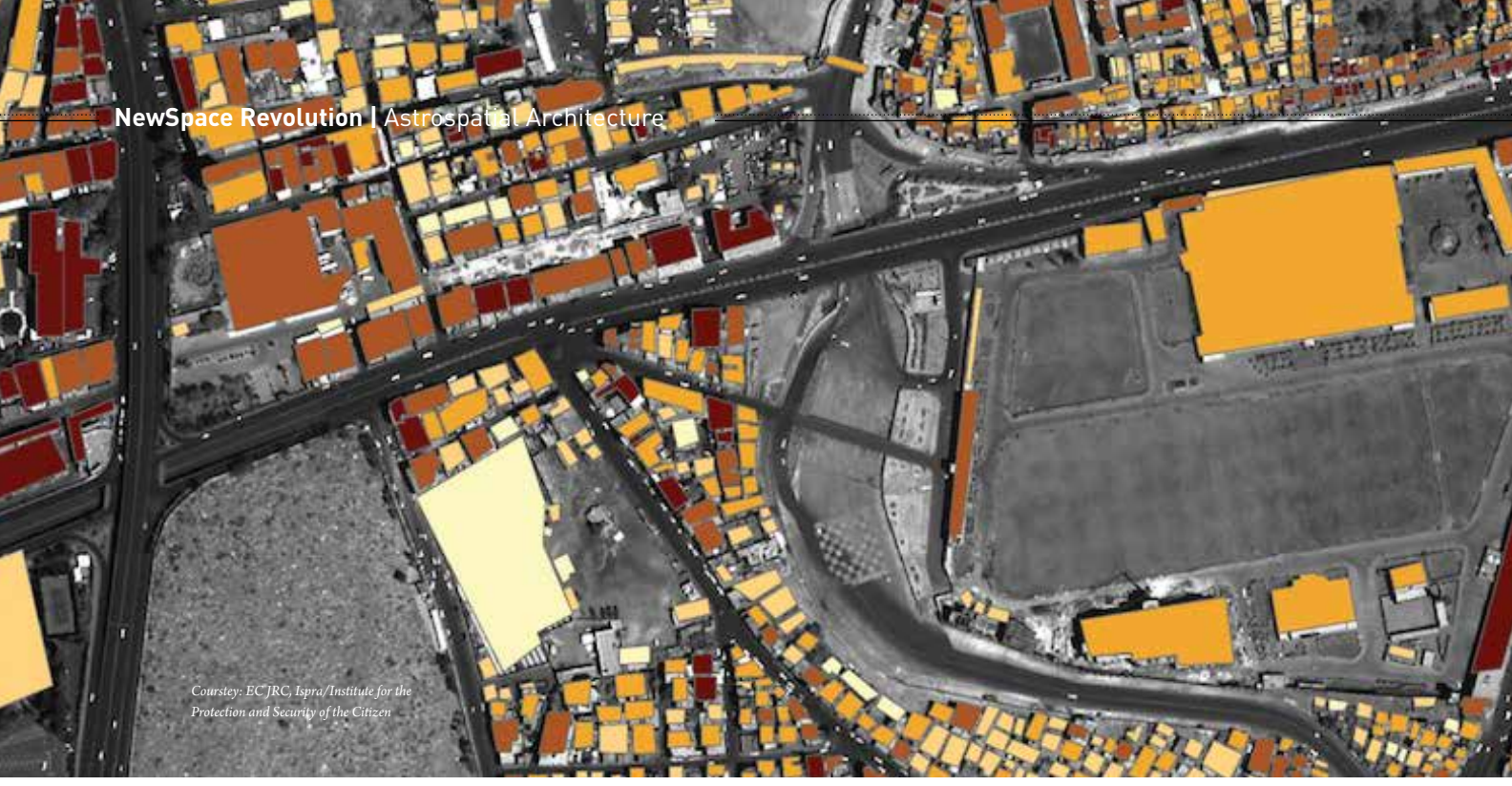
document files (released in 2007), the idea had not been applied usefully to satellite imagery. Now supported by influential EO agencies, this system seems likely to accelerate the ease of analysing how natural systems affect areas with potential for building developments.

Another promising demonstration of advanced analytics of satellite images of built environments is the European Commission's Global Human Settlement Layer (GHSL), launched in 2013 and renamed Human Planet since the UN's Habitat III conference in 2016. An EC science team at Ispra, Italy, developed a high-performance computing process, named I2Q, to automatically query sensor and population data from satellite and aerial images of cities and settlements. Tested on all types of sensors, the 12Q-GHSL system can be used to visualize built surfaces, percentages of built surfaces, average sizes of buildings and the numbers of structures for every image (tile). This introduces a widely applicable automatic processing method to generate globally consistent, optimized mapping of the structural conditions of settlements; supporting international responses to crises, and the sustainable urban development agendas of the UN and GEO systems.

Advances from scientists towards a sophisticated global system of simulating environments are not seriously accessible or cohesive yet for architects, and most geomatics experts are not equipped to design physical facilities for urban areas: this void seems propitious for entrepreneurs. Also not concerned with designing real cities — but far advanced in visualizing fantasy environments and simulating real cities (as in film scenes where famous monuments seem to explode) are entertainment industry CGI studios such as Pixar and Weta.

An emerging technique for urban simulations is procedural modeling, which saves considerable time in modeling and changing volume outlines for urban areas comprising many buildings; so is useful for planners concerned with stakeholder consultations. Parametric modeling, where structures are assembled individually with specific rules and measurements, gives more accuracy in detailing geometrically irregular buildings but is less flexible for changing basic design strategies.

All modeling methods (including non-digital) are encouraged by protagonists of the Geodesign movement, which Esri has promoted at special user conferences since 2010. Carl Steinitz, the former Harvard landscape professor who authored the first Geodesign manifesto, has said that Geodesign modeling requires both design arts and



Map of Sana'a, Yemen, showing building footprints, heights and structural materials, generated from Alpha-Tree analysis of satellite images, for the Global Human Settlement Layer, a contribution to the GEOSS and Digital Earth visions

geographic science skills, in different proportions and using different processes, to help answer six questions: 1) How should the context be described? (Representation models); 2) How does the context operate? (Process models); 3) Is the current context working well? (Evaluation models); 4) How might the context be altered? (Change models); 5) What differences might the changes cause? (Impact models); and 6) How should the context be changed? (Decision models).

One key to potential convergences in modeling buildings, cities and their natural contexts is LiDAR, which gives building professionals precisely geo-tagged simulations of the surfaces of complex structures: far more detailed architectural information than is possible with other imaging methods. Different qualities of survey data are obtained from light aircraft, drones, and balloons, moving trucks or fixed tripods. Generally the terrestrial and low-flying scanners obtain higher quality resolutions than satellite images — but they survey targets only once or infrequently, while satellites now promise constantly updated information to inform modeling over multiple decades.

Also transforming traditional visions of architecture are many designers and artists who exploit cities as after-dark stages for "licht architektur" spectacles, using post-Edison (mostly RGB LED) illumination sources and control systems. Electroluminescent (semiconductor-enabled) urban lighting technologies are equipping the most powerful new arts and architecture movement of the early 21st century. This third great wave of illumination follows the primitive paradigm of sunlight, moonlight and fossil-fueled flames, supplemented since 1879 by post-Edison electric lighting.

Today's "smart light cities" artists are breaking away from traditional exhibition containers such as museums and galleries to transform buildings, bridges, streets, skylines, fountains, waterways, parks and public spaces with multistory video projections, facade-scale pixel screens, gobo (stencil)-filtered pole lights, luminous footpath substances and radiant, technicolor sculptures with invisible sensors responding to human presences, touches, voices, steps and eye movements. Experimental protagonists include Yann Kersalé, Hervé Audibert, Hervé Descottes (L'Observatoire International), Rafael Lozano-Hemmer and Daan Roosegaarde — influencing many international designers of architectural lighting and electronic theatrics for public events.

Futuristic architecture faculties are improving their resources to educate students about emerging techniques of architectural lighting. Technology-experimental cross-disciplinary researchers seem to be pioneering novel transmedia — and trans architecture — genres where citizens may drift between virtual and physical domains of behavior. Diverse experiments with new ways of experiencing light and visually exploiting data are being encouraged especially by (for example) the Media Architecture Institute (emphasis on urban and architectural light experiments) and the International Society for Presence Research (emphasizing scientific advances with virtual reality, augmented reality and robotics).

Optics — the science domain concerned with light and vision — has always catalyzed the concepts which philosophically advanced architects interpret as themes for constructing the aesthetics of buildings. During the United Nations' International Year of Light 2015, optics was promoted as the source of most of the electroluminescent (including data-conducting) technologies that are transforming our cities and ways of life. Current theories of quantum electrodynamics (QED), clarified by Richard Feynman in lectures from 1979, interpret all optical and electromagnetic behaviors in terms of dynamic exchanges between electrons (particles of matter) and photons (particles, or what he called 'corpuscles', of light). Feynman's principles are vital for 21st century interactions between real and virtual worlds: they explain many emerging strategies

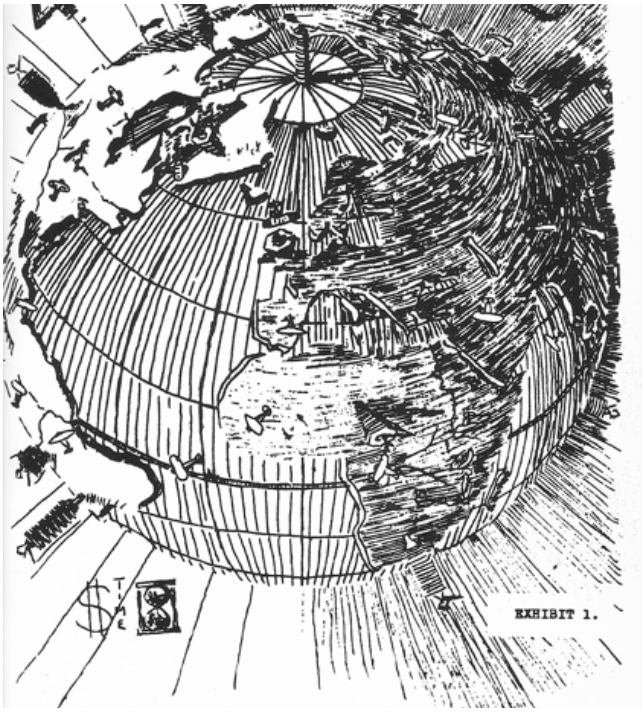
for information transmissions such as li-fi, data modeling, holograms, and virtual and augmented reality. They also underpin emerging ideas to develop a new global computing grid termed the Internet of Light (IoL), which would conduct flows of sensor data via the tiny semiconductors which activate LEDs. Offering vastly more potential than today's Wi-Fi, future Li-fi systems seem likely to deliver the next- generation data networking infrastructure necessary to implement the Internet of Things.

Astrospatial architecture: Design in digital space

What would R. Buckminster Fuller think of today's explosion of post-Edison, semiconductor-controlled electrical systems and their potentials to accelerate his "energetics-synergetics" theories?

As well as his geodesic architectural shelters and engineering of vessels and vehicles, Fuller progressed a global logistics vision from his 1928 manifesto, 4D Timelock (including an axonometric ink sketch of life on Earth, promoting his "Air-Ocean World Town Plan") to his late-1960s book, *An Operating Manual for Spaceship Earth and Posthumous (1992) volume, Cosmography.* His recognition of light as a crucial transmitter of computer data is evident in his sophisticated proposal for a "Mini-Earth" exhibit, written for the American Institute of Architects in 1963; four years before his legendary geodesic pavilion opened at the Montréal Expo '67.

Fuller wrote: "The design of a two-hundred-foot diameter Miniature Earth… fabricated of a light metal trussing. Its interior and exterior surfaces could be symmetrically dotted with ten million variable intensity light bulbs and the lights controllably connected up with an electronic computer. ... Information could be remembered by the computer, regarding all the geographical features of the Earth… under a great variety of weather conditions. …If we use the thirty-five millimeter contact prints of the photographs taken by the aerial surveyors… Man on earth… would be able to see the whole Earth and at true scale in respect to the works and habitat of man. He could pick out his own home. Thus Mini-Earth becomes a potent symbol of man visible in the universe."



Fuller air-ocean world town plan 1927

Optics — the science domain concerned with light and vision — has always catalyzed the concepts which philosophically advanced architects interpret as themes for constructing the aesthetics of buildings.

More than half a century after this lecture — and one decade into the Google Earth (GEOSS) era — these word-pictures seem almost quaint. Fuller died in 1983, two years before Feynman published his seminal book of lectures updating 1920s theories of quantum electrodynamics, but Fuller already must have recognized that QED would unlock many novel applications of his "universal architecture" and "world planning" dreams. Today, the technologies of light waves — whether visible or not to humans — are propelling a new global Enlightenment age — including a future-habitats design movement that could be named: Astrospatial Architecture.

The physical frontiers of astrospatial architecture already could be claimed to extend to the Moon and Mars, which are targets for increasingly serious research, design and 'analogue' (earthly) prototype tests involving "space architects" who focus on how earthlings might comfortably live in spacecraft or on other planets.

However, designing physical structures for real localities — whether earthly or otherworldly — is not really the key design or domain distinction of astrospatial architecture. This emerging realm of creativity is mediated entirely via planes of pixels separating human occupants of airspace from cybernetic constructs assembled in what neogeographer Andrew Hudson-Smith termed "digital space". He noted (2003) that "digital space takes many forms, and it is limited only by our imagination." Today that seems like a useful general axiom to help perceive revolutionary potentials for astrospatial architecture on, and beyond, Spaceship Earth.

This article is adapted from Davina Jackson's "Rebooting Spaceship Earth" essay in Graham Cairns' recent book Visioning Technologies: The Architectures of Sight (Routledge, 2017). Davina also edited D_City: Digital Earth | Virtual Nations | Data Cities, a 2012 "snapshot report" sponsored by GEO. Her latest book is SuperLux: Smart Light Art, Design and Architecture for Cities (Thames and Hudson, 2015).

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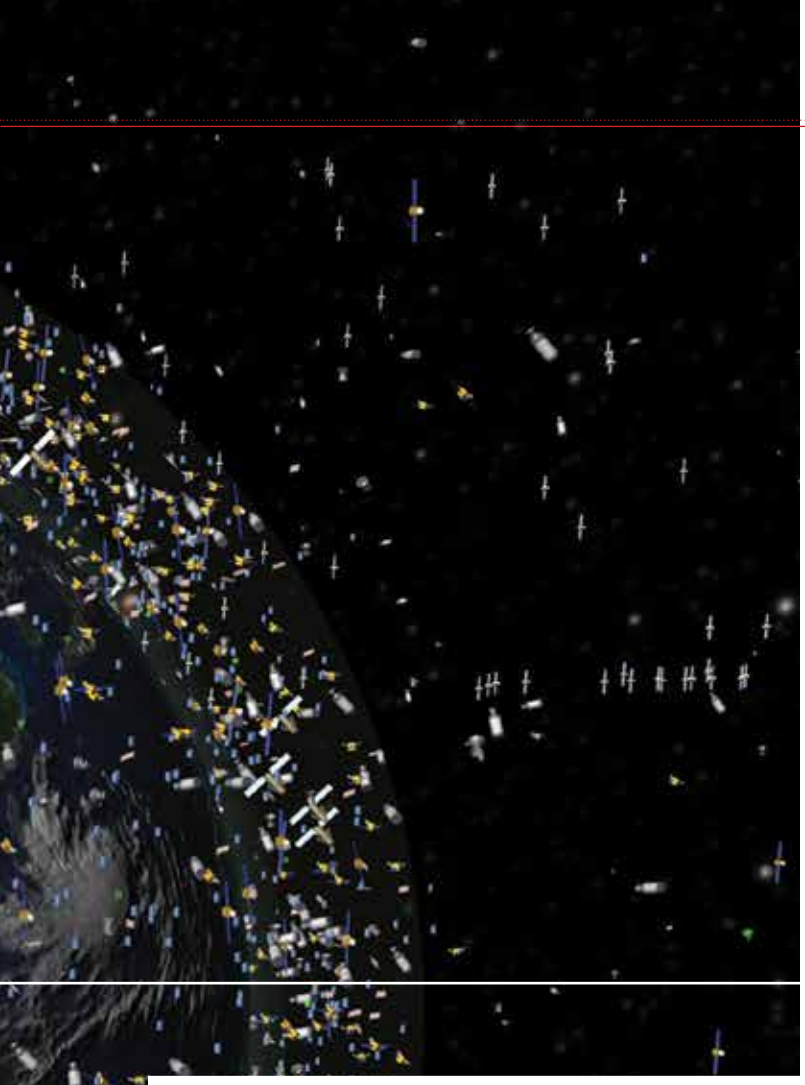
CLEANING UP SPACE DEBRIS

A spacecraft thruster that fuels itself by eating space junks is all set to take off with the Airbus Bartolomeo mission.

By Shilpi Chakravarty



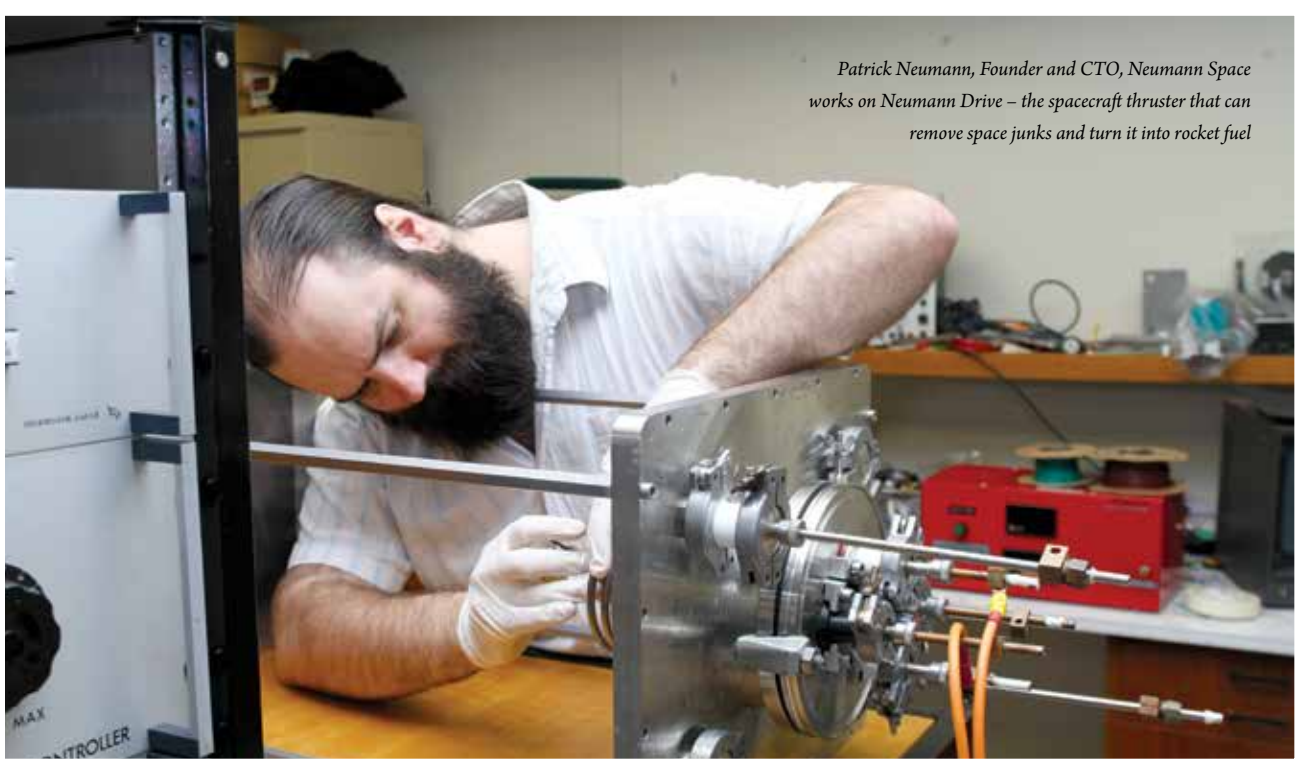
Have we ever pondered upon how floating space junks can cause major damage to the satellites orbiting around the Earth or many costly space missions? Neumann Drive can be of great help. The spacecraft thruster not only has the potential to remove fragmented rocket parts, defunct spacecraft, and other space junk, but also feeds on metal junk to power itself over long distances.

Neumann Drive is a pulsed cathodic arc plasma source that is being used as a spacecraft thruster. It has been developed by Australia-based startup Neumann Space. **Patrick Neumann, Founder and CTO, Neumann Space** says, "I developed the concept while an undergraduate at the University of Sydney, during a third-year Physics research project where I was mapping the electric potentials in titanium plasma discharge. I measured the ion motion at over 22 km/s and thought that this could make a good spacecraft thruster. As I developed the system further, the results I got encouraged me to keep going, and the concept grew from that."

While the spacecraft thruster is slated to be a big boon to the space world and has the potential to catch many eyeballs, it is cost-effective too. Now, the question is …

How does it work?

The thruster works using physics similar to those of an electric welder. A high current at low voltage passes between the cathode and anode, which erodes material from the surface of the cathode. This material is then ionized and accelerated, leaving the cathode/anode assembly as a high-velocity plasma exhaust. The exhaust velocity is so high that it can change the economics of space travel; higher exhaust velocity



Patrick Neumann, Founder and CTO, Neumann Space works on Neumann Drive – the spacecraft thruster that can remove space junks and turn it into rocket fuel

means that less fuel needs to be carried into orbit for further operations. This means lower cost and longer lifetimes for satellites, cheaper exploration missions and the capability to perform certain missions that were previously considered too expensive to be worthwhile.

"The system is useful for different things – one option is a tugboat or tow-truck device that can go around and focus on cleaning up junk, which means people who own defunct satellites have a lot less risk of hitting an active one. Another option is using the system's short, sharp thrusts of power to keep stations and satellites doing their thing and staying in orbit," says Patrick Neumann.

Perfect opportunity

However, just like in every success story there comes a rough patch, Neumann has faced it too. The biggest problem was to find that right platform. Australia has no space agency, and so on-orbit demonstration and verification were going to be difficult to make it happen.

But as they say "where there is a will, there is a way", Airbus Defence and Space has come as a blessing in disguise for the Neumann Drive.

The startup company has joined hands with Airbus for the Bartolomeo mission to the International Space Station (ISS) in 2019 to test its real-world capabilities and collect data. The spacecraft thruster will be tethered to the ISS for the year-long trial before a free-flight model is tested.

According to the ESA, there are about 18,000 large objects in orbit and more than 90% of them are space junk caused by more than 250 spacecraft explosions. There are also millions of smaller debris floating in space, which are too small for radars to track

"We met the Airbus people behind Bartolomeo at the Disrupt Space conference in 2016, and soon after we started talking we realized that this system would be perfect for us. We realized that we would not need the entirety of a payload module for our own purposes and that we could help other organizations with access to space as well," says Neumann.

Competition not a problem

Getting a positive reaction from the space industry and having a unique concept, Neumann Space is not in direct competition with companies making thruster technologies. Competing thruster technologies include the Hall Effect thruster, which is produced by companies like Busek, Fakel, and Snecma, and the gridded ion thruster, produced by companies like L-3 Technologies.

"We aren't in direct competition with these companies yet, since we have yet to test our system in space. As for our payload hosting arrangement on the space station, our main competitor is Nanoracks, and we are dealing with them by offering longer duration hosting outside the space station with more resources and at a lower cost per kilogram," says Neumann.

To give the project the solid boost, Neumann Space funded the project through some small scale share selling, and with some venture capital funding.

According to the European Space Agency (ESA), there are about 18,000 large objects in orbit and more than 90% of them are space junk caused by more than 250 spacecraft explosions. There are also millions of smaller debris floating in space, which are too small for radars to track. And Neumann has the solution to tackle this colossal problem.

"Neumann Drive can produce thrust at more than 10,000 seconds for 1lb of thrust when magnesium is used as fuel. This is significantly better than gridded iron thrusters, which max out at about 3,500 seconds. The thruster's efficiency record makes it powerful enough to send a mission from Earth's lower orbit to the lower Mars orbit and back without needing to refuel," says Neumann.

He adds, "If metal fuel stops were placed at various points in space, it could further increase the reach of the rocket, leading to deeper space exploration."

Neumann Space has recently signed an agreement with the South Australian Department of Education and Child Development that will see three STEM experiments created by South Australian public schools, join its mission to the ISS in 2019.

Due to high exhaust velocity, Neumann Drive can pave way to lower cost and longer lifetimes for satellites and cheaper exploration missions

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INDONESIA INTERNATIONAL SMART CITY EXPO & FORUM JAKARTA

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For more information please contact the organiser

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DATA REVOLUTION FOR A SUSTAINABLE WORLD

Almost one-and-a-half years since the implementation of the 2030 Agenda for Sustainable Development, it has become imperative to understand the progress that has been made so far. **By Ananya Narain**

2015 was a momentous year for change. September 5, 2015, at a historic UN Summit, the world leaders decided on the 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals, also known as Global Goals, of the 2030 Agenda officially came into force on January 1, 2016. The goals, built on the Millennium Development Goals (MDGs), continue to address the main issue of poverty while simultaneously addressing issues of ensuring more equitable development and environment sustainability. The Sustainable Development Goals highlights the world's biggest and gravest issues for the government of the 193 countries to shape their strategies and policies around these goals for implementation, monitoring and management. In many ways, these goals act as a catalyst for innovation and growth opportunities so as to drive sustainable socio-economic growth.

Open data lies at the core of data revolution and is seen to be a key driver for achieving the Agenda 2030 for Sustainable Development

It is almost one-and-a-half years since the implementation of the 2030 Agenda for Sustainable Development and it has become imperative to understand the progress that has been made since then. Unlike the Millennium Development Goals (MDGs), Sustainable Development Goals are a universal agenda. The 2030 Agenda is focussed on both developed and developing economies and it is the level of advancement that is taking place in the developing economies which shall ultimately define the progress report of the Global Goals. As **Arun Kapuria, Founder, iTech Mission** puts it, "We are just starting. It took over a year for the indicators to be finalized, so there is a lot to be done. To collect the SDG data, frameworks are yet being established." In agreement is **Aditya Aggarwal, CEO, Data4SDGs:** "Tremendous work has taken place and there is potential for much more! Every country is unique with respect to its social, cultural, economic and technical capability. The approach to attain the SDGs will be different for every country for all of these countries are at different stages of development. Also, the data ecosystem perspective for each country will be unique to meet these goals."

Nigel Clifford, CEO, Ordnance Survey, foresees an era of digital twins for the attainment of SDGs. Agreeing that it is too early to comment on the status of the Agenda 2030, Nigel Clifford establishes the role of geospatial data in Great Britain and other countries to support the delivery of SDGs. "Geospatial data is central to the helping all nations in the cycle of understanding, predicting, planning, building and maintaining, as it has always been. I firmly believe that the time is ripe for the geospatial industry to enter what is a period of creativity and collaboration, as we respond to the development challenges we face." Clifford comments.

Clearly, a data ecosystem is crucial to the success of sustainable development goals. To foster economic growth, to improve efficiency and effectiveness and establish transparency, a broad coalition of data is required to measure and incentivize progress across the goals. At present, the United Nations also recognizes the need for a comprehensive mix of robust data to strategically build and demonstrate the significance of data for development. It is the insights derived from the data — and from the integration of geospatial and non-geospatial data, that can help achieve the SDGs and help nations formulate the most effective strategic plans for action on national issues. Emphasizing on the need for integration of data sources, Aggarwal says, "It is time to bring together official national statistical data along with geospatial data, earth observation data and citizen generated data and Big Data such that more real-time data is available to address the SDGs. This will only help in both reporting and monitoring purposes and what it means for data for action and decision making."

Open data for sustainable development

Open data lies at the core of data revolution and is seen to be a key driver for achieving the Agenda 2030 for Sustainable Development. Most often, open data is the most underutilized asset lying with the government. Seen to foster economic growth, open data improves efficiency and brings in high economic and social return at all stages of development. **Barbara Ryan, Director, Group on Earth Observations (GEO),** strongly believes that open data is a precursor to meet the Sustainable Development Goal. Agreeing with Barbara's comments is Aggarwal, who further highlights, "Open data is fundamental for sustainable development as it helps to better innovate and create entrepreneurship around data hence driving the economy. It is imperative to bring Sustainable Development Goals and open data together and to not treat them separately."

Aditya Aggarwal
CEO, Data4SDGs

"Open data is fundamental for sustainable development as it helps to better innovate and create entrepreneurship around data hence driving the economy. It is imperative to bring Sustainable Development Goals and open data together and to not treat them separately."

To tackle real-life challenges and problems that are faced by the global community, open data presents unprecedented opportunities. McKinsey has estimated the value of open data to be $3 trillion a year globally which includes efficiency gains for sustainable development in sectors like, health, education, water and agriculture. With innovations happening round the clock, the stakeholders of the sustainable development community, such as governments,the private sector, the civil society and academia and research and development, have access to reliable and high-quality open data. The more open the data is, the easier and quicker it is for the stakeholders of the ecosystem to identify problem areas and tailor solutions to meet these challenges. **Frank Schott, Vice President, Global Programs, NetHope** agrees, "When you think of large amounts of data that is out there and you start thinking about opportunities like Artificial Intelligence

The UNSDGs, built on the MDGs, continue to address issues of environment sustainability

and Machine Learning, there is great opportunity to enhance the international development work by measuring outcome and seeing better ways to achieve the kind of impacts we are hoping for to achieve the SDGs. On a personal level, at NetHope, for health, refugees, human rights and other such topics that we focus on we need open and personal data to solve most of these issues."

Open data is the bedrock of the sustainable development goals. Eventually what matters is data democratization — which means making authentic data available to everyone. For the same purpose, there has to be a commitment from the stakeholders to share information. Nations have begun to realise the value of open data to achieve the development goals as diverse as economic growth, education, urban planning, food security, etc. At the global level, countries are opening up their data sets to achieve the 17 global goals. Open data is being used for city planning in Rio de Janerio, to assess school performance in Tanzania, data to create maps to improve access to education in Kenya and map the Ebola outbreak to save lives in West Africa. "Ordnance Survey is the leading exponent of open data in UK Government. We are on the verge of reaching two million downloads of our entirely free to use open data products. Open Data is benefiting millions of people daily and is also being used effectively in asset management, business development and planning, risk assessment and other areas," stresses Clifford.

Frank Schott
Vice President, Global Programs, NetHope

> "When you think of large amounts of data that is out there and you start thinking about opportunities like Artificial Intelligence and Machine Learning, there is great opportunity to enhance the international development work by measuring outcome and seeing better ways to achieve the kind of impacts we are hoping for to achieve the SDGs."

Significance of location to meet SDGs

Location and geography are significant to most of the elements of Sustainable Development Goals. It is, therefore, not a surprise that geospatial data is as important to sustainable development goals as the demographic and statistical data. To truly harness 'data' to meet the Agenda 2030, there is a need for integrating geospatial data with other available datasets so as to create visualizations through maps or 3D models which shall only help in evaluating impacts, monitor progress and improved accountability. For governments to formulate strategies, they need to identify where the citizens are and where the root of the problem lies, and this is where geospatial comes in. "The 'Where' component is central to the SDGs and that is a classic spatial problem. Spatial Data is absolutely imperative, to understand the place, the location, the communities we are working with, the people that we are serving and the context about that place, the other layers of information is absolutely essential to prepare us for advanced analysis helping us make the progress to achieve the SDGs," chips in **Steve Hellen, Director, ICT4D and GIS Manager, Catholic Relief Services.** Clifford agrees, "Geospatial and earth observation data, if analysed and modelled properly, can be visualized as a dynamic informative map. It acts as an extremely effective communication tool that transcends language and culture. When layered with more attributions and information, complex issues can be understood within seconds and problem areas can be identified instantly."

Various opportunities are foreseen for the

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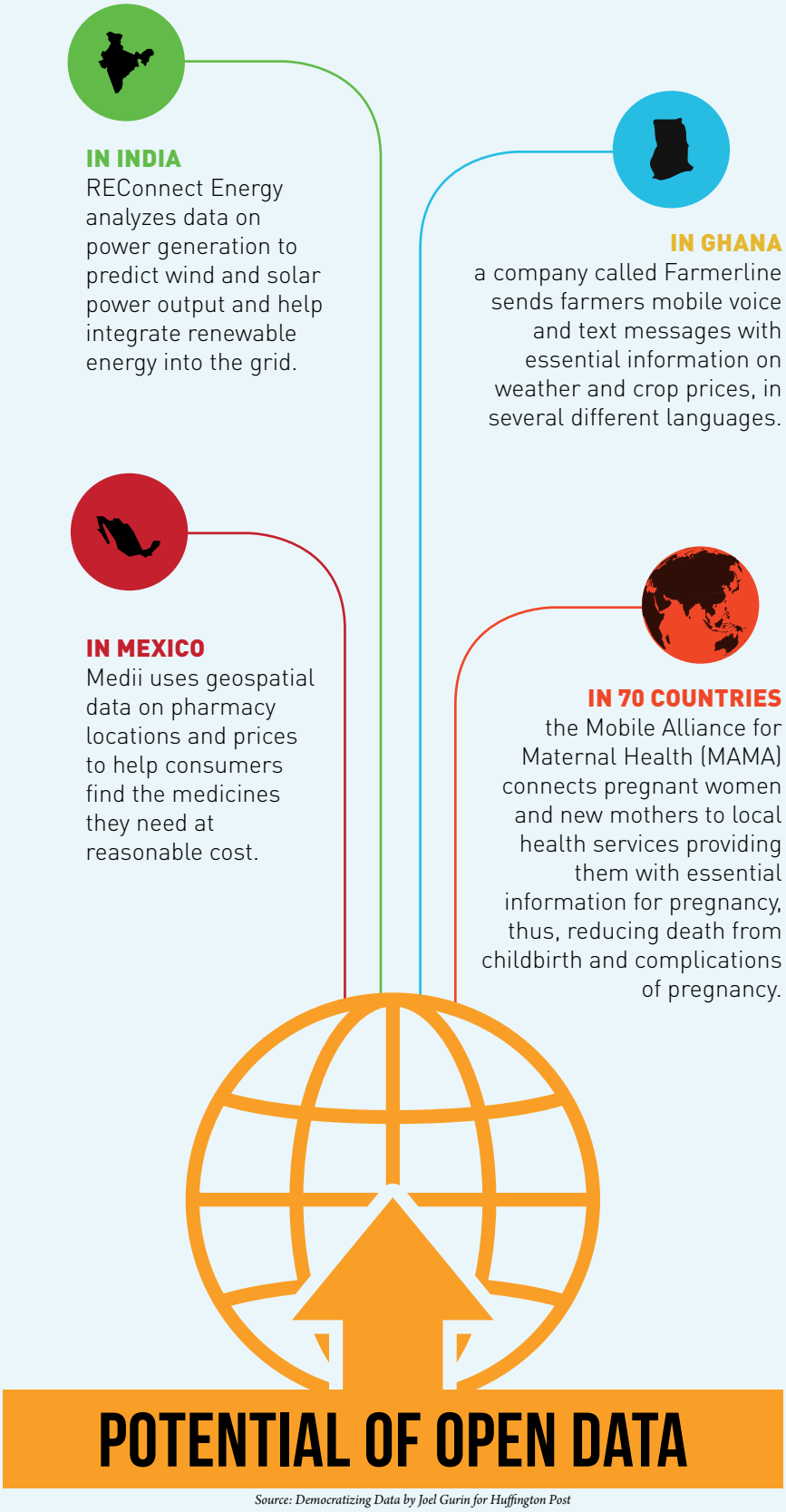

Source: Democratizing Data by Joel Gurin for Huffington Post

Steve Hellen
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global geospatial community, and there is a unique opportunity for geospatial data to be integrated into the sustainable development agenda. Global organizations like Group on Earth Observations (GEO) and United Nations Office for Outer Space Affairs, are taking a leading role in championing the SDGs. Together with National Aeronautics and Space Administration (NASA), GEO's recent initiative, NASA-GEO EO4SDGs, propagates the idea of integrating earth observation data and geospatial information with national statistics to attain the SDGs. The aim of the initiative is to establish the important role of earth observation in the sustainable development agenda and to

Courtesy: Stats SA

UN World Data Forum considering role of data, statistics for SDG implementation

identify key data related challenges and address them accordingly. GEO's commitment to GEOSS i.e. Global Earth Observation System of Systems has now scaled down from a global to a more regional level. The AmeriGEOSS, AfriGEOSS and HimalayanGEOSS initiatives are few which are developing regional programs for implementation, monitoring and management of Sustainable Development Goals.

Shaun Ferris
Director (Agricultural Livelihoods), Catholic Relief Services

> "Geospatial data was something we did not use very much until three or four years ago. I think in many ways, geospatial has not lived up to its potential yet. We have used only tiny fraction of that equipment and process. The non-profit sector is not using much analysis and forecasting – though the possibilities are limitless."

While geospatial is crucial, the challenges to using geospatial data too are many. The lack of available quality geospatial data, especially in developing countries, is one of them. According to David Bergvinson, ICRISAT the issue of data quality can be solved only by starting somewhere. According to him, there is a deluge of data available in all countries, but people do not share it or make it available because they are not confident of it. The idea should be to start using the data that is already available and create visibility around that data so as to improve the quality of data over time.

One of the other major challenges is the lack of awareness about geospatial data and its role in attaining the SDGs in general."Geospatial data was something we did not use very much until three or four years ago. I think in many ways, geospatial has not lived up to its potential yet. We have used only tiny fraction of that equipment and process. The non-profit sector is not using much analysis and forecasting – though the possibilities are limitless," says **Shaun Ferris, Director (Agricultural Livelihoods), Catholic Relief Services.** However, Aggarwal shares a different perspective, "I think a transformation is taking place especially with related to geospatial and satellite data. Now we have organizations like Planet Labs that are making available more and more data on a higher frequency and a good resolution now. I think it is a changing landscape and I only see it moving in a trajectory that more countries will use large amounts of geospatial data to meet their specific needs."

Clifford, states that even though there are multiple challenges, he is excited by the prospects of working with other stakeholders to meet them. The United Nations too corroborates the need for liaison and partnership between the geospatial industry with the government, multilateral and international organizations, and academia, to establish an effective framework for data sharing as a catalyst for growth and development.

Developing a global, regional and national framework for data

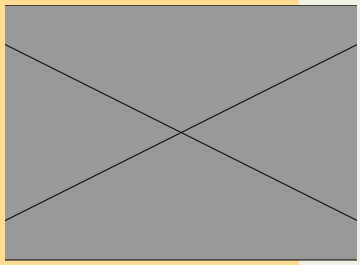
Accessibility and availability of quality data has always been a concern for the development community. The need for a framework is imperative to effectively and efficiently harness the data revolution for development. Establishing a framework will encourage synergies between data providers and data collaboratives. This will help in making data

One of the other major challenges is the lack of awareness about geospatial data and its role in attaining the SDGs in general

CASE STUDIES

Case study: Mapping the Ebola outbreak in West Africa

Till date, 9,000 lives have been claimed by the Ebola outbreak in West Africa and the spread of the disease has been difficult to track. The Humanitarian Data Exchange, using the Open Street Map, accurately mapped the spread of the disease as well as created location pin-points of available treatment centers. These maps quickly show governments and NGOs where the disease is most prevalent, and where new hotspots may be developing, thus enabling effective and targeted solutions.



Case study: Using maps to improve access to education in Kenya

Dynamic maps were used to visualize education data in Kenya, making it easy for policy makers to have access to accurate information on education, literacy rates and performance across regions. Ground Truth Initiative along with Map Kibera Trust, Development Gateway, Feedback Labs, and the Gates Foundation, among other has connected existing data to bring information to parents, school leaders and education officials of Kenya. The information presented as maps is the percentage of children not in education, hence, revealing areas of the population which may be under-served.

Case study: Monitoring child malnutrition around the world

Malnutrition is one of those areas that requires access to regional data to make urgent, well-informed decisions. The World Bank and the World Health Organization publish data on child growth and malnutrition for each country mapped. The data is also available for a 10 year period to track the performance of individual jurisdictions and to reveal vulnerability areas. The data is used to prepare global maps which showcase the prevalence of malnutrition children. Government and aid groups can use these maps to target nutrition interventions to areas where it is much needed.

accessible to each and all, to fill the data gaps, generate new datasets, create dynamic visualizations, thus enabling timely and targeted decision making to drive the SDGs. Aggarwal says, "Data sharing is an institutional issue. You have to be able to get institutions to work together to understand the value of sharing data and what that means for reducing redundancies. This also means having a more collaborative culture and putting together a more sustained institutionalized mechanism to gain value through data sharing. With respect to SDGs, you cannot work in a silo with regard to data; you have to build a structure or a framework that allows for easy data sharing." Clifford is of a different opinion. He emphasises that the need for developing a global, regional and national framework is not necessary. The reporting needs to be done at the national level so it is best left upon the national entities to decide what framework they choose fit for their respective country. Simultaneously, he also recognizes that some of the SDGs may require cross-border information and for that, a different framework will be of importance.

To develop any framework, there is a need for collaboration and partnership among the government, organizations and the multilateral and international organizations. A global multi-stakeholder partnership helps countries achieve inclusive sustainable development. Shared resources and collaboration as governments engage with multilateral organizations ensures that the SDGs are realised. It is exactly how Kapuria sees it: "One of the goals of SDGs is partnership. The governments have their own mandate. Partnerships have to happen and strong collaborations are required. As a matter of fact, we are partners for SDGS with United Nations, the United Nations Global Compact. There is a lot that United Nations is working on and we can leverage on it." Adding to it is **Sameer Thapar, Director (Technology), iTech Mission** when he says that multilateral organizations like World Bank and United Nations have a big role to play in SDGs just as they played a defining role in the Millennium Development Goals (MDGs). According to him, by making data available in the global domain, and providing platforms to use this data, they reinforce the relevance of data for furthering the goal of SDGs.

Bringing in all stakeholders at one place will help build a road-map to bring the data revolution together by taking in all the inputs from a collaborative convening, helping nations move forward

Nigel Clifford
CEO, Ordnance Survey

"Open Data is benefitting millions of people daily and is also being used effectively in asset management, business development and planning, risk assessment and other areas."

All in all, collaborations for SDGs are becoming a necessity, as it enables stakeholders of the community to leverage each other's unique individual resources, expertise and experiences to create innovative solutions. The idea is simple – to create a global platform with the intention of bringing the political clout and the implementers of SDGs at the same level. More often than not, the government is unaware of the actual work taking place and a platform of this sort will only help them understand the work that is taking place at the grassroots level. Bringing in all stakeholders at one place will help build a roadmap to bring the data revolution together by taking in all the inputs from a collaborative convening, helping nations move forward.

Light at the end of the tunnel

Almost a decade ago, the civil society was unaware of the concept of sustainable development. Times have changed; each and every individual is motivated to achieve the goals to improve their own living."Seen largely to be an issue of the government, these goals were looked as 'someone else's problem.' However, these goals are not unknown entities anymore. As the community realises that these are things that can really improve their lives, they will be a part of the demand that provides the much-needed solution." Shaun says while pointing out that considerable progress has been made to achieve the SDGs even though there is still a long way to go.

Data, the key component is also not looked as only a facilitator, but as a separate ecosystem that is a means to the end i.e. the Agenda 2030 for Sustainable Development. Development agencies, private sector, and government institutions all are coming together to contribute to the data revolution just so to achieve these goals. So what if there is a lack of perfect data available? As Bergvinson puts it, the lack of perfect data does not really matter! Any data available should be seen as a stepping stone and that is what data revolution or rather evolution is all about. As long as countries start exploiting the baseline data that is available, data can be refined, improved and can be used to track progress over time. These goals are going to be realized only one country at a time, and each country and its citizens will have to take the ownership. The progress to achieving the SDGs is never going to be fast enough, but the data revolution can open up new avenues to attain what once seemed unachievable.

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NEWEST IN THE SELF-DRIVING CARS MIX- RENTAL COMPANIES

With numerous talks about how autonomous vehicles are going to transform the transportation industry, rental car companies are making sure they don't lag behind. **By Sanskriti Shukla**

It's official! Rental car companies are the new entrants in the driveless car race.

Apple will lease six cars from Hertz Global Holdings to test its long-anticipated autonomous driving software. Apple CEO Tim Cook has called self-driving cars the "mother of all AI projects". "We're focusing on autonomous systems," Cook told Bloomberg in an interview. This news has made a buzz in the market and has further given impetus to the drive-less technology.

Another project which has kept up with this trend is the agreement between Waymo, Google's self-driving unit, and Avis. The two technology giants have partnered with rental car fleets, making the rental car companies a part of the autonomous vehicle industry.

Documents released by California Department of Motor Vehicles state that Apple would be leasing Lexus RX450h sport-utility vehicles from Hertz's Donlen fleet-management unit. The rental car firm will service and store Waymo's Chrysler Pacifica minivans in Phoenix, where Waymo is testing a ride-sharing service with volunteer members of the public.

Avis owns Zipcar, which is an on-demand rental service with over one million members, mostly in urban spaces. The new deal is limited to Waymo's vehicles in Phoenix, where it started its first pilot service in April after nearly a decade of research.

"With members of the public using our growing fleet of self-driving cars, our vehicles need standard maintenance and cleaning so they're ready for our riders at any time of the day or night," said John Krafcik, CEO, Waymo. "Avis Budget Group is an ideal partner to provide fleet support and maintenance. With thousands of locations around the world, Avis Budget Group can help us bring our technology to more people, in more places," the company said in a release.

Talking on the same lines, Larry De Shon, President and CEO, Avis Budget Group said, "We are excited to partner with Waymo, the self-driving technology leader that is changing the mobility landscape in a profoundly transformative and beneficial manner."

Shon also added, "Not only does this partnership enable us to leverage our current capabilities and assets, but it also allows us to accelerate our knowledge and hands-on experience in an emerging area as Waymo-enabled self-driving cars become available in the marketplace."

Cars as predictive personal assistants

Autonomous cars have a way of integrating with people's lifestyle to make the experience more predictive and personalized. "The car will become your personal assistant. The car will know what kind of music would you like to listen to and know your relaxing music as opposed to your invigorating music. The system will be reactive and predictive to the needs of the humans," stated Jono Anderson, principal at KPMG's Strategy and Innovation, in an interview with *JS online*.

Autonomous cars with the capability of fully driving themselves will make room for changes in the interior and exterior of the car. A steering wheel might not even be in the picture. An autonomous car might even have adaptions for the disabled.

Meanwhile, mobility service providers are changing transportation because they are increasingly becoming more affordable than driving. For example, in the city of San Francisco, parking a car can costs around $50. So, commuters are opting to use ride-sharing services like Uber or Lyft

– which costs less than driving or parking. Needless to say, when mobility service providers don't have to pay for human drivers, the fare for services are expected to decrease, making them these vehicles pocket-friendly.

Partnerships are crucial

Seeing rental car-companies entering the self-driving car scene reinforces one of the most obvious trends in the space – the automakers, tech companies, and the other assorted players who might not reach the finish line if they try to develop their systems alone. Partnerships and acquisitions will be crucial for creating the best autonomous system, especially with billions of dollars on the line. Most of the deals are focused on developing the technology that will control the vehicles, but rental-car companies could have a significant role to play as driverless cars speed forward.

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DYNAMIC CITY PLANNING THROUGH ADVANCED GIS CAPABILITY

Accurate spatial data is facilitating community development and planning for a smart city

Porirua is located on New Zealand's North Island and is one of the four cities that constitute the metropolitan area of Wellington, the nation's capital. Porirua City Council (PCC) is the local government agency servicing Porirua and its 55,000 residents.

PCC, in consultation with all its relevant stakeholders, determined a number of strategic priorities for Porirua from which several long-term goals were established. To assist with reaching these goals, PCC's long-term plan for 2015-25 incorporates a significant investment in new infrastructure and city centre development.

PCC'S LONG-TERM GOALS FOR PORIRUA INCLUDE

More affordable medium to high density housing

Growth in jobs and population

Transformation of its city centre to enable inner city living for 1,500 residents

Better public transport access and usage (and subsequently less cars)

AAM New Zealand (AAM NZ), having worked with PCC for many years in helping improve their Geographic Information System (GIS) and 3D capabilities, were commissioned to provide an accurate, accessible and interactive 3D city map of Porirua. An accurate, up-to-date 3D city map is an integral component for smart city planning, essential to carrying out PCC's long-term development plans.

The Challenge

During preparation for city development works, PCC identified inaccuracies in their spatial data that restricted planning. PCC's level of detail (LoD) building models were outdated and district plans, based on 2D static map outputs, were not interactive and lacked 3D or height enablement of data.

PCC's GIS team recognised they needed:

- The ability to approximate 3D buildings using existing models
- Accurate, up-to-date, textured 3D (LoD2) building models — a building shell with roof form and building textures
- To provide colleagues and the community with online access to city models
- A Web GIS viewer that provided easy-to-use analysis tools, layer control, map sharing, publishing and printing.

The Solution

AAM NZ agreed to ensure that PCC's cost objectives were met when delivering their required GIS solution.

AAM NZ captured aerial Imagery and LiDAR for use in producing 3D city models. This data enabled the extraction of building models and provided visualisation tools and training required by PCC.

The fully integrated solution was delivered alongside training to expand PCC's 3D capability, and comprised:

- Data acquisition – aerial data captured and delivered via oblique imagery and high density Light Detection and Ranging (LiDAR)
- Development of LoD2 models – AAM processed LiDAR data to extract buildings, ground surface and vegetation. Oblique imagery and LiDAR were further processed, using complex algorithms and photogrammetry methods, to texture the LoD2 models
- Online visualisation tools – AAM used Esri CityEngine 3D technology and Web scene templates to enable staff to visualise, interact with and analyse 3D models.

The Results

The PCC GIS team fully supports new infrastructure and city centre development with precise and detailed LoD2 models, providing an accurate, up-to-date 3D city map of Porirua and offering the following benefits:

- Improves interaction with city information by incorporating 2D and 3D visuals
- Enhances GIS and modelling functionality for better decision-making and planning
- Mitigates impacts by allowing planners to understand the interaction between the community and proposed developments
- Promotes smart city planning through accurate and current spatial data
- Facilitates easy access to maps and tools through a fully responsive, online platform.

MAPPING SANITATION

Hexagon Geospatial's technology is helping an Indian city resolve its poor sanitation and provide a better life to the less affluent communities.

Lack of adequate sanitation is a major cause of deaths and diseases in a developing country like India. Poor sanitation not only adversely affects the quality of water and environment, but also has economic consequences and harmful effects on physical and mental well-being of the citizens. While there are many active developments focused on improving the infrastructure of more affluent areas, many of the informal settlements remain some of the most neglected vicinities. In the Indian state of Maharashtra alone, more than 11 million people are affected by open defecation.

However, a civil society organization — Shelter Associates (SA) —aims to convert urban informal settlements into housing societies, to provide safer and cleaner environment, thereby giving access to basic services like water, sanitation, etc. Working in the informal settlements of Pune, Pimpri-Chinchwad, Navi Mumbai, Kolhapur, and Sangli cities of Maharashtra, over the period of last two decades, SA has facilitated successful community and household sanitation projects. The launch of Swachh Bharat Mission by the Government of India, gave a further thrust to SA's work. Thus, SA focused its attention to household sanitation in informal settlements by launching 'One Home One Toilet' (OHOT) model to overcome inadequate sanitation facilities in Pimpri-Chinchwad. Although along with inadequate sanitation, inadequate data was also a looming problem.

Limitations of conventional system

The success of any mission or program depends upon the credible data and an institutionalized tracking mechanism to measure the impacts or the adversities. Currently, in most of the Indian cities' plan there is dearth of precise data and if at all it is present, it is typically secondary data. It does not contain a detailed understanding of the existing infrastructure or topography. This absence of spatially accurate and up-to-date data, which would allow cities to explore solutions, was one of the biggest challenges faced by the Shelter Associates team.

Pre intervention: Identifying the current places for defecation in Balajinagar settlement, Pimpri-Chinchwad

> "We believe that real time spatial data serves as a powerful planning tool in the delivery of essential services that are lacking in the urban informal settlements like housing, sanitation, water supply, electricity, waste management etc. This helps to plug the gap thereby ensuring equitable distribution of resources to the urban poor."
>
> **Pratima Joshi**
> Founder & Executive Director, Shelter Associates

Enter Hexagon Geospatial

To overcome this challenge, SA opted to link the collected data with a GIS-based platform,

which could be accessed and analyzed in detail — it would facilitate data representation and identify the gaps in delivery of sanitation. Shelter Associates turned to Hexagon Geospatial's GeoMedia as an apt solution. GeoMedia is a comprehensive and dynamic GIS, which extracts powerful intelligence from geospatial data and integrates it to present actionable information. It links the queries together and view dynamically updated results as data changes.

The Shelter Associates' GIS team digitized all the houses and drainage lines on GeoMedia. The map with combined

Mapping new drainage lines and community toilet blocks using GeoMedia in Balajinagar settlement, Pimpri-Chinchwad

Post Intervention impact-Balaji Nagar, PCMC

geographic data from different sources is integrated onto a GIS platform. Several layers viz. sewer access locations, gutter lines, garbage bins, roads, water stand posts, taps, and community toilet blocks are then added. The household-level data obtained from Rapid Household Surveys (RHS) is attached to the digitized data. Following which the SA GIS team builds complex queries of the data, checking whether all houses on map are numbered, measuring proximity to water supply and drainage, identifying the occupancy of the structures, identifying the location of waste collection. This spatial data on analysis, gives rise to a comprehensive real time dataset which helps in targeting urban informal settlements strategically for carrying out interventions.

Efficiencies achieved

Hexagon Geospatial's GeoMedia efficient utilization of spatial data has helped Shelter Associates in mapping informal settlements lacking household sanitation and studies the existing drainage networks.

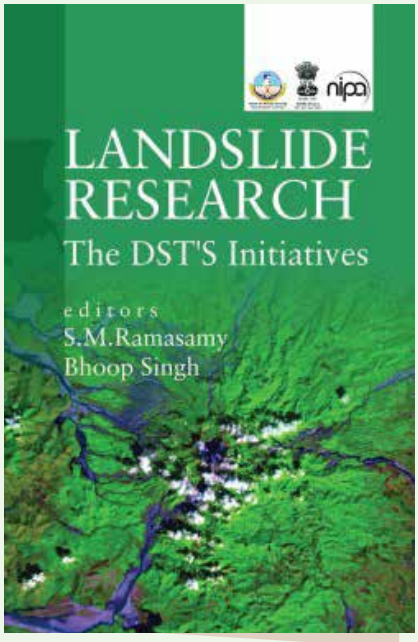
It has also facilitated in creating data on an open platform, allowing it to be analysed and studied by both Shelter Associates and the Urban Local Bodies (ULBs) for the first time. After the analysis, it is published on Google Earth enabling open viewership for everyone.

This data provides a useful planning tool to devise strategies for delivering sanitation solutions over a period of time and make budgetary provisions accordingly. The detailed data of each city where SA has been carrying out its interventions such as: Pune, Pimpri-Chinchwad, Sangli, Kolhapur, Navi Mumbai and Thane have been helping the respective city administration to plan their budgets for identifying, planning and adding/repairing/augmenting drainage lines.

> "Hexagon Geospatial's GeoMedia has been the best planning, monitoring and tracking tool for us throughout the implementation of our projects everywhere."
>
> **GIS Team**
> Shelter Associates

Benefits galore

- Provides precision, accuracy and cross querying tools which enables the integration of data effectively
- Efficiently coordinates community mobilization activities, monitors and tracks the toilet construction processes
- Provides a portable dataset, speeds up the entire processes and results in on time delivery of the project
- Flexible and open architecture adds transparency for the funders



Book Review By

Prof. Arup Dasgupta

Editors

S. M. Ramasamy and Bhoop Singh

Publisher

New India Publishing

LANDSLIDE RESEARCH

THE DST'S INITIATIVES

Landslides are an endemic problem in India. Indiscriminate deforestation coupled with unusually heavy rains and geological setting of certain areas make some parts of India landslide hazard prone. The Department of Science and Technology has taken an initiative to promote research on landslides. Lanslide Research gives a detailed overview of the studies under this initiative. The studies are covered under the headings of Earth System Processes and Landslides, Landslide Hazard Zonation Mapping, LHZ Mapping and Geotechnical Investigations, Instrumentation, Monitoring and Forewarning, Satellite Based Landslide Monitoring, and Site Specific Landslide Investigations.

Each of the headings contains papers covering the topic through case studies of specific areas. Very good use has been made of GPS data, remote sensing imagery, including DEMs and GIS as well as traditional geological, geomorphic, geo-statistical and geotechnical techniques. It is also interesting to see at least one study using Interferometric SAR data. The ground based instrumentation for landslide detection has been covered in detail. Each paper is profusely illustrated with color plates and diagrams, which greatly helps in understanding the analysis, results, and conclusions. The methodologies are explained with flow charts.

The remotely-sensed data analysis seems to have an analogue visual rather than a digital. The GIS usage also is limited to overlay analysis. The integration of datasets with ground data and the combined analysis is muffing. A section on landslide prevention would have been useful. This has been covered as parts of papers under the head mitigation; however a separate section would have been useful, particularly for anthropogenic disturbance control. For example, the consequences of indiscriminate building activities in hill stations like Nainital could have been addressed. Focus on indexing would also have helped the readers to do a keyword search.

DST has to be lauded for initiating and funding these studies and bringing out the results in book form. The case studies should be very useful to researchers in the future. It is hoped that DST continues these studies addressing some of the aspects outlined above.

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